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2020

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Project ID:	Project Acronym:	Evaluation Panel:
694694	**ChromADICT**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. GENEVIEVE ALMOUZNI**
Host Institution: Institut Curie, FR

Chromatin Adaptations through Interactions of Chaperones in Time

A central question in chromatin biology is how to organize the genome and mark specific regions with histone variants. Understanding how to establish and maintain, but also change chromatin states is a fundamental challenge. Histone chaperones, escort factors that regulate the supply, loading, and degradation of histone variants, are key in their placement at specific chromatin landmarks and bridge organization from nucleosomes to higher order structures. A series of studies have underlined chaperone-variant partner selectivity in multicellular organisms, yet recently, dosage imbalances in natural and pathological contexts highlight plasticity in these interactions. Considering known changes in histone dosage during development, one should evaluate chaperone function not as fixed modules, but as a dynamic circuitry that adapts to cellular needs during the cell cycle, replication and repair, differentiation, development and pathology.

Here we propose to decipher the mechanisms enabling adaptability to natural and experimentally induced changes in the dosage of histone chaperones and variants over time. To follow new and old proteins, and control dosage, we will engineer cellular and animal models and exploit quantitative readout methods using mass spectrometry, imaging, and single-cell approaches. We will evaluate with an unprecedented level of detail the impact on i) soluble histone complexes and ii) specific chromatin landmarks (centromere, telomeres, heterochromatin and regulatory elements) and their crosstalk. We will apply this to determine the impact of these parameters during distinct developmental transitions, such as ES cell differentiation and T cell commitment in mice.

We aim to define general principles for variants in nuclear organization and dynamic changes during the cell cycle/repair and in differentiation and unravel locus specific-roles of chaperones as architects and bricklayers of the genome, in designing and building specific nuclear domains.

Project End Date: **30-JUN-22**

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Project ID:	Project Acronym:	Evaluation Panel:
714102	**CaBiS**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. GUSTAV BERGGREN**
Host Institution: Uppsala Universitet, SE

Chemistry and Biology in Synergy - Studies of hydrogenases using a combination of synthetic chemistry and biological tools

My proposal aims to take advantage of my ground-breaking finding that it is possible to mature, or activate, the [FeFe] hydrogenase enzyme (HydA) using synthetic mimics of its catalytic [2Fe] cofactor. (Berggren et al, Nature, 2013) We will now explore the chemistry and (bio-)technological potential of the enzyme using an interdisciplinary approach ranging from in vivo biochemical studies all the way to synthetic model chemistry. Hydrogenases catalyse the interconversion between protons and H2 with remarkable efficiency. Consequently, they are intensively studied as alternatives to Pt-catalysts for these reactions, and are arguably of high (bio-) technological importance in the light of a future "hydrogen society".

The project involves the preparation of novel "artificial" hydrogenases with the primary aim of designing spectroscopic model systems via modification(s) of the organometallic [2Fe] subsite. In parallel we will prepare in vitro loaded forms of the maturase HydF and study its interaction with apo-HydA in order to further elucidate the maturation process of HydA. Moreover we will develop the techniques necessary for in vivo application of the artificial activation concept, thereby paving the way for a multitude of studies including the reactivity of artificial hydrogenases inside a living cell, but also e.g. gain-of-function studies in combination with metabolomics and proteomics. Inspired by our work on the artificial maturation system we will also draw from our knowledge of Nature's [FeS] cluster proteins in order to prepare a novel class of "miniaturized hydrogenases" combining synthetic [4Fe4S] binding oligopeptides with [2Fe] cofactor model compounds.

Our interdisciplinary approach is particularly appealing as it not only provides further insight into hydrogenase chemistry and the maturation of metalloproteins, but also involves the development of novel tools and concepts applicable to the wider field of bioinorganic chemistry.

Project End Date: **31-JAN-22**

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Project ID:	Project Acronym:	Evaluation Panel:
715024	**RAPID**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. SIMON ELSÄSSER**
Host Institution: Karolinska Institutet, SE

Chromatin dynamics resolved by rapid protein labeling and bioorthogonal capture

Histone proteins provide a dynamic packaging system for the eukaryotic genome. Chromatin integrates a multitude of signals to control gene expression, only some of which have the propensity to be maintained through replication and cell division. For our understanding of cellular memory and epigenetic inheritance we need to know what features characterize a stable, heritable chromatin state throughout the cell cycle. State-of-the-art methods such as ChIP-Seq provide population-based snapshots of the epigenomic landscape but little information on the stability and relative importance of each studied feature or modification. This project pioneers a rapid, sensitive and selective protein labeling method (termed RAPID) for capturing genome-wide chromatin dynamics resolved over a period of time ranging from minutes to days. RAPID introduces a flexible time dimension in the form of pulse or pulse-chase experiments for studying genome-wide occupancy of a protein of interest by next-gen sequencing. It can also be coupled to other readouts such as mass spectrometry or microscopy. RAPID is uniquely suited for studying cell cycle-linked processes, by defining when and where stable 'marks' are set in chromatin. I will employ mouse embryonic stem cell (mESC) as a model system for pluripotency and lineage specification. RAPID will define fundamental rules for inheritance of histone and other chromatin-associated proteins and how they are modulated by the fast cell cycle of pluripotent cells. Using RAPID in combination with other state-of-the art genetics and epigenomics, I will collect multi-dimensional descriptions of the dynamic evolution and propagation of functionally relevant chromatin states, such as interstitial heterochromatin and developmentally regulated Polycomb domains.

Project End Date: **31-DEC-21**

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Project ID:	Project Acronym:	Evaluation Panel:
725685	**POLYAMACHINES**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. LORI PASSMORE**
Host Institution: United Kingdom Research And Innovation, UK

The polyA machinery: Elucidating the molecular mechanisms of mRNA polyadenylation, deadenylation and RNA recognition

Gene expression is tightly regulated to allow rapid responses to cellular stimuli. In eukaryotes, the 3´ polyA tail of mRNAs plays key roles in post-transcriptional control. The Cleavage and Polyadenylation Factor (CPF), Ccr4–Not and Pan2–Pan3 multiprotein complexes add or remove polyA tails to regulate mRNA stability and efficiency of translation. They control expression of genes in the inflammatory response, miRNA-targeted gene silencing and expression of maternal mRNAs in oocyte development. These processes are deregulated in disease, including cancer and neurological disorders.

Although the proteins that add and remove polyA tails are known, their mechanisms are poorly understood. My lab recently established methods to reconstitute the polyA machinery. This led to new insights into the link between transcription and polyadenylation, new understanding of the molecular mechanisms of deadenylation, and details of RNA recruitment.

In this proposal, my objective is to understand the molecular basis for polyadenylation and deadenylation of specific mRNAs. This is now possible because of our novel methodological and biological advances. We will determine high-resolution structures of the polyA machinery using electron cryo-microscopy (cryo-EM), reconstitute their biochemical activities in vitro and study their in vivo functional roles. We use this integrated approach to study intact multiprotein complexes, not individual subunits or domains. This involves considerable technical challenges and an investment in developing high quality purifications and new structural methods. I will determine how the four enzymatic activities of CPF are coupled, the mechanisms by which Ccr4–Not targets specific RNAs, and the molecular basis for RNA recognition by Pan2–Pan3. Together, this will provide new biological and technological insights, leading to understanding of fundamental processes in gene expression and the role of polyA tails in disease.

Project End Date: **31-MAR-22**

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Project ID:	Project Acronym:	Evaluation Panel:
726436	**Ti-EM**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. ROUSLAN EFREMOV**
Host Institution: Vib, BE

Methodological developments for time-resolved single particle cryo-EM

Protein synthesis and degradation, energy metabolism, signalling, processing of information-encoding polymers (RNA and DNA) are facilitated and regulated by molecular machines, protein complexes that undergo significant conformational changes in time as they facilitate their function. To be able to control the biological processes rationally and with high precision it is essential to understand their mechanism at atomic level. A powerful way to gain detailed insight onto function of these proteins is to see these molecules at atomic resolution while they function. The high-resolution structures of biological macromolecules obtained by X-ray crystallography, NMR and more recently single particle electron cryogenic microscopy (cryo-EM) have provided insights onto the way many molecular machines are constructed. These methods generally provide snapshots of discrete long-lived states, visualizing the conformational changes along the reaction trajectory at high-resolution often remains an elusive objective.

The aim of my proposal is to develop methods for visualizing transient conformations of protein complexes by time-resolved single particle cryo-EM. Time-resolved cryo-EM combines structural study with kinetics by freeze-trapping kinetic intermediates in a biological reaction and has potential to provide atomic-resolution 'movies' of functioning biological complexes. Technical limitations however so far restricted widespread use and utilization of the complete potential of this technique.

Main part of this project is dedicated to development of microfluidic instruments for cryo-EM sample preparation. If successful, our approaches will allow trapping kinetic intermediates of molecular machines with millisecond time-resolution using picogram amounts of protein sample. The developed method will be applied to resolve key functional conformations of respiratory complex I and observe regulatory trajectories of ligand-gated ion channels.

Project End Date: **31-MAY-22**

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Project ID:	Project Acronym:	Evaluation Panel:
759661	**SPOCkS MS**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. CHARLOTTE UETRECHT**
Host Institution: Heinrich-Pette Institut Leibniz Institut Fuer Experimentelle Virologie, DE

Sampling Protein cOmplex Conformational Space with native top down Mass Spectrometry

The main question to be addressed by SPOCk'S MS is how protein complex conformation adapts to local changes, such as processing of polyproteins, protein phosphorylation or conversion of substrates. While labelling strategies combined with mass spectrometry (MS), such as hydrogen deuterium exchange and hydroxyl footprinting, are very versatile in studying protein structure, these techniques are employed on bulk samples averaging over all species present. SPOCk'S MS will remedy these by studying the footprinting and therefore exposed surface area on conformation and mass selected species. Labelling still happens in solution avoiding gas phase associated artefacts. The labelling positions are then read out using newly developed top-down MS technology. Ultra-violet and free-electron lasers will be employed to fragment the protein complexes in the gas phase. In order to achieve the highest possible sequence and thus structural coverage, lasers will be complemented by additional dissociation and separation stages to allow MS^N. SPOCk'S MS will allow sampling conformational space of proteins and protein complexes and especially report about the transient nature of protein interfaces. Constraints derived in MS will be fed into a dedicated software pipeline to derive atomistic models. SPOCk'S MS will be used to study intracellular viral protein complexes, especially coronaviral replication/transcription complexes, which are highly flexible and often resist crystallisation and are barely accessible by conventional structural biology techniques.

Objectives:

- Integrate labelling with complex species selective native MS for time-resolved structural studies
- Combine fragmentation techniques to maximise information content from MS
- Develop software suite to analyse data and model protein complex structures based on MS constraints
- Apply SPOCk'S MS to protein complexes of human pathogenic viruses

Project End Date: **31-DEC-22**

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Project ID:	Project Acronym:	Evaluation Panel:
787926	**RIBOFOLD**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. MARINA RODNINA**
Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Ribosome Processivity and Co-translational Protein Folding

Protein domains start to fold co-translationally while they are being synthesized on the ribosome. Co-translational folding starts in the confined space of the ribosomal polypeptide exit tunnel and is modulated by the speed of translation. Although defects in protein folding cause many human diseases, the mechanisms of co-translational folding and the link between the speed of translation and the quality of protein folding is poorly understood. Here I propose to study when, where and how proteins emerging from the ribosome start to fold, how the ribosome and auxiliary proteins bound at the polypeptide exit affect nascent peptide folding, what causes ribosome pausing during translation, and how pausing affects nascent peptide folding. Our recent results (Holtkamp et al., Science 2015; Buhr et al., Mol Cell 2016) provide the proof of principle for monitoring translation and protein folding simultaneously at high temporal resolution. First, we will follow translation processivity and folding trajectories for proteins of different domain structure types using time-resolved ensemble kinetics and single-molecule setups. The structures of complexes with stalled folding intermediates will be solved by cryo-electron microscopy. Second, we will investigate the effects of the chaperone trigger factor, the signal recognition particle, and other protein biogenesis factors on the folding landscape. Third, we will analyze transient ribosome pauses in vivo (based on ribosome profiling data) and in vitro (based on time-resolved translation assays and mathematical modeling) and identify the events that cause pausing. Finally, we will probe how changes in translational processivity affect the conformational landscape of a protein. We expect that these results will open new horizons in understanding co-translational protein folding and will help to understand the molecular basis of many diseases.

Project End Date: **31-JUL-23**

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Project ID:	Project Acronym:	Evaluation Panel:
789121	**EditMHC**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. ROBERT TAMPÉ**
Host Institution: Johann Wolfgang Goethe Universitaet Frankfurt Am Main, DE

How MHC-I editing complexes shape the hierarchical immune response

Our body constantly encounters pathogens or malignant transformation. Consequently, the adaptive immune system is in place to eliminate infected or cancerous cells. Specific immune reactions are triggered by selected peptide epitopes presented on major histocompatibility complex class I (MHC-I) molecules, which are scanned by cytotoxic T lymphocytes.

Intracellular transport, loading, and editing of antigenic peptides onto MHC-I are coordinated by a highly dynamic multisubunit peptide-loading complex (PLC) in the ER membrane. This multitasking machinery orchestrates the translocation of proteasomal degradation products into the ER as well as the loading and proofreading of MHC-I molecules.
Sampling of myriads of different peptide/MHC-I allomorphs requires a precisely coordinated quality control network in a single macromolecular assembly, including the transporter associated with antigen processing TAP1/2, the MHC-I heterodimer, the oxidoreductase ERp57, and the ER chaperones tapasin and calreticulin. Proofreading by MHC-I editing complexes guarantees that only very stable peptide/MHC-I complexes are released to the cell surface.

This proposal aims to gain a holistic understanding of the PLC and MHC-I proofreading complexes, which are essential for cellular immunity. We strive to elucidate the mechanistic basis of the antigen translocation complex TAP as well as the MHC-I chaperone complexes within the PLC. This high-risk/high-gain project will define the inner working of the PLC, which constitutes the central machinery of immune surveillance in health and diseases. The results will provide detailed insights into the architecture and dynamics of the PLC and will ultimately pave the way for unraveling general principles of intracellular membrane-embedded multiprotein assemblies in the human body. Furthermore, we will deliver a detailed understanding of mechanisms at work in viral immune evasion.

Project End Date: **31-DEC-23**

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Project ID:	Project Acronym:	Evaluation Panel:
789267	**REPLICHROMA**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. NYNKE DEKKER**
Host Institution: Technische Universiteit Delft, NL

Eukaryotic DNA replication: a single-molecule approach to the study of yeast replication on chromatin

DNA replication is essential to cellular function. During a lifetime, each of us synthesizes a light-year's length of DNA, but this process is so robust that few of us will develop cancer. In eukaryotes, DNA is packed into chromatin, a hierarchical DNA-protein assembly of which the nucleosome forms the basic unit. Chromatin replication convolves DNA replication with the duplication and reassembly of all DNA-associated proteins. Understanding the coupling between these processes has fundamental implications for epigenetic inheritance and cancer.

The goal of this proposal is to gain spatiotemporal insight into chromatin replication by using our biophysical expertise in replication and chromosomal dynamics to build up a mechanistic timeline of the process. We will harness recent advances in the reconstitution of the yeast replisome alongside our novel, high-throughput single-molecule approach to visualize and quantify the collaboration between a single yeast replisome and the histone chaperones to achieve chromatin replication. We will:

•Monitor the assembly of the replisome on chromatin and visualize how nucleosomes impact its progression.

•Quantify how the replisome and histone chaperones disrupt nucleosomes and retain histones for further processing.

•Detect the deposition of newly synthesized histones behind the replisome and reveal the interactions between replisome components and histone chaperones that couple replication to nucleosome assembly.

•Report on the phenomenon of epigenetic inheritance by imaging histone recycling between parental and daughter DNA. We will examine its timing and efficiency, the conformations of reassembled nucleosomes, and any preferential recycling to either daughter DNA.

This proposal places us in a unique position to make major contributions to the field of chromatin replication, and to provide the field with a powerful tool to investigate topics from fundamental questions in molecular biology to the performance of new cancer drugs.

Project End Date: **31-AUG-23**

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Project ID:	Project Acronym:	Evaluation Panel:
819299	**MIGHTY_RNA**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. CHIRLMIN JOO**
Host Institution: Technische Universiteit Delft, NL

Repurposing small RNA from ciliates for genome editing: single-molecule study

Genome editing is an essential tool for life sciences. Recent ground-breaking discovery in microbiology drew our attention to the genome editing ability of bacteria (CRISPR). Since its discovery, CRISPR has revolutionized the way of editing a genome. Despite its wide use, CRISPR-genome editing has limitations, especially in the use for medical applications. Numerous studies have shown that it suffers from the off-target effect. Its use is also restricted by its particular sequence requirement and its poor accessibility to a structured genome. Furthermore, recent studies suggested that it might act as a virulence factor within human cells. These limitations demand new genome editing tools.

This proposal sets out to understand the molecular mechanism of Tetrahymena DNA elimination. This naturally occuring genome editing is mediated by a eukaryotic RNA system (Twi1). This system uses an entirely different mechanism from CRISPR and has potential to perform more effectively. I will first investigate how small RNA-loaded Twi1 (“target searcher”) recognizes its target and whether its performance exceeds other target searchers including CRISPR/Cas9. I will use single-molecule fluorescence for high resolution observations and develop a high-throughput single-molecule method for transcriptome-wide understanding. Second, I aim to identify a Twi1-related DNA nuclease(s) that carries out DNA elimination. I will use cutting-edge tools of single-molecule pull-down and multi-color FRET together with mass spectrometry. The nanoscopic understanding of a searcher (Twi1) and the identification of a nuclease will help create a new genome editing tool (e.g. a fusion of Twi1 and the nuclease) that potentially perform better than Cas9. Thereby, this fundamental study on “mighty RNA” will make a long-term impact for applications in science and technology. To realize this ambitious project, I will utilize my experience of studying small RNAs (funded by ERC Starting Grant).

Project End Date: **30-APR-24**

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Project ID:	Project Acronym:	Evaluation Panel:
852798	**ConflictResolution**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. STEPHAN HAMPERL**
Host Institution: Helmholtz Zentrum Muenchen Deutsches Forschungszentrum Fuer Gesundheit Und Umwelt Gmbh, DE

Transcription-replication conflicts in disease and development

Genetic and epigenetic instability contribute to cancers, aging, developmental disorders, and neurological diseases, so in-depth understanding how this instability arises is an important question affecting millions in Europe. Physical conflicts between the transcription and DNA replication machineries are a potent endogenous source of this instability.

My preliminary data indicate that a single collision can trigger long-term epigenetic changes and affect the normal expression state of genes. I hypothesize that collisions can rewire gene expression networks and lead to cellular transformations relevant to disease and development. Unfortunately, this mechanism is largely understudied owing to the lack of suitable cellular systems to characterize collisions in molecular detail. My proposal will address this key gap in knowledge.

I recently pioneered a unique human cell-based episomal system to analyse collisions in an inducible and localized fashion. Using this highly tractable system, we will molecularly characterize the (epi)genetic consequences and identify novel factors that prevent or resolve collisions (Aim 1).

To address the relevance of collisions in disease, we will establish a novel proximity-labelling system (Split-APEX2) to map collision sites and identify their associated genetic and chromatin changes in a breast cancer cell model. This cutting-edge technology will decipher their role in pathological transformations observed in breast cancer genomes (Aim 2).

To link collisions to developmental transformations, we will determine their potential to induce local epigenetic changes during zygotic genome activation in mouse embryonic cells. This approach can shift the paradigm how cells in development first start to differ from each other and reprogram their genome into different cell types (Aim 3).

Uncovering the key principles of collisions may implement highly innovative approaches to avoid or establish cellular transformations in disease and development.

Project End Date: **31-JAN-25**

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Project ID:	Project Acronym:	Evaluation Panel:
862137	**POST-IT**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. GEERT VAN DEN BOGAART**
Host Institution: Rijksuniversiteit Groningen, NL

Pathogen Oriented SNARE Trafficking for Immune Tailoring

ImImmune clearance of infectious diseases requires correct T cell activation by macrophages and dendritic cells (DCs) that present peptides derived from ingested pathogens on major histocompatibility complexes (MHC). Yet, macrophages and DCs also ingest self-antigens present in healthy cells and their presentation might trigger autoimmune disease. Presentation of the minority of ingested pathogens is promoted by so-called phagosome-autonomous trafficking. Here, pathogen binding to Toll-like receptors in phagosomes triggers recruitment of proteases and transporters to these phagosomes, but not to other phagosomes present in the same cell, promoting specific presentation of pathogen-derived peptides. However, a molecular understanding of this pathogen-oriented phagosome-autonomous trafficking is lacking.

The goal of this project is to determine how phagosome-autonomous pathogen recognition promotes presentation of pathogen-derived over harmless self-antigens. Based on my preliminary data and literature, I hypothesize that Toll-like receptor signaling triggers phosphorylation of multiple SNARE proteins at the phagosomal membrane. As SNARE phosphorylation can promote or prevent membrane fusion, this alters delivery of proteases and transporters to these phagosomes, which in turn promotes presentation of pathogen-derived peptides.

Objective 1 is to determine how SNARE function is altered upon pathogen-recognition in phagosomes using my novel quantitative Förster resonance energy transfer-fluorescence lifetime imaging microscopy (FRET-FLIM)-based technique. Objective 2 is to address how Toll-like receptor-mediated SNARE phosphorylation affects phagosome-autonomous trafficking. Objective 3 is to resolve the functional roles of SNAREs in antigen presentation using a novel bio-orthogonal chemistry-based method. This study will explain the high sensitivity of the adaptive immune system for pathogens and could lead to better vaccinations and therapies for infectious diseases.

Project End Date: **30-APR-25**

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Project ID:	Project Acronym:	Evaluation Panel:
866011	**MemDense**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. ROBERT ERNST**
Host Institution: Universitaet Des Saarlandes, DE

Cellular control of membrane protein density in the endoplasmic reticulum via the unfolded protein response

All cells must balance the production of proteins and lipids to maintain membrane functions. Imbalances in protein folding and lipid metabolism cause endoplasmic reticulum (ER) stress associated with a wide range of complex diseases including diabetes, neurodegeneration, and viral infections. The central homeostatic program of the ER is the unfolded protein response (UPR), which senses unfolded proteins in the ER to control protein synthesis, chaperone abundance, and lipid metabolism. Through these mechanisms, the UPR centrally controls decisions between cell survival, adaptation, and apoptosis. The field has focused almost exclusively on soluble proteins as triggers of the UPR, while the more abundant membrane proteins have been neglected. Our finding of UPR activation by membrane aberrancies provides a radically new perspective and allows us to address central questions in membrane and cell biology: How is the density of ER membrane proteins sensed and controlled? How are misfolded membrane proteins recognized to mount adaptive responses?
Focusing on the conceptual advance that UPR transducers sense signals from the membrane, we will 1) establish and reconstitute the machinery for sensing membrane protein crowding, 2) identify mechanisms coordinating protein and lipid homeostasis between organelles, 3) study the molecular recognition of misfolded membrane proteins by the UPR.
Key to this endeavor is our unique combination of genetic, biochemical, and biophysical tools for parallel characterization of the UPR in vivo and in vitro. Combining this framework with novel strategies for an immuno-isolation of organelles, we are primed to answer how membrane aberrancies cause chronic ER stress. By establishing the UPR as a quality control system for membrane proteins, and providing novel tools and valuable resources to the community, MemDense will have wide impact on our molecular and cellular understanding of ER homeostasis and the many diseases related to ER stress.

Project End Date: **31-MAR-25**

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Project ID:	Project Acronym:	Evaluation Panel:
866166	**RiboTrace**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. STEFAN AMERES**
Host Institution: Institut Fuer Molekulare Biotechnologie Gmbh, AT

Bridging temporal resolution gaps to dissect RNA silencing at the molecular and genomic scale

The implementation of distinct gene expression profiles is essential for organismal development, physiological responses to external stimuli or pathogens, and defines a primary cause for human disease. While much attention has been paid to the regulation of transcription, the control over RNA fate and function has only recently emerged as a central hallmark of gene regulation with enormous biological, technological and biomedical implications.

Here, we propose to study the molecular principles of RNA silencing, the least understood aspect of post-transcriptional gene regulation. We aim to systematically dissect the mechanisms and biological functions of RNA 3´end uridylation to determine the emerging role of RNA modifications in the regulation of gene expression; we will elucidate fundamental principles of RNA turnover at the genomic scale by time-resolved transcriptomics; and we will use functional genomics and haploid genetics to systematically delineate post-transcriptional gene regulatory pathways. Throughout, we will link our results back to the established function of RNA silencing in the control of organismal development, physiology and disease. Our goal is to acquire fundamental insights into the processes that survey the quality and quantity of the transcriptome to determine possible molecular causes for aberrant RNA levels that have been associated with diverse human diseases.

Because of its genetic and biochemical tools, we will use Drosophila melanogaster as a model organism. We will employ a combination of in vivo genetics, cell-free biochemical experiments, bioinformatics, and cell culture methods. What we learn in flies we will test for its conservation in mammalian cell extracts and cultured cells.

Overall, we will determine fundamental biological mechanisms of gene regulation trough pathways with enormous biological impact in health and disease.

Project End Date: **31-JAN-25**

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Project ID:	Project Acronym:	Evaluation Panel:
866250	**mARs**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. ORSOLYA BARABAS**
Host Institution: European Molecular Biology Laboratory, DE

mARs: Mobile DNA driven antibiotic resistance spreading: molecular strategies, control and evolution for broad distribution

Antibiotic resistance (AR) is spreading rapidly, leading to the development of highly virulent pathogens and multidrug-resistant 'superbugs', a major health concern of our era. Mobile DNA elements, transposons and integrons, effectively drive the spread of AR genes in microbial interaction hotspots, such as bacterial communities in humans and natural environments. Yet, our knowledge of their mechanisms remains very sparse. It is unclear how DNA movement occurs on the molecular level and how it is controlled in cells and communities; biochemical and structural data are rare and our view on their diversity and evolution is limited. Here I propose an integrated approach combining bioinformatics, genetics, microbiology, biochemistry, and structural biology to elucidate the mechanisms and diversity of mobile DNA driven resistance spreading. I want to (a) investigate the molecular mechanisms and regulation of AR gene movement in vitro, in model bacteria and in gut bacterial communities; (b) dissect the structure of the underlying molecular machineries to reveal how protein-DNA interplay promotes gene transfer; and (c) characterize the diversity, evolution and functional success of distinct molecular pathways. Mechanistic work will focus on selected mobile elements that confer resistance to last resort drugs and promiscuous gene carriers with high prevalence in health care. Bioinformatic quests will draw on recent (meta)genomic data to chart the clinical significance of molecular insights in situ. By bridging disciplines, I want to provide functionally annotated molecular movies of gene movement and explain how specific molecular strategies evolved to enable broad dissemination of resistance determinants. The insights gained in this research will provide in-depth knowledge on major AR transfer pathways and will have key implications for the development of novel intervention strategies and preventive measures aimed at reducing dissemination of drug resistance in bacteria.

Project End Date: **31-DEC-25**

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Project ID:	Project Acronym:	Evaluation Panel:
882357	**CHROMATRANS**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. PATRICK CRAMER**
Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Structural biology of chromatin transcription

Transcription of protein-coding genes by RNA polymerase II (Pol II) governs cell identity and fate. We previously provided the structural basis of Pol II transcription initiation (ERC Advanced Grant TRANSIT: Sainsbury, Nature 2012; Lariviere, Nature 2012, Plaschka, Nature 2015) and of Pol II elongation regulation (ERC Advanced Grant TRANSREGULON: Vos, Nature 2018; Vos & Farnung, Nature 2018). These studies elucidated the mechanisms of transcription regulation. However, they were conducted on naked DNA, and not on chromatin, which is the natural template in cells and regulates transcription in many ways. As a consequence, the molecular mechanism underlying chromatin transcription and the regulatory interplay between chromatin and the transcription machinery remain poorly understood. Here I propose to take the next big step towards an understanding of the transcription mechanism and investigate the structural basis for Pol II transcription of chromatin templates. Integrated structural biology will provide structures of the transcription machinery on nucleosomal DNA. Nucleosomes are the building blocks of chromatin and regulate transcription in many ways. In particular, we will solve structures of pioneer factors bound to nucleosomes, to investigate how chromatin is opened locally for transcription (aim 1). We will solve the structure of the Pol II pre-initiation complex on the '+1' nucleosome at the beginning of a gene, to understand how initiation is regulated by this specialized nucleosome (aim 2). Finally, we will determine structures of mammalian Pol II elongation complexes with many factors during nucleosome passage, to elucidate how Pol II transcribes chromatin (aim 3). Together with functional analysis in vitro and in vivo, these ground-breaking efforts will take the structural biology of transcription regulation to the chromatin level. The proposed research will also advance methods for the reconstitution and analysis of transient, higher-order complexes.

Project End Date: **30-JUN-25**

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Project ID:	Project Acronym:	Evaluation Panel:
883240	**MONOCHROME**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. GIJS WUITE**
Host Institution: Stichting Vu, NL

Disentangling metaphase chromosome organisation one chromosome at a time

Chromosomes assume their most compact state during metaphase just before they are separated. In this process of cell division the chromosomes experience high forces and genomic defects can occur then. Many techniques have built considerable understanding of metaphase chromosome structure and a multitude of models have been put forward how cells organize their chromosomes during metaphase. Yet, given the complexity of the process and limitations of the methods to study them, it is far from being fully understood. The breakthrough opportunity in this regard is the development of tools that allow real-time, 3D, super-resolution imaging and manipulation of entire non fixed metaphase chromosomes under nearphysiological conditions.

Here I propose to quantitatively image the proteins that establish the architecture of metaphase chromosomes and disentangle the connection between its architecture, internal protein dynamics and mechanics at the multi-protein as well as the single-molecule level. For this project I plan to expand the combination of optical manipulation and fluorescent microscopy by introducing force-induced expansion microscopy together with advanced labeling and imaging techniques that ultimately will permit real-time, 3D, super-resolution quantitative analysis of complex (protein) structures within native non-fixed metaphase chromosomes. With this kind of instrument it becomes possible to validate and/or challenge the current models of metaphase organization as well as explore the physical properties of chromosomes but also study chromosome
separation dynamics.

My extensive experience handling biological systems and pushing instrumental boundaries gives me an excellent starting point to address key research questions with regards to metaphase chromosomes. In doing so I can improve our understanding of chromosome organization which is important because chromosome defects can have devastating consequences leading to for example cancer or fragile X syndrome.

Project End Date: **31-DEC-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
883605	**DSBSunrise**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. BERNARD DE MASSY**
Host Institution: Centre National De La Recherche Scientifique, FR

Identifying the steps required for meiotic DNA double-strand break formation

At the onset of prophase of the first meiotic division, meiotic cells undergo complex molecular events with the induction of several hundred DNA double-strand breaks. These DNA breaks are required because they initiate recombination between homologous chromosomes and to allow chromosome segregation during meiosis. They are essential for fertility. However, they represent a major challenge for genome integrity.
It is thought that meiotic DNA break formation is under tight control to ensure that all breaks are properly repaired to maintain genome integrity. But how this control implemented is unknown.

We postulate that three critical steps take place to ensure meiotic DNA break formation at the right time, right place, and right frequency. We will test this hypothesis by addressing in mice the three following questions:
Q1: We will ask whether a homology-sensing process brings homologous chromosomes in spatial proximity before DNA break formation to improve DSB repair efficiency and avoid topological conflicts. If this is the case, we will determine the molecular mechanism.
Q2: We will determine whether the genomic sites undergoing DNA breakage interact with structural components of chromosome axes before break formation, and how. This interaction is predicted to be necessary for proper DSB repair.
Q3: We will determine how DNA cleavage is activated. We will do this through in vitro reconstitution of meiotic DSB formation.
Answering these key questions will be possible by using in vivo and in vitro approaches. We will pioneer in vitro meiotic differentiation of mouse embryonic stem cells to overcome the current limitations for identifying novel components and interactions.

We will thus decipher how a molecular machinery that has evolved from a DNA type II topoisomerase family has been selected and modified to promote a complex reaction initiated by DNA cleavage at multiple sites along chromosomes followed by their repair by homologous recombination.

Project End Date: **30-NOV-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
885632	**FLEXINGPLEXIN**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. EDITH YVONNE JONES**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Oxford, UK

A structure-function analysis to discover how receptor conformations and interactions determine semaphorin-neuropilin-plexin signalling outputs.

During the development of a multicellular organism cell guidance proteins interact with their cognate cell surface receptors to guide cells to their correct location. Such functions continue to be essential in the adult to maintain tissue homeostasis. Semaphorins use plexins as their main receptors for signalling and the semaphorin and plexin families together constitute one of the largest and functionally diverse of the cell guidance systems in vertebrates. We have gained some insight into the architecture and interactions which trigger semaphorin-plexin signalling, but fundamental questions remain and some of the most puzzling, and of potential clinical importance, concern the mechanisms of action of the secreted class 3 semaphorins (Sema3s), and their (co-)receptors. Neuropilin co-receptors play pivotal roles for Sema3 function and have been implicated in context dependent switching of cell guidance signalling outputs. There is an urgent need for information on molecular mechanism to underpin the design and interpretation of studies into biological function and clinical pathology. To advance the field we will combine structural biology and cellular imaging based approaches with functional studies (in house and in collaboration).
The research plan is sub-divided into three inter-related sections that aim to discover:
1. The structural determinants and mechanisms of action by which class 3 semaphorins exert differing effects on signalling.
2. The conformational state of the plexin ectodomain in different contexts and its contribution to signal outcome.
3. The mechanisms by which neuropilin binding can switch the outcomes of plexin signalling.
Molecular level answers to the questions posed by semaphorin-neuropilin-plexin signalling will take us beyond the current state of the art, and impact on diverse disciplines, for example cellular immunology and developmental biology, as well as guiding the design of novel therapeutic agents.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715727	**GENOMIS**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. MARZENA MAGDA BIENKO**
Host Institution: Karolinska Institutet, SE

Illuminating GENome Organization through integrated MIcroscopy and Sequencing

In human cells, two meters of DNA sequence are compressed into a nucleus whose linear size is five orders of magnitude smaller. Deciphering how this amazing structural organization is achieved and how DNA functions can ensue in the environment of a cell's nucleus represent central questions for contemporary biology.

Here, I embrace this challenge by establishing a comprehensive framework of microscopy and sequencing technologies coupled with advanced analytical approaches, aimed at addressing three fundamental highly-interconnected questions: 1) What are the design principles that govern DNA compaction? 2) How does genome structure vary between different cell types as well as among cells of the same type? 3) What is the link between genome structure and function? In preliminary experiments, we have devised a powerful method for Genomic loci Positioning by Sequencing (GPSeq) in fixed cells with optimally preserved nuclear morphology. In parallel, we are developing high-end microscopy tools for simultaneous localization of dozens of genomic locations at high resolution in thousands of single cells.

We will obtain first-ever genome-wide maps of radial positioning of DNA loci in the nucleus, and combine them with available DNA contact probability maps in order to build 3D models of the human genome structure in different cell types. Using microscopy, we will visualize chromosomal shapes at unprecedented resolution, and use these rich datasets to discover general DNA folding principles. Finally, by combining high-resolution chromosome visualization with gene expression profiling in single cells, we will explore the link between DNA structure and function. Our study shall illuminate the design principles that dictate how genetic information is packed and read in the human nucleus, while providing a comprehensive repertoire of tools for studying genome organization.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
726417	**PATHORISC**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. PETER BRODERSEN**
Host Institution: Kobenhavns Universitet, DK

Reprogramming of small RNA function in plant-pathogen interactions

RNA silencing relies on small RNAs that act in RNA induced silencing complexes (RISCs). RISCs use base pairing to select mRNAs or invading nucleic acids such as viruses for repression. RNA silencing may facilitate gene expression changes, for example in host-pathogen interactions. Such changes require reprogramming of RISC, since a different set of RNAs must be rapidly repressed upon pathogen perception. RISC reprogramming is non-trivial: new small RNAs must be produced and be rapidly incorporated into RISC, while unwanted repression by pre-existing RISCs must be eliminated. This project focuses on understanding three central aspects of RISC reprogramming in plant-pathogen interactions. First, we will define mechanisms that allow invading RNA, but not self-RNA, to engage in positive feedback loops for small RNA synthesis, and we will investigate the specific importance of these positive feedback loops in antiviral defense. Second, we will explore how rapid proteolysis of the central RISC component ARGONAUTE1 (AGO1) governs rapid incorporation of newly synthesized small RNA. We will also explore the hypothesis that non-RNA bound AGO1 is degraded to minimize vulnerability to pathogens that use small RNAs as virulence factors to repress host immune signaling. The relevance of these mechanisms of AGO1 proteolysis in plant immunity will be investigated. These studies take advantage of our recent discovery of proteins required specifically for turnover of AGO1. Finally, we explore the hypothesis that rapid chemical modification of mRNA by N6-adenosine methylation (m6A) may bring mRNAs with poor small RNA binding sites under RISC repression. This scenario is supported by interactions between m6A reader proteins and AGO1 discovered in current work in the group. This mechanism may enable reprogramming of RISC specificity rather than composition upon pathogen perception. Our project will fill gaps in knowledge on RNA silencing and elucidate their importance in plant immunity.

Project End Date: **30-APR-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757411	**PUNCTUATION**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. ANDREAS SEBASTIAN MARQUARDT**
Host Institution: Kobenhavns Universitet, DK

Pervasive Upstream Non-Coding Transcription Underpinning Adaptation

Genomic DNA represents the blueprint of life: it instructs solutions to challenges during life cycles of organisms. Curiously DNA in higher organisms is mostly non-protein coding (e.g. 97% in human). The popular “junk-DNA” hypothesis postulates that this non-coding DNA is non-functional. However, high-throughput transcriptomics indicates that this may be an over-simplification as most non-coding DNA is transcribed. This pervasive transcription yields two molecular events that may be functional: 1.) resulting long non-coding RNA (lncRNA) molecules, and 2.) the act of pervasive transcription itself. Whereas lncRNA sequences and functions differ on a case-by-case basis, RNA polymerase II (Pol II) transcribes most lncRNA. Pol II activity leaves molecular marks that specify transcription stages. The profiles of stage-specific activities instruct separation and fidelity of transcription units (genomic punctuation). Pervasive transcription affects genomic punctuation: upstream lncRNA transcription over gene promoters can repress downstream gene expression, also referred to as tandem Transcriptional Interference (tTI). Even though tTI was first reported decades ago a systematic characterization of tTI is lacking. Guided by my expertise in lncRNA transcription I recently identified the genetic material to dissect tTI in plants as an independent group leader. My planned research promises to reveal the genetic architecture and the molecular hallmarks defining tTI in higher organisms. Environmental lncRNA transcription variability may trigger tTI to promote organismal responses to changing conditions. We will address the roles of tTI in plant cold response to test this hypothesis. I anticipate our findings to inform on the fraction of pervasive transcription engaging in tTI. My proposal promises to advance our understanding of genomes by reconciling how the transcription of variable non-coding DNA sequences can elicit equivalent functions.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759708	**Enhancer3D**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. YAD GHAVI-HELM**
Host Institution: Centre National De La Recherche Scientifique, FR

Regulatory genomics during Drosophila embryogenesis: dissecting enhancer-promoter interactions

In eukaryotes, the complex regulation of temporal- and tissue-specific gene expression is controlled by the binding of transcription factors to enhancers, which in turn interact with the promoter of their target gene(s) via the formation of a chromatin loop. Despite their importance, the properties governing enhancer function and enhancer-promoter loops in the context of the three-dimensional organisation of the genome are still poorly understood.

My recent work suggests that (i) developmental genes are often regulated by multiple enhancers, sometimes located at great linear distances, (ii) the spatio-temporal activity of a large fraction of those enhancers remains unknown, (iii) enhancer-promoter interactions are usually established before the target gene is expressed and are largely stable during embryogenesis, and (iv) stable interactions seem to be associated with the presence of paused RNA Polymerase II at the promoter before gene activation.

Building upon these results, we propose to advance to the next level in the dissection of enhancer-promoter interaction functionality in the context of Drosophila embryogenesis. Specifically, we will address three important questions: (i) What determines the specificity of promoter-enhancer interactions in a complex genome? (ii) Are enhancer-promoter interactions tissue-specific, and what are the drivers of this specificity? (iii) Are all enhancer-promoter interactions functional, and how does the activity of an enhancer relate to the expression of the gene it interacts with?

To this end, my group will apply an interdisciplinary approach, combining state-of-the-art methods in genetics and genomics, including novel single-cell techniques, using Drosophila embryogenesis as a model system. Our results will provide a unique view of the functionality of enhancer-promoter interactions in a developing embryo, a significant step towards understanding the link between chromatin organisation and transcription regulation.

Project End Date: **30-APR-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
773026	**MOSAIC**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. JAN KORBEL**
Host Institution: European Molecular Biology Laboratory, DE

Relationship of Somatic Structural Variation Mosaicism to Aging and Disease Phenotypes

Advances in DNA sequencing technology, enabling routine genetic variation studies, have uncovered that genomic structural variants (SVs; e.g. deletions and inversions) account for most varying bases in human genomes. SVs are also disproportionally associated with disease phenotypes when compared to single nucleotide variants by number. Studies are increasingly implicating genetic polymorphisms with diseases – yet why some humans develop diseases while others do not, and why disease incidences often increase with age, is largely unclear.

Intriguingly, recent studies showed that human genetic variation extends markedly beyond heritable variants. Soon after fertilization, mutations naturally accumulate in healthy tissues resulting in somatic genetic mosaicism (SGM), a highly understudied form of variation. Among SGM classes, 'SV mosaicisms' likely account for most varying bases, are increased at age, are seen in the context of clonal cell expansion, and are associated with diseases of the elderly including type 2 diabetes and cancer. This indicates that to understand the basis of particular diseases we may first need to comprehend how naturally formed somatic SVs impact human cells.

Here we aim to uncover the extent and impact of SV mosaicism. We aim to pursue single cell analyses, which offer the most direct way to detect somatic SVs in individual cells. Performing SV analysis in single cells at scale, however, is not a mainstream approach: current methods identify copy-number variants (CNVs), but miss key copy-neutral SV classes (e.g. inversions) likely to be highly relevant. We aim to develop new experimental and computational tools to construct a single cell catalog of a wide variety of relevant SV classes in different cell types (i.e. the blood compartment and skin) and ages. Using this catalog, we aim to study the functional impact of SV mosaicism on the cellular level, as a foundation for elucidating roles of somatic SVs in age-related phenotypes and diseases.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
773089	**METACELL**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. THEODORE ALEXANDROV**
Host Institution: European Molecular Biology Laboratory, DE

Metabolism of a cell pictured by single-cell approach

Every cell is unique. Metabolites define the composition of each cell and play key roles in essential intracellular processes of energy production and uptake, signaling, regulation, and cell death. Obtaining metabolite signatures of individual cells and linking them to cellular phenotypes is of paramount importance for a holistic understanding of these processes. This requires high-throughput single-cell metabolomics that is not generally attainable due to the limited sensitivity, low throughput, and disruptiveness of state-of-the-art metabolomics methods.

I propose to develop a spatial single-cell metabolomics approach for human cell culture systems. The approach will be based on using metabolite imaging mass spectrometry and will provide metabolite profiles of individual cells and metabolite signatures of single-cell phenotypes identified by light microscopy. With this approach developed, I will investigate the link between the intracellular metabolism and single-cell phenotype and focus on the following questions: How is the intracellular metabolism linked to cellular heterogeneity? How high is the variation of essential metabolites in a cell population? How do the energy metabolism and lipids biosynthesis change through the cell cycle and infection stages? What is the metabolic response to inflammatory signals?

I will scale up the analysis to discover novel cell phenotypes both in the cell culture systems and in big metabolite imaging mass spectrometry data from various biological systems provided to us by our collaborators and the community, and representing billions of cells.

My project will enable spatial single-cell metabolomics on a large scale and will provide yet lacking capacity for investigating and visualizing the intracellular metabolism on a single-cell level. It will advance our molecular understanding of key biological processes and pave the way to discoveries of molecular mechanisms of inflammation, cancer, and infection.

Project End Date: **30-JUN-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787702	**UPRmt**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. JOHAN HENRI LOUISE AUWERX**
Host Institution: Ecole Polytechnique Federale De Lausanne, CH

The Mitochondrial Unfolded Protein Response

Mitochondria—organelles specialized in energy harvesting through oxidative phosphorylation (Oxphos)—critically influence metabolism, health and lifespan. Evolved from endosymbiotic proteobacteria, mitochondria retained the vestige of the bacterial genome, the mitochondrial DNA, which encodes 13 subunits of the Oxphos complexes, while the remaining ~80 Oxphos components and the rest of the mitochondrial proteome are encoded on nuclear DNA, translated in the cytoplasm and imported in the mitochondria. The control of the mitochondrial proteome by two genomes exposes these organelles to proteotoxic stress in case of an imbalance between the nuclear- and mitochondrial-encoded proteins. Upon such stress, several mitochondrial protein quality control (mtPQC) pathways, including the mitochondrial unfolded protein response (UPRmt), will sense, transmit and re-establish mitochondrial proteostasis through mitonuclear regulatory circuits. Although a robust UPRmt circuit improves health and lifespan in C. elegans, much less is known about mtPQC in vertebrates. We propose here to characterize UPRmt pathways across 3 species by: (1) mapping mammalian UPRmt genes and networks in vivo after the induction of the UPRmt in a large murine genetic reference population at 3 different times throughout life with 2 different inducers; (2) integrating these UPRmt networks with a wide set of clinical, mitochondrial, and molecular phenotypes collected throughout life to establish links between UPRmt mechanisms and health- and lifespan; (3) mechanistically validating the most important UPRmt pathways, using loss-of-function studies in cells, worms and mice; and (4) clinically translating promising UPRmt hits, using genetic association studies in human cohorts. The insight gained will mechanistically define the UPRmt networks from worms to humans and will provide the next step in translating the benefits of activating the UPRmt—initially observed in invertebrates—into targeted human therapies.

Project End Date: **31-MAR-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788937	**CTCFStableGenome**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. DUNCAN ODOM**
Host Institution: Deutsches Krebsforschungszentrum, DE

CTCF control of genome stability in ageing

. Genome stability is one of the most important features in maintaining tissue homeostasis throughout the human lifespan. The research presented here will dissect how the insulator protein CCCTC-binding factor (CTCF), a ubiquitous 11 zinc finger transcription factor, controls the stability of the mammalian genome during ageing.

. In Aim 1, we will elucidate how CTCF and tissue-specific master regulators maintain the functional stability of the genome during healthy ageing by developing a novel protocol to map simultaneously transcription and open chromatin in isolated hepatocyte nuclei. Using this protocol, we will explore how CTCF binding stabilizes cellular homeostasis during ageing by knocking down CTCF in vivo, both in isolation and simultaneously with knock down of liver-specific master regulators.

. In Aim 2, we will reveal the molecular mechanisms underlying CTCF binding sites as susceptibility loci for somatic mutations. We will profile the mutations in open chromatin of single nuclei immediately following acute exposure to a chemical mutagen; comparing how the pattern of mutations in CTCF bound regions changes across an allelic series of CTCF knockdown mice will reveal how CTCF binding shapes the stability of the genome towards mutations.

. These integrated strategies develop and deploy powerful, cutting-edge experimental approaches to reveal novel aspects of how CTCF binding stabilises the mammalian genome during healthy ageing as well as during mutagenesis.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
801747	**EcoBox**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. KAROLINE FAUST**
Host Institution: Katholieke Universiteit Leuven, BE

Ecosystem in a box: Dissecting the dynamics of a defined microbial community in vitro

The dynamics of microbial communities may be driven by the interactions between community members, controlled by the environment, shaped by immigration or random events, influenced by evolutionary processes or result from an interplay of all these factors. This project aims to improve our understanding of how community structure and the environment impact community dynamics. Towards this aim, a defined in vitro community of human gut bacteria will be assembled, since their genomes are available and their metabolism is comparatively well resolved.

In the first step, we will quantify the intrinsic variability of community dynamics and look for alternative stable states. Next, we will systematically vary community structure as well as nutrient supply and monitor their effects on the dynamics. Finally, we will measure model parameters, evaluate to what extent different community models predict observed community dynamics and validate the models by identifying and experimentally validating keystone species.

Studies of microbial community dynamics are hampered by the cost of obtaining densely sampled time series in replicates and by the difficulty of community manipulation. We will address these challenges by setting up an in vitro system for parallel and automated cultivation in well-controlled conditions and by working with defined communities, where every community member is known.

The proposed project will discern how external factors and community structure drive community dynamics and encode this knowledge in mathematical models. Moreover, the project has the potential to transform our view on alternative microbial communities and their interpretation. In addition, the project will extend our knowledge of human gut microorganisms and their interactions. These insights will ease the design of defined gut communities optimized for therapeutic purposes.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803375	**KryptonInt**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. JOSE ANTONIO ESCUDERO**
Host Institution: Universidad Complutense De Madrid, ES

Erasing the superintegron to understand the role of chromosomal integrons in bacterial evolution

Integrons are genetic platforms that enhance bacterial evolvability through the acquisition and stockpiling of new genes encoded in mobile elements named cassettes. They are found in the chromosomes of environmental bacteria but some have acquired mobility through their association to transposons and conjugative plasmids. These mobile integrons (MI) caused the unexpected rise of multidrug resistance that is now a major threat to modern medicine, and are good proof of the adaptive power of integrons. Class 1 integrons are the most relevant MI and the major experimental model. Yet little is known about the hundreds of sedentary chromosomal integrons (SCI) that have driven bacterial evolution for eons. The paradigm of SCI is the superintegron (SI), an extremely large integron located in the chromosome of Vibrio cholerae, the causative agent of Cholera disease. Despite its role in the adaptability of one of the deadliest pathogens in history, the SI is poorly characterized because it is only functional in its native genetic background, yet its presence interferes with, and precludes all studies performed in V. cholerae. I propose to solve this paradoxical situation by deleting the SI, an ambitious project not only for its size (126 Kb) but because it is highly stabilized by 17 toxin-antitoxin systems. To do so, I have developed SeqDelTA, a novel method that is already giving excellent preliminary results. I will then use V. choleraeΔSI to study fundamental aspects of SCIs, yet out of reach. I will elucidate the functions encoded in SI cassettes to understand the role and adaptive value of integrons in nature; I will also unravel the genesis of cassettes: how a gene is exapted from its genetic context to become a mobile module; and I will explore the circulation of antibiotic resistance cassettes among humans, animals, food, and the environment with a novel biosynthetic tool (the I3C). KryptonInt will open and explore the historically inaccessible field of study of SCIs.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803852	**Mito-recombine**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. HANSONG MA**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

Homologous recombination and its application in manipulating animal mitochondrial DNA

Mitochondrial DNA (mtDNA) is a multi-copy genome that works with the nuclear genome to control energy production and various cellular processes. To date, disorders associated with mutations in mtDNA are among the most common genetically inherited metabolic diseases1. However, our knowledge regarding many aspects of mtDNA biology remains limited, and we know even less about how it influences development and organismal traits. This is largely due to our inability to manipulate mtDNA. Recently, a colleague and I developed novel genetic tools in Drosophila that allowed us to isolate animal mitochondrial mutants for the first time, and to create heteroplasmic organisms containing two mitochondrial genotypes2,3. These advances make Drosophila a powerful system for mtDNA studies. Importantly, I showed that Drosophila mtDNA could undergo homologous recombination. Furthermore, I established a system to induce recombination at specific sites and select for progeny containing only the recombinant genome4. Thus, my work has demonstrated the existence of recombination in animal mitochondria, and opens up the possibility of developing a recombination system for functional mapping and manipulating animal mtDNA. Here I propose to 1) identify components of the mitochondrial recombination machinery by a candidate RNAi screen; 2) develop a recombination toolkit to map trait-associated mtDNA sequences/SNPs; and 3) build a site-directed mutagenesis system by establishing robust ways to deliver DNA into fly mitochondria. Given the essential functions of mitochondria and their involvement in incurable diseases, the genetic tools developed in this proposal will transform the field by making it possible to link mtDNA variations to phenotypic differences and introduce specific mutations into mtDNA for functional studies at organismal level. These advances will open many possibilities to accelerate our understanding on how mtDNA impacts health, disease and evolution.

Project End Date: **29-FEB-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819941	**EpiRIME**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. NICOLA IOVINO**
Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Epigenetic Reprogramming, Inheritance and Memory: Dissect epigenetic transitions at fertilisation and early embryogenesis

During gametogenesis, germ cells undergo profound chromatin reorganisation, condensation and transcriptional shutdown. Upon fertilization, gamete chromatin is epigenetically reprogrammed, generating a totipotent zygote that can give rise to all cell types of the adult organism. The maternal factors that reprogram gametes to totipotency are unknown. The current dogma suggests that the parental epigenetic information must be erased in order to establish totipotency.

In contrast, we have recently discovered that maternal gametes transmit the epigenetic H3K27me3 histone modification to the next generation (Zenk et al., Science, 2017) adding to increasing evidence suggesting that gametes convey more than just DNA to the offspring. Nevertheless, the underlying mechanisms and the impact of epigenetic inheritance through the gametes are not yet fully resolved. Critically, the mechanisms and impact of (i) paternal gamete reprogramming, (ii) paternal epigenetic inheritance and (iii) de novo establishment of the zygotic epigenome remain essentially unknown.

The objective of this proposal is to unravel the fundamental principles underlying these three major epigenetic transitions in vivo in Drosophila.

We will achieve our objective via three aims: (i) We will investigate the mechanisms underlying the reprogramming of sperm chromatin at fertilization. Specifically, we will determine the nature and extent of the contributions of two proteins essential for sperm chromatin reprogramming (ii) We will examine the mechanism of histone H3K27me3 inheritance through the paternal germline (iii) We will genetically dissect the de novo establishment of constitutive heterochromatin in the newly formed zygote.

Our investigations of these epigenetic transitions are expected to reveal novel insights into the first steps in the formation of life, and to ultimately advance reproductive and regenerative medicine.

Project End Date: **30-JUN-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
835300	**RNPdynamics**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. JERNEJ ULE**
Host Institution: Kemijski Institut, SI

Multivalent interactions driving RNP dynamics in development and disease

Ribonucleoprotein complexes (RNPs) play many key regulatory roles in development. Moreover, mutations causing cancer or neurodegenerative diseases, such as amyotrophic lateral sclerosis (ALS), often occur in RNA-binding proteins (RBPs). These mutations are concentrated in the intrinsically disordered regions (IDRs), which play a central role in the control of RNP assembly and disassembly. RNP dynamics is often driven by multivalent interactions that are mediated by multiple elements within IDRs of RBPs, which can condense the RNP such that it separates from the surrounding liquid through the phenomenon of liquid-liquid phase separation. Transcriptomic insights into the physiological functions of such multivalent RNP assembly are needed to understand their regulation, or deregulation through disease-causing mutations. Here, we will build a framework of experimental and computational methods to study the mechanisms by which the dynamic multivalent interactions drive RNP remodelling, and how such RNP dynamics contributes to cellular transitions in development and disease. The first objective will be to identify the functions of specific RBPs in cell-state transitions during neuronal differentiation, and the mechanisms of IDR-mediated multivalent interactions in these functions. The next objective will be to establish new tools to manipulate RNP assembly through multivalent RNA binding sites and IDRs. Finally, the new insights and tools will be integrated with the goal to fine-tune the RNP assembly of ALS-mutant RBPs, and thereby ameliorate their toxicity.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850405	**CHROMREP**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. ANIEK JANSSEN**
Host Institution: Universitair Medisch Centrum Utrecht, NL

Dissecting the chromatin response to DNA damage in silenced heterochromatin regions

Cells are continuously exposed to insults that can break or chemically modify their DNA. To protect the DNA, cells have acquired an arsenal of repair mechanisms. Proper repair of DNA damage is essential for organismal viability and disease prevention. What is often overlooked is the fact that the eukaryotic nucleus contains many different chromatin domains that can each influence the dynamic response to DNA damage. Different chromatin environments are defined by specific molecular and biophysical properties, which could necessitate distinct chromatin responses to ensure safe DNA damage repair.

The aim of this proposal is to understand how diverse chromatin domains, and in particular the dense heterochromatin environment, shape the dynamic chromatin response to DNA damage.

I recently developed locus-specific DNA damage systems that allow for in-depth analysis of chromatin domain-specific repair responses in Drosophila tissue. I will employ these systems and develop new ones to directly observe heterochromatin-specific dynamics and repair responses. I will combine these systems and state-of-the art chromatin analysis with high-resolution live imaging to dissect the DNA damage-associated heterochromatin changes to determine their function in repair -kinetics, -dynamics and -pathway choice.

Deciphering the chromatin dynamics that regulate DNA damage repair in heterochromatin will have broad conceptual implications for understanding the role of these dynamics in other essential nuclear processes, such as replication and transcription. More importantly, understanding how chromatin proteins promote repair will be important in determining how cancer-associated mutations in these chromatin proteins impact genetic instability in tumours in the long run.

Project End Date: **30-NOV-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851288	**Demos**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. EDOUARD HANNEZO**
Host Institution: Institute Of Science And Technology Austria, AT

Design Principles of Branching Morphogenesis

Branching morphogenesis, the process by which branched organs such as the lung, prostate, kidney or mammary gland are generated, is a paradigmatic example of complex developmental processes bridging multiple scales. The mechanisms through which given molecular signals and cellular behaviours give rise to a robust organ structure remains a fundamental and open question, for which theoretical methods are needed. Our experience in modelling cytoskeletal mechanics, stem cell dynamics and branching processes puts us in a unique position to tackle this fascinating problem, by combining systems biology and biophysical approaches at multiple scales. In particular, we will focus on:

1. Understanding how stochastic rules lead to robust morphogenetic outputs at the organ scale, and which constraints and optimal design principles they impose on physiological function.
2. Characterizing at the cellular scale the bi-directional feedbacks coordinating fate choices of stem/progenitor cells and niche signals during the extensive remodelling events that branching morphogenesis entails.
3. Developing at the subcellular and cellular scale an integrated mechanochemical theory of pattern formation in branched organs, to understand the coordination of mechanical forces and chemical signals defining their global structure.

Towards these goals, we will combine analytical and numerical tools with data analysis methods, to reach a quantitative understanding of the emergent mechanisms driving branching morphogenesis. We will challenge our theoretical predictions with published datasets available for different organs, as well as design specific experimental tests in collaboration with experimental biology groups. This will allow us to compare and contrast different systems, and extract generic classes of design principles of organogenesis across length scales. With this, we expect to generate novel insights of broad relevance for the fields of systems, computational and developmental biology.

Project End Date: **30-JUN-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851360	**EVOMENS**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. CAMILLE BERTHELOT**
Host Institution: Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

The evolution of menstruation in primates

Menstruation is a recent evolutionary innovation in primates: the trait is present in some species (humans, baboons) but not in closely related others (orangutans, vervets). In the latter and in most mammals, the uterine endometrium is reabsorbed at the end of the cycle instead of being shed when fecundation has not occurred. The molecular and genetic underpinnings of this complex process are not fully understood, despite its critical involvement in gynaecological conditions. I propose to discover the molecular mechanisms leading to menstruation by comparing the uterine linings from five primate species at the cellular, functional and genetic levels. The objectives are to identify the gene networks and non-coding regulatory elements that control the advent of menstruation in primates, and to understand how this genetically inherited trait was acquired in primate genomes during the evolution of the human lineage.

In Aim 1, I will leverage single-cell transcriptomics to uncover the cellular composition and marker modifications that differentiate the uterine linings of menstruating and non-menstruating primates.

In Aim 2, I will use deep transcriptomics and accessible chromatin assays on sorted endometrial cell populations to identify genes and non-coding regulatory regions differentially activated in menstruating species. This analysis will reveal the molecular pathways, regulation networks and cellular interplay involved in uterine tissue shedding vs. reabsorption.

In Aim 3, I will replace these modifications within the context of primate genome evolution: I will elucidate the mutational dynamics by which genetic novelty has emerged during the adoption of menstruation, and how the functional divergence of the endometrium compares to other reproductive and somatic tissues.

This project will enhance our understanding of a key physiological trait for human reproduction as well as a dramatic example of functional innovation in the primate lineage.

Project End Date: **30-JUN-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852865	**EmbryoMethFunc**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. YONATAN STELZER**
Host Institution: Weizmann Institute Of Science, IL

Cell-Type Specific DNA Methylation Changes During Mammalian Development: Beyond Mapping

DNA methylation is essential for normal mammalian development. While seminal work has provided tremendous insight into the dynamic regulation of DNA methylation throughout embryogenesis, comprehensive understanding of how cell-specific methylation programs are established and maintained, and how they are involved in defining cell states in vivo through regulation of target genes, remains a formidable task. Revolutionary technologies now offer unprecedented opportunities for understanding the function of DNA methylation in specifying, memorizing and modulating embryonic programs. These powerful tools motivate further development of novel experimental systems, to integrate single-cell monitoring with flexible engineering of markers, reporters and perturbations. This will make it possible to precisely target key rare embryonic cell populations for in-depth analysis.

Here, combining cutting-edge methods for single cell mapping of DNA methylation and gene expression, and by developing a novel approach for inferring spatial information from single cell genomic data, we propose to comprehensively chart the post-implantation embryo, at unprecedented resolution. To move to functional studies, we will implement our recently established reporter system that enables monitoring and isolation of cells based on endogenous locus-specific changes in DNA methylation. Together with site-specific methylation editing tools, mouse genetics, and in vitro differentiation of pluripotent stem cells, we will study the developmental potential of rare epiblast cells that we identified that exhibit lower-than-expected genome-wide methylation levels. We will further study the effects of cell-specific methylation changes at an imprinted control region on gene dosage by genetic and epigenetic perturbation, during mouse development. Our combined approach will open new avenues for elucidating the contribution of cell-specific DNA methylation changes to cell-state and function following implantation

Project End Date: **30-SEP-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
853640	**PLANMod**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. OMRI WURTZEL**
Host Institution: Tel Aviv University, IL

Regulation of extreme plasticity in planarian stem cells by mRNA modifications

PlanaPioneering studies on post-transcriptional modifications of mRNA have revealed a hidden layer of regulatory complexity. The most abundant mRNA modification, N6-methyladenosine (m6A), regulates critical cellular processes and it is found in a huge diversity of Eukaryotes. Despite pivotal roles of m6A in development, only few animal models are available for m6A research. We poorly understand what cellular and intercellular factors modulate the RNA methylome, and how do changes in the cellular RNA methylome affect organism-level processes. There is an urgent need for innovative animal models. My primary objective is to establish an animal model for studying m6A regulation in multiple resolutions: molecular, cellular, and organismal, and use this system to uncover the interplay between of intercellular signaling and the dynamics of cellular mRNA modification. Planarians are free-living flatworms that can regenerate from any injury using a population of stem cells. Upon injury, planarian stem cells respond to extracellular injury signals and give rise to the missing tissues. Our preliminary data show that planarian stem cells require a functional m6A pathway for regeneration and tissue maintenance, raising the hypothesis that m6A regulates stem cell responses to extracellular signals. We propose to harness the power of planarians for (1) systematic studies of gene function in the context of cellular differentiation; (2) finding the molecular underpinnings of phenotypes associated with the m6A pathway; and (3) uncovering the interplay between injury signals, morphogens and stem cells that is required for regeneration. We will use multiple experimental approaches, including gene inhibition, sequencing and confocal microscopy to decode the contribution of organismal processes to mRNA modifications. Our proposal will lead to conceptual advances linking RNA-based regulation and cell signaling, and will provide infrastructure for studying other RNA-regulatory mechanisms.

Project End Date: **31-OCT-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
862022	**PoisedLogic**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. ALVARO RADA-IGLESIAS**
Host Institution: Universidad De Cantabria, ES

Dissecting the regulatory logic of poised enhancers

The mechanisms that, despite the noisy and stochastic nature of transcription, enable the specific, precise and robust deployment of developmental gene expression programs are poorly understood. We previously identified Poised Enhancers (PEs) as a conserved set of cis-regulatory elements essential for the induction of major anterior neural genes upon ESC differentiation. Importantly, before becoming active in anterior neural progenitors, PEs are already bookmarked in embryonic stem cells (ESC) with unique chromatin and topological features, including binding by polycomb-group protein complexes (PcG) and pre-formed contacts with their target genes. Here I hypothesize that the competence of pluripotent cells to faithfully execute an anterior neural gene expression program is genetically encoded and dependent on the unique modular composition of PEs, consisting of a cluster of highly conserved transcription factor binding sites (TFBS) and a nearby CpG island (CGI). This modular composition might endow PEs with privileged regulatory properties, whereby the TFBS confer cis-activation capacity, while the CGI bestow permissive chromatin and topological features that boost the PEs regulatory activity and increase transcriptional precision. Furthermore, I hypothesize that, together with architectural proteins, this modular composition dictates the specificity, compatibility and responsiveness between PEs and their target genes. Using ESC as a tractable system and genomic, single-cell/single-allele and genetic engineering methods, we will systematically dissect the contribution of each PE module (i.e. TFBS, CGI) and of different epigenetic (e.g. PcG, DNA methylation) and architectural factors (e.g. Cohesin, CTCF) to the regulatory logic of PEs. By systematically dissecting PEs, our work will illuminate novel and general mechanisms whereby enhancer pre-marking facilitates the precise and specific establishment of gene expression programs during vertebrate embryogenesis.

Project End Date: **30-JUN-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
863664	**ExpoBiome**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. PAUL WILMES**
Host Institution: Universite Du Luxembourg, LU

Deciphering the impact of exposures from the gut microbiome-derived molecular complex in human health and disease

The human gut microbiome is a complex ecosystem, which contributes essential functions to human physiology. Changes to the microbiome are associated with several chronic diseases characterised by inflammation, including neurodegenerative and autoimmune diseases. Microbiome-derived effector molecules comprising nucleic acids, (poly)peptides and metabolites are present at high levels in the gut but have so far eluded systematic study. This gap in knowledge is limiting mechanistic understanding of the microbiome's functional impact on chronic diseases such as Parkinson's disease (PD) and rheumatoid arthritis (RA). Here, I will for the first time integrate a combination of advanced high-resolution methodologies to comprehensively identify the constituents of this molecular complex and their impact on the human immune system. First, I will perform a quantitative, integrated multi-omic analysis on microbiome samples collected from healthy individuals and patients with newly diagnosed PD or RA. I will integrate and analyse the data using a newly developed knowledge base. Using contextualised prior knowledge (ExpoBiome Map) and machine learning methods, I will identify microbial molecules associated with condition-specific immunophenotypes. Second, I will validate and track the biomarker signature during a model clinical intervention (therapeutic fasting) to predict treatment outcomes. Third, microbes and molecules will be screened in personalised HuMiX gut-on-chip models to identify novel anti-inflammatory compounds. By providing mechanistic insights into the molecular basis of human-microbiome interactions, the project will generate essential new knowledge about causal relationships between the gut microbiome and the immune system in health and disease. By facilitating the elucidation of currently unknown microbiome-derived molecules, it will identify new genes, proteins, metabolites and host pathways for the development of future diagnostic and therapeutic applications.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864971	**BacNanoMachine**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. MARC ERHARDT**
Host Institution: Humboldt-Universitaet Zu Berlin, DE

Reconstructing the coordinated self-assembly of a bacterial nanomachine

Life has evolved diverse protein machines and bacteria provide many fascinating examples. Despite being unicellular organisms of relatively small size, bacteria produce sophisticated nanomachines with a high degree of self-organization. The motility organelle of bacteria, the flagellum, is a prime example of complex bacterial nanomachines. Flagella are by far the most prominent extracellular structures known in bacteria and made through self-assembly of several dozen different kinds of proteins and thus represents an ideal model system to study sub-cellular compartmentalization and self-organization. The flagellum can function as a macromolecular motility machine only if its many building blocks assemble in a coordinated manner. However, previous studies have focused on phenotypic and genetic analyses, or the characterization of isolated sub-components. Crucially, how bacteria orchestrate the many different cellular processes in time and space in order to construct a functional motility organelle remains enigmatic. The present proposal constitutes a comprehensive research program with the aim to obtain a holistic understanding of the underlying principles that allow bacteria to control and coordinate the simultaneous self-assembly processes of several multi-component nanomachines within a single cell. Towards this goal, we will combine for the first time the visualization of the dynamic self-assembly of individual flagella with quantitative single-cell gene expression analyses, re-engineering of the genetic network and biophysical modeling in order to develop a biophysical model of flagella self-assembly. This novel, integrative approach will allow us to move beyond the classical, descriptive characterization of protein complexes towards an engineering-type understanding of the extraordinarily robust and coordinated assembly of a multi-component molecular machine.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714055	**TORPEDO**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. BERT DE RYBEL**
Host Institution: Vib, BE

Understanding the molecular mechanisms controlling the orientation of plant cell divisions

Due to the presence of a rigid cell wall, plant cells are fixed within their tissue context and cannot move relative to each other during development. Plants thus need to rely on directed cell elongation and cell division to generate a full three-dimensional (3D) structure. Controlling cell division orientations relative to the tissue axis is therefore the fundamental basis for 3D growth. In the root, plant cells are organised in cell files and undergo two main types of cell division to allow directional growth: anticlinal cell divisions (AD, adding cells within a cell file) and periclinal cell divisions (PD, creating new cell files, organs and tissues). Understanding the mechanisms that control cell division orientation is a key question in developmental biology and the main focus of this application.
PDs are challenging to study as they only occur sporadically and typically in the most inner tissues of the root. I recently constructed a powerful system to induce strong, fast and homogenous PDs in any tissue type. I therefore now have the perfect tool at hands to tackle the fundamental question of how plants control the orientation of its cell divisions by:

1. Understanding the cellular events that occur prior to PD using a set of complementary techniques.
2. Identifying novel downstream components that translate the known genetic triggers for PD into changes in cell division orientation by performing an unbiased genetic screen.
3. Determining the developmental specificity and convergence of the known genetic pathways capable of inducing PD through studying their transcriptional targets in an ectopic tissue context.
4. Establishing a cell-culture based system for genetic and high throughput chemical perturbation studies of cell division orientation.

I thus aim to perform a global and comprehensive study of cell division orientation, a process crucial for 3D growth in general and vascular development in specific.

Project End Date: **31-JAN-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714739	**IlluMitoDNA**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. CHRISTOF OSMAN**
Host Institution: Ludwig-Maximilians-Universitaet Muenchen, DE

Illuminating the mechanisms of mitochondrial DNA quality control and inheritance

Essential subunits of the mitochondrial respiratory chain, which generates the majority of energy in eukaryotic cells, are encoded in the mitochondrial genome (mtDNA) that is present in hundreds of copies in every cell. Mutations within mtDNA have been identified as the cause for a multitude of human diseases and have been tightly linked to the ageing process and altered stem cell homeostasis. Accordingly, to ensure organismal health, good copies of mtDNA have to be faithfully inherited during cell division, their integrity needs to be maintained over generations and they need to be distributed throughout the mitochondrial network to provide all mitochondrial segments with mtDNA encoded proteins. Astonishingly, it remains poorly understood how cells accomplish these fundamental tasks.

Through the development of a novel system that for the first time allowed minimally invasive tracking of mtDNA in living cells, we have gained unique insights into the cellular principles that govern distribution and inheritance of mtDNA and the maintenance of its integrity. This work paved the way to understand the molecular mechanisms that underlie these processes and provides the tools required to elucidate them. We will build on this work and combine cutting-edge microscopy and next generation sequencing with biochemical and genetic approaches to identify and characterize the machineries responsible for (1) mtDNA inheritance and distribution and (2) mtDNA quality control. While these first two aims will exploit the unique experimental advantages of S. cerevisiae, our ultimate goal is (3) to transfer our findings to higher eukaryotes through the development of a mammalian mtDNA imaging system.

This powerful multipronged approach will mechanistically unravel mtDNA dynamics and quality control and will thus provide the necessary basis to understand diseases where these processes are dysregulated.

Project End Date: **31-JUL-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716910	**MetEpiStem**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. GRAZIANO MARTELLO**
Host Institution: Universita Degli Studi Di Padova, IT

Dissecting the crosstalk between metabolism and transcriptional regulation in pluripotent stem cells.

Pluripotent Stem cells (PSCs) can give rise to all differentiated cells of the body and the germ line, which makes them conceptually fascinating and a valuable tool for regenerative medicine. Mouse PSCs are devoid of any developmental restriction partly thanks to their “open” chromatin, characterised by remarkably low levels of repressive epigenetic modifications. Metabolism is a key feature that can be adjusted to meet the cell’s needs, and that has the potential to feedback on transcription and epigenetics. How metabolism is regulated in PSCs and whether this is important for their biology remains largely unknown.

We recently found a new molecular mechanism by which energy production is coupled to pluripotency. Here we propose to deepen our understanding of how metabolism, epigenetics and transcription are reciprocally regulated for the self-renewal and differentiation of PSCs. To gain insights into how metabolism is dynamically regulated in concert with the transcriptome and epigenome, we will also use somatic cell reprogramming into PSCs, a process in which both the metabolic and epigenetic profiles must be reset to match those of PSCs. Moreover, taking advantage of the recent generation of novel human PSCs sharing most of the transcriptional and epigenetic features found in naïve mouse PSCs, we will explore how metabolic regulatory mechanisms key for the generation and maintenance of pluripotency are conserved throughout evolution. Altogether, large-scale transcriptional, epigenetic and metabolic profiling of PSCs, combined with cutting edge technologies for their generation, expansion and genetic manipulation, will give us the unprecedented opportunity to build a comprehensive computational model of the metabolic network in PSCs, and to study how gene transcription and metabolism regulate each other.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
726049	**InPhoTime**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. DAVID DOLEZEL**
Host Institution: Biologicke Centrum Av Cr, V. V. I., CZ

Insect Photoperiodic Timer

Daylength measuring devices such as the photoperiodic timer enable animals to anticipate and thus survive adverse seasons. This ability has contributed to the great success of insects living in temperate regions. Yet the basis of photoperiodic sensing remains elusive, because of the lack of suitable genetic models expressing photoperiod-dependent seasonal phenotypes. We have developed the linden bug, Pyrrhocoris apterus, into a genetically tractable model with a robust, photoperiod-dependent reproductive arrest (diapause). With the available tools, this insect has become ideal for deciphering the regulation of seasonality. The project has 3 clear and ambitious objectives: 1). Our goal is to define the molecular and anatomical bases of the photoperiodic timer. To achieve this, we propose to identify photoperiodic timer genes, genes regulating input to the timer, and early output markers, through an RNA interference screen(s). To define the molecular mechanism of the timer, we will employ genome editing to precisely alter properties of the key players. 2). Next, we will combine techniques of neuronal backfilling, in-vivo fluorescent reporters, and microsurgery to define the photoperiodic timer anatomically and to examine its spatial relationship to the circadian clock in the insect brain. 3). We will exploit the great natural geographic variability of photoperiodic timing in P. apterus to explore its genetic basis. Genetic variants correlating with phenotypic differences will be causally tested by genome editing within the original genetic backgrounds. Both the established and the innovative strategies provide a complementary approach to the first molecular characterization of the seasonal photoperiodic timer in insects. The proposed research aspires to explain mechanisms underlying the critical physiological adaptation to changing seasons. Deciphering mechanisms underpinning widespread adaptation might bring general implications for environment-friendly pest control.

Project End Date: **31-MAR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757557	**MECHABLASTO**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. JEAN-LÉON MAÎTRE**
Host Institution: Centre National De La Recherche Scientifique, FR

Morphogenesis during pre-implantation development: molecular and mechanical regulation

During the first days of mammalian development, blastomeres organize themselves into the blastocyst, which implants the embryo into the maternal uterus. Failure to build the blastocyst will result in a miscarriage and yet the mechanisms underlying the construction of the blastocyst are mostly unknown. The blastocyst is sculpted by forces generated by its constituent cells. Without a tool to study the mechanics of the mammalian embryo, it is challenging to identify the molecules and cellular processes controlling morphogenetic forces. Using biophysical methods, I have recently measured the forces shaping the mouse blastocyst and identified cellular processes generating and controlling them. This approach enables the identification of the molecules controlling morphogenesis and constitutes the first step towards a complete theoretical modelling of blastocyst morphogenesis.

The aim of this project is to understand the molecular and mechanical aspects of blastocyst morphogenesis. By developing novel biophysical tools for the developing blastocyst, we will measure uncharacterized mechanical properties such as cytoplasmic and luminal pressure, adhesion strength and viscosity. The resulting mechanical map of the blastocyst will help understand the mechanisms of action of genes involved in its morphogenesis. To identify novel candidate genes involved in blastocyst morphogenesis, we will carry out a screen using live high-resolution confocal microscopy of mouse embryos injected with siRNA. Together, this will reveal the molecular, cellular and mechanical processes controlling blastocyst morphogenesis. I expect this to shed light on how blastomeres self-organize into the blastocyst and to reveal the physical laws underlying morphogenesis in general. Importantly, the knowledge and non-invasive biophysical techniques that we will develop will help developing Assisted Reproduction Technologies, which will be greatly beneficial to the fertility of the ageing European population.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759282	**CELL HORMONE**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. ALEXANDER JONES**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

Bringing into focus the cellular dynamics of the plant growth hormone gibberellin

During an organism's development it must integrate internal and external information. An example in plants, whose development stretches across their lifetime, is the coordination between environmental stimuli and endogenous cues on regulating the key hormone gibberellin (GA). The present challenge is to understand how these diverse signals influence GA levels and how GA signalling leads to diverse GA responses. This challenge is deepened by a fundamental problem in hormone research: the specific responses directed by a given hormone often depend on the cell-type, timing, and amount of hormone accumulation, but hormone concentrations are most often assessed at the organism or tissue level. Our approach, based on a novel optogenetic biosensor, GA Perception Sensor 1 (GPS1), brings the goal of high-resolution quantification of GA in vivo within reach. In plants expressing GPS1, we observe gradients of GA in elongating root and shoot tissues. We now aim to understand how a series of independently tunable enzymatic and transport activities combine to articulate the GA gradients that we observe. We further aim to discover the mechanisms by which endogenous and environmental signals regulate these GA enzymes and transporters. Finally, we aim to understand how one of these signals, light, regulates GA patterns to influence dynamic cell growth and organ behavior. Our overarching goal is a systems level understanding of the signal integration upstream and growth programming downstream of GA. The groundbreaking aspect of this proposal is our focus at the cellular level, and we are uniquely positioned to carry out our multidisciplinary aims involving biosensor engineering, innovative imaging, and multiscale modelling. We anticipate that the discoveries stemming from this project will provide the detailed understanding necessary to make strategic interventions into GA dynamic patterning in crop plants for specific improvements in growth, development, and environmental responses.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
770877	**STEMpop**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. SARA WICKSTRÖM**
Host Institution: Helsingin Yliopisto, FI

Mechanisms of stem cell population dynamics and reprogramming

How complex but stereotyped tissues are formed, maintained and regenerated through local growth, differentiation and remodeling is a fundamental open question in biology. Understanding how single cell behaviors are coordinated on the population level and how population-level dynamics is coupled to tissue architecture is required to resolve this question as well as to develop stem cell (SC) therapies and effective treatments against cancers.

As a self-renewing organ maintained by multiple distinct SC populations, the epidermis represents an outstanding, clinically highly relevant research paradigm to address this question. A key epidermal SC population are the hair follicle stem cells (HFSCs) that fuel hair follicle regeneration, repair epidermal injuries and, when deregulated, initiate carcinogenesis. The major obstacle in mechanistic understanding of HFSC regulation has been the lack of an in vitro culture system enabling their precise monitoring and manipulation. We have overcome this barrier by developing a method for long-term maintenance of multipotent HFSCs that recapitulates the complexity of HFSC fate decisions and dynamic crosstalk between HFSCs and their progeny.

This breakthrough invention puts me in the unique position to investigate how HFSCs self-organize into a network of SCs and progenitors through population-level signaling crosstalk and phenotypic plasticity. This project will uncover the spatiotemporal dynamics of HFSCs fate decisions and establish the role of the niche in this process (Aim1), decipher key gene-regulatory networks and epigenetic barriers that control phenotypic plasticity (Aim2), and discover druggable signaling networks that drive bi-directional reprogramming of HFSCs and their progeny (Aim3). By deconstructing complex tissue-level behaviors at an unprecedented spatiotemporal resolution this study has the potential to transform the fundaments of adult SC biology with immediate implications to regenerative medicine.

Project End Date: **30-APR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771599	**ICEBERG**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. MANUEL THERY**
Host Institution: Commissariat A L Energie Atomique Et Aux Energies Alternatives, FR

Exploration below the tip of the microtubule

Microtubules (MTs) are dynamic cytoskeleton filaments. They permanently transit between growth and shrinkage. This famous “dynamic instability” is governed by the addition and loss of tubulin dimers at their tips. In contrast to the tip, the MT lattice was considered to be a passive structure supporting intracellular transport. However, we recently found that MT lattice is dynamic and active! Actually, tubulin dimers can be exchanged with the cytoplasmic pool along the entire length of the MT. These incorporations can repair sites on the lattice that have been mechanically damaged. These repair sites protect the MTs from depolymerisation and increase the MT’s life span. This discovery opens up a new vista for understanding MT biology.

First, we will investigate the biochemical consequences of MT-lattice turnover. We hypothesise that tubulin turnover affects the recruitment of MAPs, motors and tubulin-modifying enzymes. These recruitments may feedback on lattice turnover and further regulate MT life span and functions.

Second, we will investigate the mechanical impact of the MT-lattice plasticity. Tubulin removal is likely to be associated with a local reduction of MT stiffness that can impact MT shape and the propagation of forces along the lattice. We anticipate that such effects will require us to reformulate the biophysical rules directing network architecture.

To achieve this, we will use reconstituted MT networks in vitro to investigate the molecular mechanism regulating MT-lattice plasticity, and cultured cells to test the physiological relevance of these mechanisms. In both approaches, microfabricated devices will be used to control the spatial boundary conditions directing MT self-organisation.

By exploring the hidden 90% of MT iceberg we aim to show that the MT lattice is a dynamic mechano-sensory structure which regulates interphase MT-network architectures and possibly confers them unexpected functions.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788363	**HITSCIL**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. ERWIN J G PETERMAN**
Host Institution: Stichting Vu, NL

How intraflagellar transport shapes the cilium: a single-molecule systems study

Sensory cilia are organelles extending like antennas from many eukaryotic cells, with crucial functions in sensing and signalling. Cilia consist of an axoneme built of microtubules, enveloped by a specialized membrane. Ciliary development and maintenance depend critically on a specific, microtubule-based intracellular transport mechanism, intraflagellar transport (IFT). In my laboratory, we study the chemosensory cilia of C. elegans, which sense water-soluble molecules in the animal's environment for chemotaxis. Over the past years, we have developed a unique set of quantitative, single-molecule fluorescence microscopy tools that allow us to visualize and quantify IFT dynamics with unprecedented detail in living animals. So far, our focus has been on the cooperation of the motor proteins driving IFT. The overall objective of my current proposal is to zoom out and shed light on the connection between ciliary structure, chemosensory function and IFT, from a systems perspective. Recent work has indicated that axoneme length is controlled by IFT. Preliminary results from my laboratory show that axoneme length changes dynamically in response to perturbations of IFT or cilia. Furthermore, we have shown that IFT is substantially affected upon exposure of animals to known repellent solutions. The four major aims in my proposal are to:

• determine how directional changes in IFT are regulated and are affected by external disturbances,
• understand the dynamics of the axonemal microtubules and how IFT affects these dynamics and vice versa,
• study how sensory ciliary function affects IFT and ciliary structure,
• further develop our (single-molecule) fluorescence microscopy toolbox by improving instrumentation and using better fluorescent probes and sensors.

These experiments will place my lab in a unique position to push forward our understanding of the relationship between structure, function and dynamics of transport of this fascinating and fundamental organelle.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788442	**INPHORS**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. ANDREAS MAYER**
Host Institution: Universite De Lausanne, CH

Intracellular phosphate reception and signaling: A novel homeostatic system with roles for an orphan organelle?

Cells face a phosphate challenge. Growth requires a minimal concentration of this limiting resource because intracellular phosphate (Pi) is a compound of nucleic acids and modifies most cellular proteins. At the same time, cytosolic Pi may not rise much, because elevated cytosolic Pi can stall metabolism. It reduces the free energy that nucleotide triphosphate hydrolysis can provide to drive energetically unfavorable reactions.

I will undertake a pioneering study to elucidate how cells strike this critical balance. We will identify a novel pathway for intracellular phosphate reception and signaling (INPHORS) and explore the role of acidocalcisomes in it. These studies may identify a key function of these very poorly understood organelles, provide one reason for their evolutionary conservation and elucidate a novel homeostatic system of critical importance for cellular metabolism.

We recently provided first hints that a dedicated pathway for sensing and signaling intracellular Pi might exist, which regulates multiple systems for import, export and acidocalcisomal storage of Pi, such that cytosolic Pi homeostasis is guaranteed 1. Yeast cells will serve as an powerful model system for exploring this pathway and its physiological relevance. Yeast Pi transport and storage proteins are known. Furthermore, we can establish cell-free in vitro systems that reconstitute Pi-regulated transport and storage processes, providing an excellent basis for identifying signaling complexes and studying their dynamics.
We will (A) generate novel tools to uncouple, individually manipulate and measure key parameters for the INPHORS pathway; (B) identify its components, study their interactions and regulation; (C) elucidate how acidocalcisomes are targeted by INPHORS and how they contribute to Pi homeostasis; (D) study the crosstalk between INPHORS and Pi-regulated transcriptional responses; (E) test the relevance of INPHORS for Pi homeostasis in mammalian cells.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788954	**CODE**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. HARALD STENMARK**
Host Institution: Universitetet I Oslo, NO

Coincidence detection of proteins and lipids in regulation of cellular membrane dynamics

Specific recruitment of different proteins to distinct intracellular membranes is fundamental in the biology of eukaryotic cells, but the molecular basis for specificity is incompletely understood. This proposal investigates the hypothesis that coincidence detection of proteins and lipids constitutes a major mechanism for specific recruitment of proteins to intracellular membranes in order to control cellular membrane dynamics. CODE will establish and validate mathematical models for coincidence detection, identify and functionally characterise novel coincidence detectors, and engineer artificial coincidence detectors as novel tools in cell biology and biotechnology.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803048	**CELLONGATE**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. MATYAS FENDRYCH**
Host Institution: Univerzita Karlova V Praze, CZ

Unraveling the molecular network that drives cell growth in plants

Plants differ strikingly from animals by the almost total absence of cell migration in their development. Plants build their bodies using a hydrostatic skeleton that consists of pressurized cells encased by a cell wall. Consequently, plant cells cannot migrate and must sculpture their bodies by orientation of cell division and precise regulation of cell growth. Cell growth depends on the balance between internal cell pressure – turgor, and strength of the cell wall. Cell growth is under a strict developmental control, which is exemplified in the Arabidopsis thaliana root tip, where massive cell elongation occurs in a defined spatio-temporal developmental window. Despite the immobility of their cells, plant organs move to optimize light and nutrient acquisition and to orient their bodies along the gravity vector. These movements depend on differential regulation of cell elongation across the organ, and on response to the phytohormone auxin. Even though the control of cell growth is in the epicenter of plant development, protein networks steering the developmental growth onset, coordination and termination remain elusive. Similarly, although auxin is the central regulator of growth, the molecular mechanism of its effect on root growth is unknown. In this project, I will establish a unique microscopy setup for high spatio-temporal resolution live-cell imaging equipped with a microfluidic lab-on-chip platform optimized for growing roots, to enable analysis and manipulation of root growth physiology. I will use developmental gradients in the root to discover genes that steer cellular growth, by correlating transcriptome profiles of individual cell types with the cell size. In parallel, I will exploit the auxin effect on root to unravel molecular mechanisms that control cell elongation. Finally, I am going to combine the live-cell imaging methodology with the gene discovery approaches to chart a dynamic spatio-temporal physiological map of a growing Arabidopsis root.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803952	**MCS-MD**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. STEFANO VANNI**
Host Institution: Universite De Fribourg, CH

The Molecular Dynamics of Membrane Contact Sites

The goal of this project is to obtain an atomistic structural and dynamical characterization of the inner workings of membrane contact sites (MCS) between intracellular organelles, in order to understand how molecular processes such as non-vesicular lipid transport at MCS might modulate lipid homeostatic processes at the whole-cell scale.

Investigation of the mechanisms taking place at MCS has emerged as a central topic in cellular biology in the last few years, and it has led to a large amount of novel cellular, biochemical and structural data that has drastically revolutionized our general understanding of lipid homeostasis in the cell. Yet, due to limitations of experimental methods, a high-resolution understanding of how MCS proteins work is still limited, and the specific molecular details of these mechanisms are still under intense debate, and especially concerning the specificity of lipid transport or the discrimination between lipid sensing and lipid transport.

To understand these processes with unprecedented molecular detail, I will develop high-throughput protocols based on atomistic and coarse-grain molecular dynamics simulations that leverage and take advantage of all the available, yet often scattered, experimental data. With these approaches, that have not been used so far to investigate MCS because of the extreme complexity of these cellular machineries, I will obtain a detailed understanding of key molecular processes taking place at MCS, including the specificity of membrane binding, the mechanism of lipid uptake and release, the influence of confinement on protein activity, and the role of membrane lipid composition in the regulation of lipid transport.

This approach will drive forward our perception of the limits of structure-based in-silico methods, and it will contribute to our mechanistic understanding of key cellular biology processes by providing new quantitative results that are beyond the current possibilities of experimental approaches.

Project End Date: **31-MAY-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
817758	**APOSITE**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. ANA GARCIA SAEZ**
Host Institution: Universitaet Zu Koeln, DE

Apoptotic foci: composition, structure and dynamics

Apoptotic cell death is essential for development, immune function or tissue homeostasis, and it is often deregulated in disease. Mitochondrial outer membrane permeabilization (MOMP) is central for apoptosis execution and plays a key role in its inflammatory outcome. Knowing the architecture of the macromolecular machineries mediating MOMP is crucial for understanding their function and for the clinical use of apoptosis.

Our recent work reveals that Bax and Bak dimers form distinct line, arc and ring assemblies at specific apoptotic foci to mediate MOMP. However, the molecular structure and mechanisms controlling the spatiotemporal formation and range of action of the apoptotic foci are missing. To address this fundamental gap in our knowledge, we aim to unravel the composition, dynamics and structure of apoptotic foci and to understand how they are integrated to orchestrate function. We will reach this goal by building on our expertise in cell death and cutting-edge imaging and by developing a new analytical pipeline to:

1) Identify the composition of apoptotic foci using in situ proximity-dependent labeling and extraction of near-native Bax/Bak membrane complexes coupled to mass spectrometry.

2) Define their contribution to apoptosis and its immunogenicity and establish their assembly dynamics to correlate it with apoptosis progression by live cell imaging.

3) Determine the stoichiometry and structural organization of the apoptotic foci by combining single molecule fluorescence and advanced electron microscopies.

This multidisciplinary approach offers high chances to solve the long-standing question of how Bax and Bak mediate MOMP. APOSITE will provide textbook knowledge of the mitochondrial contribution to cell death and inflammation. The implementation of this new analytical framework will open novel research avenues in membrane and organelle biology. Ultimately, understanding of Bax and Bak structure/function will help develop apoptosis modulators for medicine.

Project End Date: **31-MAR-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819314	**DCRIDDLE**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. SOPHIE JANSSENS**
Host Institution: Vib, BE

A novel physiological role for IRE1 and RIDD..., maintaining the balance between tolerance and immunity?

Dendritic cells (DCs) play a crucial role as gatekeepers of the immune system, coordinating the balance between protective immunity and tolerance to self antigens. What determines the switch between immunogenic versus tolerogenic antigen presentation remains one of the most puzzling questions in immunology. My team recently discovered an unanticipated link between a conserved stress response in the endoplasmic reticulum (ER) and tolerogenic DC maturation, thereby setting the stage for new insights in this fundamental branch in immunology.
Specifically, we found that one of the branches of the unfolded protein response (UPR), the IRE1/XBP1 signaling axis, is constitutively active in murine dendritic cells (cDC1s), without any signs of an overt UPR gene signature. Based on preliminary data we hypothesize that IRE1 is activated by apoptotic cell uptake, orchestrating a metabolic response from the ER to ensure tolerogenic antigen presentation. This entirely novel physiological function for IRE1 entails a paradigm shift in the UPR field, as it reveals that IRE1's functions might stretch far from its well-established function induced by chronic ER stress. The aim of my research program is to establish whether IRE1 in DCs is the hitherto illusive switch between tolerogenic and immunogenic maturation. To this end, we will dissect its function in vivo both in steady-state conditions and in conditions of danger (viral infection models). In line with our data, IRE1 has recently been identified as a candidate gene for autoimmune disease based on Genome Wide Association Studies (GWAS). Therefore, I envisage that my research program will not only have a large impact on the field of DC biology and apoptotic cell clearance, but will also yield new insights in diseases like autoimmunity, graft versus host disease or tumor immunology, all associated with disturbed balances between tolerogenic and immunogenic responses.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819422	**CORKtheCAMBIA**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. ARI PEKKA MÄHÖNEN**
Host Institution: Helsingin Yliopisto, FI

Thickening of plant organs by nested stem cells

Growth originates from meristems, where stem cells are located. Lateral meristems, which provide thickness to tree stems and other plant organs, include vascular cambium (produces xylem [wood] and phloem); and cork cambium (forms cork, a tough protective layer).
We recently identified the molecular mechanism that specifies stem cells of vascular cambium. Unexpectedly, this same set of experiments revealed also novel aspects of the regulation of cork cambium, a meristem whose development has remained unknown. CORKtheCAMBIA aims to identify the stem cells of cork cambium and reveal how they mechanistically regulate plant organ thickening. Thus, stemming from these novel unpublished findings and my matching expertise on plant stem cells and lateral growth, the timing is perfect to discover the molecular mechanism underlying specification of stem cells of cork cambium.
To identify the origin of stem cells of cork cambium, 1st-we will combine lineage tracing with a detailed molecular marker analysis. To deduce the cell dynamics of cork cambium, 2nd-we will follow regeneration of the stem cells after ablation of this meristem. To discover the molecular factors regulating the stem cell specification of cork cambium, 3rd-we will utilize molecular genetics and a novel method (inducible CRISPR/Cas9 mutant targeting) being developed in my lab. Since the lateral growth is orchestrated by two adjacent, nested meristems, cork and vascular cambia, the growth process must be tightly co-regulated. Thus, 4th-an in silico model of the intertwined growth process will be generated. By combining modelling with experimentation, we will uncover mechanistically how cork and vascular cambium coordinate lateral growth.

CORKtheCAMBIA will thus provide long-awaited insight into the regulatory mechanisms specifying the stem cells of lateral meristem as whole, lay the foundation for studies on radial thickening and facilitate rational manipulation of lateral meristems of crop plants and trees.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819753	**ChaperoneRegulome**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. RITWICK SAWARKAR**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

ChaperoneRegulome: Understanding cell-type-specificity of chaperone regulation

Protein misfolding causes devastating health conditions such as neurodegeneration. Although the disease-causing protein is widely expressed, its misfolding occurs only in certain cell-types such as neurons. What governs the susceptibility of some tissues to misfolding is a fundamental question with biomedical relevance.

Molecular chaperones help cellular proteins fold into their native conformation. Despite the generality of their function, chaperones are differentially expressed across various tissues. Moreover exposure to misfolding stress changes chaperone expression in a cell-type-dependent manner. Thus cell-type-specific regulation of chaperones is a major determinant of susceptibility to misfolding. The molecular mechanisms governing chaperone levels in different cell-types are not understood, forming the basis of this proposal. We will take a multidisciplinary approach to address two key questions: (1) How are chaperone levels co-ordinated with tissue-specific demands on protein folding? (2) How do different cell-types regulate chaperone genes when exposed to the same misfolding stress?

Cellular chaperone levels and their response to misfolding stress are both driven by transcriptional changes and influenced by chromatin. The proposed work will bring the conceptual, technological and computational advances of chromatin/ transcription field to understand chaperone biology and misfolding diseases. Using in vivo mouse model and in vitro differentiation model, we will investigate molecular mechanisms that control chaperone levels in relevant tissues. Our work will provide insights into functional specialization of chaperones driven by tissue-specific folding demands. We will develop a novel and ambitious approach to assess protein-folding capacity in single cells moving the chaperone field beyond state-of-the-art. Thus by implementing genetic, computational and biochemical approaches, we aim to understand cell-type-specificity of chaperone regulation.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833867	**DIRNDL**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. DOLF WEIJERS**
Host Institution: Wageningen University, NL

Directions in Development

Cells in multicellular organisms organise along body and tissue axes. Cellular processes, such as division plane orientation, must be aligned with these polarity axes to generate functional 3-dimensional morphology, particularly in plants, where cell walls prevent cell migration. While some polarly localized plant proteins are known, molecular mechanisms of polarity establishment or its translation to division orientation are elusive, in part because regulators in animals and fungi appear to be missing from plant genomes. Cell polarity is first established in the embryo, but this has long been an intractable experimental model. My team has developed the genetic, cell biological and biochemical tools that now render the early Arabidopsis embryo an exquisite model for studying cell polarity and oriented division. Recent efforts already led to the unexpected identification of a novel family of deeply conserved polar plant proteins that share a structural domain with key animal polarity regulators. In the DIRNDL project, we will capitalize upon our unique position and foundational results, and use complementary approaches to discover the plant cell polarity and division orientation system. Firstly, we will address the function of the newly identified conserved polarity proteins, and determine mechanistic convergence of polarity regulators across multicellular kingdoms. Furthermore, we will use proteomic approaches to systematically identify polar proteins, and a genetic approach to identify regulators of polarity and division orientation, essential for embryogenesis. We will functionally analyse polar proteins and regulators both in Arabidopsis and the liverwort Marchantia to help prioritize conserved components, and to facilitate genetic analysis of protein function. Finally, we will use a cell-based system for engineering polarity de novo using the regulators identified in the project, and thus reveal the mechanisms that provide direction in plant development.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834221	**RINFEC**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. JENS STOUGAARD**
Host Institution: Aarhus Universitet, DK

The Roots of Infection

Plant roots and soil microbes have been associated since the emergence of plants on land. Nevertheless the mechanisms that have coevolved to control these commensal and mutualistic associations are currently unknown. RINFEC will identify both plant and bacterial genes involved in root colonization by commensal and mutualistic bacteria with an approach that would be transformative in the field. The ambitious challenge is to identify and functionally characterize the central genes controlling root cells competence for infection. RINFEC´s central hypothesis is that key components of ancient pathways for bacterial colonization of the root surface (rhizosphere) and root interior (endosphere) were adapted during evolution of mechanism(s) controlling colonization of legume roots by symbiotic rhizobia. RINFEC will uncover the genetics and biochemistry of these shared mechanisms by characterizing a novel, unexplored intercellular infection mode observed for certain rhizobia that act as endophytes in non-legume plants and are able to infect the model legume Lotus japonicus. The unique biological feature exploited in RINFEC is the capacity of Lotus to support either intercellular entry (conserved mode) or legume specific infection thread entry, dependent on the rhizobia encountered. This allows comparative investigations of these two infection modes in simple binary interactions with the same host. Given the exceptional ability of different rhizobia for intercellular endophytic colonization of non-legume roots this provides an unprecedented platform to identify mechanisms by which plants selectively enable a subset of bacteria to infect roots. RINFEC will build on my considerable expertise with Lotus and pioneers novel plant and bacterial genetic methods, cell-layer transcriptomics, phospho-proteomics and advanced biochemistry to break new ground in understanding infection and soil microbe influences on plant performance under environmental stress conditions.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
835243	**Sperm-Egg Phusion**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. KODI RAVICHANDRAN**
Host Institution: Vib, BE

Unexpected connections between a phagocytic machinery and mammalian fertilization

Fertilization is essential for a species to survive. Mammalian sexual reproduction requires the fusion between the haploid gametes sperm and egg to create a new diploid organism. Although fertilization has been studied for decades, and despite the remarkable recent discoveries of Izumo (on sperm) and Juno (on oocytes) as a critical ligand:receptor pair, due to the structure of Izumo and Juno, it is clear that other players on both the sperm and the oocytes must be involved. While the focus of our laboratory over the years has been in understanding apoptotic cell clearance by phagocytes, we accidentally noted that viable, motile, and fertilization-competent sperm exposes phosphatidylserine (PtdSer). PtdSer is a phospholipid normally exposed during apoptosis and functions as an 'eat-me' signal for phagocytosis. Further, masking this PtdSer on sperm inhibits fertilization in vitro. Based on additional exciting preliminary data, in this ERC proposal, we will test the hypothesis that PtdSer on viable sperm and the complementary PtdSer receptors on oocytes are key players in mammalian fertilization. We will test this at a molecular, biochemical, cellular, functional, and genetic level. From the sperm perspective — we will ask how does PtdSer changes during sperm maturation, and what molecular mechanisms regulate the exposure of PtdSer on viable sperm. From the oocyte perspective — we will test the genetic relevance of different PtdSer receptors in fertilization. From the PtdSer perspective — we will test PtdSer induces novel signals within oocytes. By combining the tools and knowledge from field of phagocytosis with tools from spermatogenesis/fertilization, this proposal integrates fields that normally do not intersect. In summary, we believe that these studies are innovative, timely, and will identify new players involved in mammalian fertilization. We expect the results of these studies to have high relevance to both male and female reproductive health and fertility.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
835312	**PLASTINET**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. AUSTIN SMITH**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

Plasticity of the Pluripotency Network

A few days after fertilisation mammalian embryos form a blastocyst comprised of three tissues; trophoblast and hypoblast are the forebears of extraembryonic structures, while naive epiblast cell are the pluripotent source of the embryo proper. Classical mouse embryological studies indicate that lineage potencies are determined concomitant with segregation of the three founder tissues. Textbook definitions of pluripotency thus exclude extraembryonic potential. Consistent with this paradigm, mouse embryonic stem cells are generally ineffective in producing trophoblast or hypoblast derivatives. However, we have discovered that human naïve pluripotent cells have high intrinsic competence for trophoblast formation. Furthermore, unlike in mouse, extraembryonic transcription factors are present in human epiblast in vivo. These findings challenge the dogma of early lineage restriction but may be compatible with the ancestral origin of pluripotency. We hypothesise that extraembryonic plasticity underlaid by entwined regulatory networks is the evolutionary template of pluripotency. Consequently, signal modulation to suppress extraembryonic specification may be crucial for capture of stem cells representative of naïve epiblast in most mammals. We will examine human and non-human primates, farm animals in which embryos undergo extended development before implantation, and a marsupial in which pluripotent cells are generated from the trophoblast. In a cross-disciplinary approach we will employ transcriptomics, embryo and stem cell experimentation, and formal computational modelling to uncover the core biological program moulded by evolution into different forms. We aim to establish hitherto elusive chimaera-competent embryonic stem cells from species of importance for research, biomedical applications and livestock improvement. We will obtain fresh insight into the molecular logic governing early development, lineage plasticity, pluripotent identity, and stem cell self-renewal.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
835322	**CENGIN**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. PIERRE GÖNCZY**
Host Institution: Ecole Polytechnique Federale De Lausanne, CH

Deciphering and engineering centriole assembly

Deciphering and engineering the assembly of cellular organelles is a key pursuit in biology. The centriole is an evolutionarily conserved organelle well suited for this goal, and which is crucial for cell signaling, motility and division. The centriole exhibits a striking 9-fold radial symmetry of microtubules around a likewise symmetrical cartwheel containing stacked ring-bearing structures. Components essential for generating this remarkable architecture from alga to man have been identified. A next critical step is to engineer assays to probe the dynamics of centriole assembly with molecular precision to fully understand how these components together build a functional organelle. Our ambitious research proposal aims at taking groundbreaking steps in this direction through four specific aims:

1) Reconstituting cartwheel ring assembly dynamics. We will use high-speed AFM (HS-AFM) to dissect the biophysics of SAS-6 ring polymer dynamics at the root of cartwheel assembly. We will also use HS-AFM to analyze monobodies against SAS-6, as well as engineer surfaces and DNA origamis to further dissect ring assembly.

2) Deciphering ring stacking mechanisms. We will use cryo-ET to identify SAS-6 features that direct stacking of ring structures and set cartwheel height. Moreover, we will develop an HS-AFM stacking assay and a reconstituted stacking assay from human cells.

3) Understanding peripheral element contributions to centriole biogenesis. We will dissect the function of the peripheral centriole pinhead protein Cep135/Bld10p, as well as identify and likewise dissect peripheral A-C linker proteins. Furthermore, we will further engineer the HS-AFM assay to include such peripheral components.

4) Dissecting de novo centriole assembly mechanisms. We will dissect de novo centriole formation in human cells and water fern. We will also explore whether de novo formation involves a phase separation mechanism and repurpose the HS-AFM assay to probe de novo organelle biogenes

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851080	**MYOCLEM**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. ORI AVINOAM**
Host Institution: Weizmann Institute Of Science, IL

Elucidating the Molecular Mechanism of Myoblast Fusion in Vertebrates

Cell-to-cell fusion is a ubiquitous phenomenon essential for the physiological function of numerous tissues. A striking example is the fusion of myoblasts to form multinucleated myofibers during skeletal muscle development and regeneration. During myoblast fusion, membrane architecture must be radically remodeled. Yet, how membrane remodeling occurs on the molecular level is poorly understood as, until now, there was no approach available for visualizing dynamic changes in the cellular ultrastructure and the organization of the fusion machinery in situ.

To fill this gap, we have developed correlative light and 3D electron microscopy (CLEM) methods that allow us to identify fluorescent signals within EM samples with high sensitivity and subsequently localize the source of these signals with high precision. In this proposal, we will apply these methods in combination with live-cell imaging, biochemistry and cryo-electron tomography (ET) to deliver fundamental knowledge about the mechanism of myoblast fusion. Our specific aims are:

Aim 1: To resolve the molecular and ultrastructural events underlying cell fusion, by revealing how plasma membrane architecture is remodeled at sites of fusion using 3D EM.

Aim 2: To dissect the mechanism driving membrane remodeling during fusion, by visualizing how the fusion machinery assembles at sites of fusion and how its assembly is mirrored by changes in membrane shape, using biochemistry and live-cell imaging.

Aim 3: To determine the structure of the fusion machinery in situ, by using cryo-ET and subtomogram averaging.

Our synergetic experimental strategy will generate a quantitative, dynamic high-resolution view of the fusogenic synapse of vertebrate muscle, revealing how the fusion machinery remodels the plasma membrane at sites of fusion. These data are vital for deriving a biophysical model of myoblast fusion, understanding the general mechanism of cell fusion, and developing strategies to treat primary muscle diseases.

Project End Date: **31-OCT-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852136	**LIP-ATG**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. AMELIE BERNARD**
Host Institution: Centre National De La Recherche Scientifique, FR

The missing link: how do membrane lipids interplay with ATG proteins to instruct plant autophagy

Autophagy is an intracellular catabolic process critical to eukaryotic life and indispensable for plant survival to drought, nutrient scarcity or pathogen attacks. Autophagy relies on the formation of specialized vesicles called autophagosomes (AP) which engulf and deliver cell components to the lytic vacuole. AP biogenesis is carried out by a group of dedicated proteins (named ATG) and hinges on intense remodelling events and on the remarkable capacity of an initial membrane, the phagophore, to assemble de novo, shape like a cup, expand while maintaining structure and function and re-shape to a complete vesicle. To date the molecular mechanisms underlying these events remain elusive. Research has focused on the role of autophagy proteins but, despite AP biogenesis being a membrane-based process, the fundamental contributions of lipids to AP membrane formation, identity and activities have been largely unexplored; in other words, when it comes to AP formation we are only looking at half of the picture.

I propose to address the fundamental question of how APs form and shape from a novel angle: by exploring how lipids' nature, dynamics and lateral heterogeneity instruct the phagophore structure, its protein composition and its functions. The project builds on our recent results and expands on strategies that we have developed, integrating proteomic/bioinformatic approaches, lipidomics and high-resolution 3D imaging. We will tackle 3 complementary objectives: 1) Reveal the dynamic lipid signature of the phagophore, 2) Elucidate the implication of lipids nature and repartition in the phagophore ultrastructure, 3) Decrypt the molecular mechanisms by which lipids interplay with ATG proteins to control autophagy activity and plant physiology. Overall the project will articulate an integrated vision of the molecular processes controlling autophagy and provide fundamental knowledge in our understanding of plant adaptive programs.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866355	**CiliaCircuits**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. PLEASANTINE MILL**
Host Institution: The University Of Edinburgh, UK

Molecular Principles of Mammalian Axonemal Dynein Assembly

Motile cilia are tiny microtubule-based projections which create fluid flow and are essential to human health. Cilia movement is powered by coordinated action of complex macromolecular motors, the axonemal dyneins. During differentiation, as cells produce hundreds of motile cilia, millions of dynein subunits must be pre-assembled in the cytoplasm into very large complexes in the correct stoichiometry which are then trafficked into growing cilia. This poses a sizeable challenge for the cell in terms of allocation of a significant fraction of the global translational machinery for streamlined assembly of dyneins within a crowded cellular space.

The key question remains: How does the cell know how much is enough? This is an extreme example of a common problem in cell biology. Responsive and adaptive mechanisms must exist to prevent futile expenditure of cellular resources in making a surplus of large molecules like dyneins that may also pose a risk of toxic aggregation. While a well-defined transcriptional code for induction of cilia motility genes exists, the translational dynamics and subsequent feedback circuitry coordinating dynein pre-assembly with ciliogenesis remain unexplored.

The molecular logic underlying the construction of motile cilia assembly are still not fully understood. The ambitious nature of CiliaCircuits proposes to use super-resolution and systems approaches to elucidate key mechanisms regulating this process in health and disease.

Human genetics tells us that making cilia motile is a complex process. To date, almost 40 genes have been implicated in primary ciliary dyskinesia (PCD), the disease of motile cilia, for which there is no cure. The long-term vision is to understand this dynamic control operating over a specialized proteome in time and space in order to develop effective PCD therapeutics and identify additional candidate genes involved in this translation regulation.

Project End Date: **31-JUL-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647057	**rEnDOx**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. MASSIMO SANTORO**
Host Institution: Universita Degli Studi Di Padova, IT

REDOX SIGNALING AND METABOLIC STATES IN ANGIOGENESIS IN HEALTH AND DISEASE

Endothelial cells (ECs) exhibit a remarkable and unique plasticity in terms of redox biology and metabolism. They can quickly adapt to oxygen, nitric oxide and metabolic variations. Therefore, EC must be equipped with a selective and unique repertoire of redox and metabolic mechanisms, that play a crucial role to preserve redox balance, and adjust metabolic conditions in both normal and pathological angiogenesis. The identification of such redox signaling and metabolic pathways is crucial to the gaining of better insights in endothelial biology and dysfunction. More importantly, these insights could be used to establish innovative therapeutic approaches for the treatment of those conditions where aberrant or excessive angiogenesis is the underlying cause of the disease itself. However, the formation, actions, key molecular interactions, and physiological and pathological relevance of redox signals in ECs remain unclear. Here, by using cutting-edge real-time redox imaging platforms, and innovative molecular and genetic approaches in different in vivo animal models, we will (1) reveal the working of redox signaling in EC in health and disease, (2) shed light on the novel role for the mevalonate metabolic pathway in angiogenesis and (3) provide solid evidence, that manipulation of endothelial redox and metabolic state by genetic alteration of the redox rheostat UBIAD1, is a valuable strategy by which to block pathological angiogenesis in vivo.
The ultimate objective is to open the way for the development of innovative (cancer) therapeutic strategies and complement the existing ones based on genetic or pharmacological manipulation of redox rheostats to balance oxidative or reductive stress in angiogenic processes. The success of this project is built upon our major expertise in the field of angiogenesis in small vertebrate animal models as well as on the collaborations with leading laboratories that are active in research on the pre-clinical stages for angiogenesis-rel

Project End Date: **31-DEC-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695069	**BYPASSWITHOUTSURGERY**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. JENS JUUL HOLST**
Host Institution: Kobenhavns Universitet, DK

Reaching the effects of gastric bypass on diabetes and obesity without surgery

Gastric bypass surgery results in massive weight loss and diabetes remission. The effect is superior to intensive medical treatment, showing that there are mechanisms within the body that can cure diabetes and obesity. Revealing the nature of these mechanisms could lead to new, cost-efficient, similarly effective, non-invasive treatments of these conditions. The hypothesis is that hyper-secretion of a number of gut hormones mediates the effect of surgery, as indicated by a series of our recent studies, demonstrating that hypersecretion of GLP-1, a hormone discovered in my laboratory and basis for the antidiabetic medication of millions of patients, is essential for the improved insulin secretion and glucose tolerance. But what are the mechanisms behind the up to 30-fold elevations in secretion of these hormones following surgery? Constantly with a translational scope, all elements involved in these responses will be addressed in this project, from detailed analysis of food items responsible for hormone secretion, to identification of the responsible regions of the gut, and to the molecular mechanisms leading to hypersecretion. Novel approaches for studies of human gut hormone secreting cells, including specific expression analysis, are combined with our advanced and unique isolated perfused gut preparations, the only tool that can provide physiologically relevant results with a translational potential regarding regulation of hormone secretion in the gut. This will lead to further groundbreaking experimental attempts to mimic and engage the identified mechanisms, creating similar hypersecretion and obtaining similar improvements as the operations in patients with obesity and diabetes. Based on our profound knowledge of gut hormone biology accumulated through decades of intensive and successful research and our successful elucidation of the antidiabetic actions of gastric bypass surgery, we are in a unique position to reach this ambitious goal.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695190	**MANNA**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. NEKTARIOS TAVERNARAKIS**
Host Institution: Idryma Technologias Kai Erevnas, GR

MacroAutophagy and Necrotic Neurodegeneration in Ageing

Necrosis contributes critically in devastating human pathologies such as stroke, ischemia, and age-associated neurodegenerative disorders. Ageing increases susceptibility to neurodegeneration, in diverse species ranging from the lowly nematode Caenorhabditis elegans to humans. The mechanisms that govern necrotic neurodegeneration and its modulation by ageing are poorly understood. Autophagy has been implicated in necrosis and neurodegeneration, both with pro-survival and a pro-death roles. Autophagic flux declines with age, while induction of autophagy enhances longevity under conditions such as low insulin/IGF1 signalling and dietary restriction, which extend lifespan across diverse taxa. Our recent findings indicate that organelle-specific autophagy, including mitophagy, pexophagy and nucleophagy, is an important, evolutionarily conserved, determinant of longevity. We propose to dissect the molecular underpinnings of neuron vulnerability to necrosis during ageing, focusing on cargo-specific macroautophagy. To this end, we will implement a multifaceted approach that combines the power and versatility of C. elegans genetics with advanced, in vivo neuronal imaging and microfluidics technology. Our objectives are fourfold. First, we will monitor autophagic flux of organellar cargo, during neurodegeneration, under conditions that alter lifespan and identify mediators of organelle-specific autophagy in neurons. Second, we will conduct genome-wide screens for modifiers of age-inflicted neurodegeneration. Third, we will interrogate nematode models of human neurodegenerative disorders for organelle-specific autophagy and susceptibility to necrosis, upon manipulations that alter lifespan. Fourth, we will investigate the functional conservation of key mechanisms in mammalian models of neuronal necrosis. Together, these studies will deepen our understanding of age-related neurodegeneration and provide critical insights with broad relevance to human health and quality of life.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714551	**BONEPHAGY**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. CARMINE SETTEMBRE**
Host Institution: Fondazione Telethon, IT

Defining the role of the FGF – autophagy axis in bone physiology

Autophagy is a fundamental cellular catabolic process deputed to the degradation and recycling of a variety of intracellular materials. Autophagy plays a significant role in multiple human physio-pathological processes and is now emerging as a critical regulator of skeletal development and homeostasis. We have discovered that during postnatal development in mice, the growth factor FGF18 induces autophagy in the chondrocyte cells of the growth plate to regulate the secretion of type II collagen, a major component of cartilaginous extracellular matrix. The FGF signaling pathways play crucial roles during skeletal development and maintenance and are deregulated in many skeletal disorders. Hence our findings may offer the unique opportunity to uncover new molecular mechanisms through which FGF pathways regulate skeletal development and maintenance and to identify new targets for the treatment of FGF-related skeletal disorders. In this grant application we propose to study the role played by the different FGF ligands and receptors on autophagy regulation and to investigate the physiological relevance of these findings in the context of skeletal growth, homeostasis and maintenance. We will also investigate the intracellular machinery that links FGF signalling pathways to the regulation of autophagy. In addition, we generated preliminary data showing an impairment of autophagy in chondrocyte models of Achondroplasia (ACH) and Thanathoporic dysplasia, two skeletal disorders caused by mutations in FGFR3. We propose to study the role of autophagy in the pathogenesis of FGFR3-related dwarfisms and explore the pharmacological modulation of autophagy as new therapeutic approach for achondroplasia. This application, which combines cell biology, mouse genetics and pharmacological approaches, has the potential to shed light on new mechanisms involved in organismal development and homeostasis, which could be targeted to treat bone and cartilage diseases.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715491	**INVESTIGERFE**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. LÉON KAUTZ**
Host Institution: Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

Investigating the regulation of iron homeostasis by erythroferrone and therapeutic applications

The existence of an “erythron-related regulator” that intensifies iron absorption and its release from stores to meet the requirements for red blood cells synthesis was proposed in the 1950s. Delineating this mechanism is of high biomedical importance as the pathway could be targeted to develop novel treatments for iron-restricted anemias that are very frequent but for which current therapies are ineffective (e.g. infections, inflammatory bowel disease, cancer, or chronic kidney disease) and for iron-loading anemias (e.g. thalassemias). We have recently identified the hormone erythroferrone (ERFE) and showed that it could be the long-sought erythroid regulator of iron homeostasis. ERFE suppresses the synthesis of the iron-regulatory hormone hepcidin to facilitate the recovery from anemia but leads to secondary iron overload in β-thalassemia. The potential of ERFE in the treatment of iron disorders is tremendous but understanding its mechanism of action is a prerequisite to envision ERFE-based therapies. The identification of ERFE has opened new research areas and our project will be organized around four axes.

1) Develop an assay to measure ERFE levels in human pathologies. Its contribution is not known and needs to be confirmed.

2) Identify the receptor for ERFE, the signaling pathways triggered by ERFE, and molecules with agonist/antagonist effects, a prerequisite in the development of new therapies.

3) Search for potential other erythroid regulators. We will take advantage of the Erfe-/- mice to determine whether hepcidin could be suppressed by an ERFE-independent mechanism.

4) Study the potential of ERFE manipulation in therapy in the mouse. We will first establish a proof of principle in a mouse model of anemia (B. abortus). The benefits of ERFE antagonization will be addressed in thalassemic mice. We will also examine the role of ERFE in murine models of chronic anemia: chronic kidney disease, inflammatory bowel disease, rheumatoid arthritis and infections.

Project End Date: **30-APR-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715782	**COLGENES**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. KEVIN MYANT**
Host Institution: The University Of Edinburgh, UK

Defining novel mechanisms critical for colorectal tumourigenesis

Cancer genome sequencing has led to a paradigm shift in our understanding of oncogenesis. It has identified thousands of genetic alterations that segregate into two groups, a small number of frequently mutated genes and a much larger number of infrequently mutated genes. The causative role of frequently mutated genes is often clear and are the focus of concerted therapeutic development efforts. The role of those infrequently mutated is often unclear and can be difficult to separate from 'mutational noise'. Determining the relevance of low frequency mutations is important for providing a full understanding of processes driving tumourigenesis and if functionally relevant may have broader implications on the applicability of targeted therapies.

This project aims to begin addressing this by defining the function of all genes mutated in colorectal cancer (CRC) in the earliest stages of tumour formation. I have performed a whole genome screen in a 3D organoid CRC initiation model identifying several potentially important mediators of this process. Crucially, some of these genes are mutated in CRC at low frequency but not described as cancer driver genes. Thus, I hypothesize that rather than 'mutational noise' infrequently mutated genes contribute to CRC initiation. I will test this by addressing two aims:

1) Determine the role of genes mutated in CRC during tumour initiation

2) Validate and determine the function of a subset of identified genes potentially defining novel cancer mechanisms

I will use a combination of CRISPR genetic disruption in state-of-the-art 3D mouse and human organoid cultures and advanced mouse models to address these aims. This comprehensive approach will provide a foundation for understanding the importance of the entire spectrum of mutations in CRC and open new avenues of research into the function of these genes. More broadly, it has the potential to make a profound impact on how we think about tumourigenic mechanisms and cancer therapeutics.

Project End Date: **31-JUL-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715884	**OptoBETA**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. DAVID HODSON**
Host Institution: The University Of Birmingham, UK

Multicellular regulation of insulin secretion from pancreatic islets

Type 2 diabetes mellitus, one of the major healthcare challenges of our time, is characterized by failure of beta cells to functionally adapt to increased peripheral insulin resistance. The resulting chronic elevations in blood glucose concentration are associated with heart, kidney, liver, nerve and retinal disease, as well as cancer. Here, by combining novel optogenetic, photopharmacological and innovative imaging approaches, we aim to unravel the complexity underlying the multicellular regulation of insulin secretion from islets of Langerhans during health and disease. In particular, we will examine a role for privileged pacemakers/hubs in orchestrating population responses to stimuli, identify what makes these specialized cells unique at the RNA/protein level, and understand how they contribute to islet development and failure. Furthermore, we will address whether the intraislet regulation of insulin secretion operates in vivo to determine glucose homeostasis, focusing on the neural-endocrine interface. Lastly, the mechanisms underlying islet cross-talk will be investigated directly in situ within the pancreas of living mice, paying close attention to the roles of the vasculature and secreted factors. As such, these studies should unveil a new route for restoration of insulin secretion in man, as well as provide the foundation for the de novo construction of islets for transplantation.

Project End Date: **31-MAY-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716379	**MetResistance**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. BINZHI QIAN**
Host Institution: The University Of Edinburgh, UK

The role of tumour microenvironment in metastatic hormone-refractory prostate cancer

The goal of this proposal is to investigate the role of tumor microenvironment in metastatic hormone-refractory prostate cancer (mHRPC). Prostate Cancer (PC) is the most common malignancy in men in Europe while mHRPC is the most lethal form of the disease, causing over 95% of PC related deaths. Extensive clinical and preclinical research using state-of-the-art tumour models has led to the development of several new therapeutics that, unfortunately, provide only marginal patient benefit. One key element missing in standard preclinical models is the relevant metastasis microenvironment associated with mHRPC that may dramatically affect disease outcome. Here, I plan to significantly advance our understanding in mHRPC associated microenvironment with the first androgen dependent PC bone metastasis model I developed that mimics both the pathology and disease progression in patients. My preliminary data indicate that metastasis associated stromal cells may form a unique bone metastasis microenvironment that promotes mHRPC. I aim to identify the underlying molecular mechanisms using a multidisciplinary approach combining intra-vital microscopy, dynamic ADT resistance reporter system, innovative adoptive transfer approach and genetic tools of lineage specific knockout. This work is also designed to translate findings made in mouse models into human disease using innovative humanized in vivo models of mHRPC. The findings generated in this project will lead to innovative therapeutic approaches that can effectively treat mHRPC thus relieve this lethal threat on European societies. MetResistance will make a step change in the field of cancer medicine research by providing new standards to study therapy resistance of metastatic cancer an area representing the number one challenge in cancer research and patient care.

Project End Date: **31-MAR-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
742067	**DeAge**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. CARLOS LOPEZ OTIN**
Host Institution: Universidad De Oviedo, ES

Deconstructing Ageing: from molecular mechanisms to intervention strategies

Over many years, our research group has explored the complex relationship between cancer and ageing. As part of this work, we have generated mouse models of protease deficiency which are protected from cancer but exhibit accelerated ageing. Further studies with these mice have allowed us to unveil novel mechanisms of both normal and pathological ageing, to discover two new human progeroid syndromes, and to develop therapies for the Hutchinson-Gilford progeria syndrome, now in clinical trials. We have also integrated data from many laboratories to first define The hallmarks of ageing and the current possibilities for Metabolic control of longevity. Now, we propose to leverage our extensive experience in this field to further explore the relative relevance of cell-intrinsic and -extrinsic mechanisms of ageing. Our central hypothesis is that ageing derives from the combination of both systemic and cell-autonomous deficiencies which lead to the characteristic loss of fitness associated with this process. Accordingly, it is necessary to integrate multiple approaches to understand the mechanisms underlying ageing. This integrative and multidisciplinary project is organized around three major aims: 1) to characterize critical cell-intrinsic alterations which drive ageing; 2) to investigate ageing as a systemic process; and 3) to design intervention strategies aimed at expanding longevity. To fully address these objectives, we will use both hypothesis-driven and unbiased approaches, including next-generation sequencing, genome editing, and cell reprogramming. We will also perform in vivo experiments with mouse models of premature ageing, genomic and metagenomic studies with short- and long-lived organisms, and functional analyses with human samples from both progeria patients and centenarians. The information derived from this project will provide new insights into the molecular mechanisms of ageing and may lead to discover new opportunities to extend human healthspan.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759248	**MODVASC**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. KONSTANTINOS STELLOS**
Host Institution: University Of Newcastle Upon Tyne, UK

Endothelial RNA Modifications in Vascular Homeostasis and Disease

Endothelial cells cover the entire arterial and venous tree, and play a pivotal role in vascular and organ homeostasis. In general, cardiovascular risk factors induce endothelial cell activation towards a pro-inflammatory phenotype leading to atherosclerosis, a major cause of mortality in the Western world. Understanding the mechanisms that orchestrate endothelial cell functions and response to environmental stimuli is essential for the discovery and development of novel biomarkers and therapeutic strategies in vascular disease.

RNA base modifications increase the RNA alphabet from the 4 canonical nucleotides to more than 140. Adenosine methylation at the N6 position (m6A) is the most prevalent RNA modification in eukaryotic mRNA and is catalyzed by a multiprotein methyltransferase complex. Accumulating recent evidence suggests that m6A RNA methylation is a critical posttranscriptional regulator of RNA metabolism. In preliminary unpublished work we have identified methylated RNA targets, which may critically regulate endothelial cell functions. Since the impact of m6A RNA methylation on vascular function is completely unknown, MODVASC aims to explore the role of m6A RNA methylation in vascular growth, homeostasis and disease. By m6A-RNA immunoprecipitation followed by RNA-sequencing we will identify the transcriptome-wide m6A RNA methylation in endothelial cells under basal and stress conditions. With the help of advanced molecular biology and biochemical methods, we will describe in single nucleotide level the impact of m6A RNA methylation on mRNA fate and RNA-protein interactions and define its functional consequences in endothelial cell functions. In vivo studies will consolidate the impact of endothelial RNA methylation on vascular growth and homeostasis as well as its contribution to atherosclerosis. Finally, MODVASC will evaluate the clinical relevance of our findings in patients with cardiovascular disease.

Project End Date: **31-MAY-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771431	**SympatimmunObesity**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. ANA DOMINGOS**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Sympathetic and immune mechanisms underlying obesity

The era of molecular genetics has enabled the mechanistic dissection of brain circuits as well as the immune system in spectacular ways. However, the molecular and cellular organization of the sympathetic nervous system (SNS), which innervates all known organs, is essentially unexplored. In an attempt to push this frontier, we have recently uncovered a direct physical functional connection between the SNS and the adipose tissue. Further, we found this neuro-adipose junction to drive lipolysis and fat mass reduction (1). In this proposal we aim to define the molecular mechanisms that link SNS neurons, the immune system and the adipose tissue. A major entry point is our recent discovery of a novel population of Sympathetic Associated Macrophages (SAMs) that suppress the output of SNS. We propose to unravel their contribution to obesity in rodents (Aim 1) and in humans (Aim 2). Another major objective of this proposal is to establish a functional and molecular neuronanatomical map of the SNS, which defines subpopulations of neurons that specifically innervate fat (Aim 3). To achieve this, we will build molecular genetics tools for rapid non-invasive optocoustic visualization and functional probing of SNS circuits. A molecular and realistic atlas of the SNS will allow us to systematically access the functional anatomy of one of the most elusive tissues of the mammalian body and will form a blueprint upon which our neuroimmune mechanistic studies can be build. Our identification of the fundamental biological mechanisms that govern the neuro-adipose junction will set the stage for a new anti-obesity therapy that would circumvent the challenge of drug delivery to the brain, i.e. by targeting an excitatory drug directly to SAMs or sympathetic inputs in adipose tissue.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771486	**MetaRegulation**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. SARAH-MARIA FENDT**
Host Institution: Vib, BE

Metabolic regulation of metastatic growth

Metastatic growth of cancer cells requires extracellular matrix (ECM) production. The current understanding is that transcription factors regulate ECM production and thus metastatic growth by increasing the expression of collagen prolyl 4-hydroxylase (CP4H). In contrast, we recently discovered that metabolism regulates CP4H activity independently of the known transcription factors. Specifically, we found that loss of pyruvate metabolism inhibits CP4H activity and consequently ECM–dependent breast cancer cell growth. Based on this discovery we propose the novel concept that metabolism regulates metastatic growth by increasing ECM production.

In this project we will investigate the following questions: 1) What is the mechanism by which pyruvate regulates CP4H activity in breast cancer cells? To address this question we will investigate pyruvate metabolism and ECM production in 3D cultures of various breast cancer cell lines using 13C tracer analysis, metabolomics, and two-photon microscopy based ECM visualization. 2) How can this novel metabolic regulation be exploited to inhibit breast cancer-derived lung metastases growth? To address this question we will inhibit pyruvate metabolism in metastatic breast cancer mouse models using genetically modified cells and small molecules in combination with immuno- and chemotherapy. 3) How can this novel regulation be translated to different metastatic sites and cancers of different origin? To address this question we will determine the in vivo metabolism of breast cancer-, lung cancer-, and melanoma-derived liver and lung metastases (using metabolomics and 13C tracer analysis), and link it to ECM production (using two-photon microscopy based ECM visualization).

With this project we will deliver a novel concept by which metabolism regulates metastatic growth. In a long-term perspective we expect that targeting this novel metabolic regulation will pave the way for an unexplored approach to treat cancer metastases.

Project End Date: **31-MAY-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771704	**NoMePaCa**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. GUIDO BOMMER**
Host Institution: Universite Catholique De Louvain, BE

Novel Metabolic Pathways in Cancer

Metabolic adaptations in central carbon metabolism play a key role in cancer. Yet, the success of therapeutic interventions in major pathways has been limited, although some of the changes have been known to exist for almost 100 years.

Biochemical textbooks present intermediary metabolism as something canonical, and the molecular identity of most enzymes required for the production of known intermediary metabolites is indeed known. Yet, the function of many putative enzymes is still unknown, indicating that novel metabolic pathways containing so far unknown metabolites exist.

We have recently discovered a novel metabolic pathway containing two metabolites that have never been described before. Preliminary data indicate that this pathway might play an important role in a group of cancers sharing specific mutations. Furthermore, genetic inactivation of a component of this pathway in mice is compatible with normal development, indicating that pharmacological inhibition should be well tolerated.

In the present project, we will use a multi-dimensional approach combining biochemical, genetic and pharmacological techniques, to identify missing components of this metabolic pathway and assess its role in cellular metabolism and cancer development. In the process of this, we will develop tools that will allow us to test whether this pathway can be targeted in vivo. Thus, our work will lead to the description of a novel metabolic pathway, should reveal novel regulatory circuits and might open novel therapeutic avenues in cancer and beyond.

Project End Date: **30-APR-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772487	**STARNEL**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. DANIJELA VIGNJEVIC MATIC**
Host Institution: Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

supracellular contractility of myofibroblasts in gut homeostasis and cancer invasion

There has been tremendous progress in understanding the importance of the microenvironment and its chemical signals for homeostasis of stem cell niche in the intestine and for tumor invasion and metastasis formation in many different tissues. However, the way stromal cells such as myofibroblasts or cancer-associated fibroblasts (CAFs) use mechanical forces to shape the extracellular matrix and consequently dictate the response of epithelial cells remains unexplored at the single-cell level mainly due to limited imaging tools. Here we propose a multi-disciplinary approach, at the interface of cancer cell biology and physics, aimed to understand how myofibroblasts contractility influences epithelial cell functions in physiological (homeostasis) and pathological (cancer) conditions using the gut as a model.

Specific aims:

1. Characterize myofibroblasts in gut mucosa. Using omics analysis, mouse models and optogenetic tools we will obtain molecular signatures of myofibroblasts, characterize their migration, proliferation and contractile capacities.

2. Determine the role of myofibroblasts contractility in gut epithelial homeostasis. Using gut-on-chip and intravital imaging we will determine if supracellular contractility of myofibroblasts is necessary to maintain crypt shape upon mechanical stimuli.

3. Determine the role of CAF alignment in cancer progression. We will use 3D in vitro models to explore if CAFs alignment prevents or stimulates cancer cell invasion. Using mesentery metastasis mouse model, we will test if CAFs alignment can generate collagen bundles that cancer cells use to metastasize.

4. Explore if CAF alignment can induce therapy resistance and tumor relapse. Using human samples of rectal cancer before and after chemo-radiotherapy we will determine if CAFs alignment can protect cancer cells from therapy and stimulate metastasis formation.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
773076	**ANTILEAK**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. PIPSA SAHARINEN**
Host Institution: Helsingin Yliopisto, FI

Development of antagonists of vascular leakage

Dysregulation of capillary permeability is a severe problem in critically ill patients, but the mechanisms involved are poorly understood. Thus, there are no targeted therapies to stabilize leaky vessels in various common, highly fatal diseases, such as systemic inflammation and sepsis, which affect 18 million people annually. The ANTILEAK project will explore a novel autocrine endothelial permeability regulatory system as a potentially universal mechanism associated with vascular leakage in inflammation. The project is based on our novel discovery that inflammation-induced endothelial Angiopoietin-2 (Ang2) growth factor activates α5β1-integrin, switching it into a molecule that destabilizes vascular barriers in response to various inflammatory agents (Hakanpaa et al. Nat. Commun, 2015; Korhonen et al, JCI, 2016). Remarkably, inhibition of this mechanism can prevent endotoxemia-induced systemic vascular leakage in mice (submitted to Nat. Cell. Biol).
Angiopoietin antagonists that are currently in clinical trials target the C-terminal Tie2-binding domain of angiopoietins, whereas my discovery shows that Ang2 promotes leakage via α5β1-integrin activation. Therefore, I propose 1) to determine the structural basis of Ang2-α5β1-integrin signalling, 2) to characterize vascular processes dependent on Ang2/α5β1-integrin signalling in vivo using gene-targeted integrin signalling mouse mutants, chimeric Ang2 knock-in mice and CRISPR/Cas9 gene editing, and 3) to develop bi-specific Ang2 antibodies blocking both Ang2-Tie2 and Ang2-integrin signalling to halt pathological vascular leak in preclinical mouse models. The expected outcomes include important insights into endothelial signalling and permeability regulation that go beyond the current state of the art, and proof-of-concept antibodies to control endothelial activation and vascular leakage for the development of next-generation targeted therapeutics against septic shock.

Project End Date: **30-APR-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
773208	**ImmunoFit**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. MASSIMILIANO MAZZONE**
Host Institution: Vib, BE

Harnessing tumor metabolism to overcome immunosupression

Anti-cancer immunotherapy has provided patients with a promising treatment. Yet, it has also unveiled that the immunosuppressive tumor microenvironment (TME) hampers the efficiency of this therapeutic option and limits its success. The concept that metabolism is able to shape the immune response has gained general acceptance. Nonetheless, little is known on how the metabolic crosstalk between different tumor compartments contributes to the harsh TME and ultimately impairs T cell fitness within the tumor.

This proposal aims to decipher which metabolic changes in the TME impede proper anti-tumor immunity. Starting from the meta-analysis of public human datasets, corroborated by metabolomics and transcriptomics data from several mouse tumors, we ranked clinically relevant and altered metabolic pathways that correlate with resistance to immunotherapy. Using a CRISPR/Cas9 platform for their functional in vivo selection, we want to identify cancer cell intrinsic metabolic mediators and, indirectly, distinguish those belonging specifically to the stroma. By means of genetic tools and small molecules, we will modify promising metabolic pathways in cancer cells and stromal cells (particularly in tumor-associated macrophages) to harness tumor immunosuppression. In a mirroring approach, we will apply a similar screening tool on cytotoxic T cells to identify metabolic targets that enhance their fitness under adverse growth conditions. This will allow us to manipulate T cells ex vivo and to therapeutically intervene via adoptive T cell transfer. By analyzing the metabolic network and crosstalk within the tumor, this project will shed light on how metabolism contributes to the immunosuppressive TME and T cell maladaptation. The overall goal is to identify druggable metabolic targets that i) reinforce the intrinsic anti-tumor immune response by breaking immunosuppression and ii) promote T cell function in immunotherapeutic settings by rewiring either the TME or the T cell itself.

Project End Date: **30-JUN-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787171	**POLICE**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. ANDREAS VILLUNGER**
Host Institution: Medizinische Universitat Innsbruck, AT

The PIDDosome in Centrosome and Ploidy-Surveillance

Tight control of the number of chromosome sets in a cell (ploidy) is fundamental for normal development and organismal health. Most cells in our body are diploid, yet, some cells, including cardiomyocytes or hepatocytes require a balanced increase in ploidy for proper function. Polyploidization is accompanied by an accumulation of centrosomes, structures needed for nucleating the mitotic spindle and ciliogenesis. Extra centrosomes, however, promote aneuploidy in proliferating cells by causing errors in chromosome segregation, underlying a series of human pathologies, most notably cancer and premature ageing. How polyploidization is controlled in organogenesis and how errors in ploidy control contribute to disease is poorly understood.

We recently demonstrated that the “PIDDosome” complex polices centrosome numbers in mammalian cells, alerting the tumor suppressor p53 in response to extra centrosomes. This is achieved by inactivating MDM2, the key-inhibitor of p53, by targeted proteolysis. MDM2-processing is mediated by caspase-2, a neglected member in a protease family that controls cell death and inflammation, activated in the PIDDosome.

This exciting finding allows examining the consequences of deregulated ploidy and centrosome number in development and disease without interfering with p53, nor the cell fusion or cytokinesis machineries. This puts us in pole position to carry out an integrative study that aims to develop the PIDDosome as a new therapeutic target in cancer, related inflammation and in regenerative medicine. To meet this aim, we will define

(i) the relevance of the PIDDosome in aneuploidy tolerance of cancer

(ii) the role of the PIDDosome in controlling sterile inflammation and immunity

(iii) the PIDDosome as a key-regulator of organ development and regeneration

POLICE will open new lines of research at the interface of cell cycle, cell death & inflammation control and promote the PIDDosome as new target in our efforts to improve human health.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787971	**CuRE**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. MAURO GIACCA**
Host Institution: King'S College London, UK

Cardiac REgeneration from within

Biotechnological therapies for patients with myocardial infarction and heart failure are urgently needed, in light of the breadth of these diseases and a lack of curative treatments. CuRE is an ambitious project aimed at identifying novel factors (cytokines, growth factors, microRNAs) that promote cardiomyocyte proliferation and can thus be transformed into innovative therapeutics to stimulate cardiac regeneration. The Project leads from two concepts: first, that cardiac regeneration can be obtained by stimulating the endogenous capacity of cardiomyocytes to proliferate, second that effective biotherapeutics might be identified through systematic screenings both in vivo and ex vivo. In the mouse, CuRE will take advantage of two unique arrayed libraries cloned in adeno-associated virus (AAV) vectors, one corresponding to the secretome (1200 factors) and the other to the miRNAome (800 pri-miRNA genes). Both libraries will be functionally screened in mice to search for factors that enhance cardiac regeneration. This in vivo selection approach will be complemented by a series of high throughput screenings on primary cardiomyocytes ex vivo, aimed at systematically assessing the involvement of all components of the ubiquitin/proteasome pathway, the cytoskeleton and the sarcomere on cell proliferation. Cytokines and miRNAs can both be developed to become therapeutic molecules, in the form of recombinant proteins and synthetic nucleic acids, respectively. Therefore, a key aim of CuRE will be to establish procedures for their production and administration in vivo, and to assess their efficacy in both small and large animal models of myocardial damage. In addition to this translational goal, the project will entail the successful achievement of several intermediate objectives, each of which possesses intrinsic validity in terms of basic discovery and is thus expected to extend technology and knowledge in the cardiovascular field beyond state-of-the art.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802435	**PRiSM**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. SOPHIE STECULORUM**
Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Programming Sensory regulation of Metabolism

Sensory perception has recently emerged as a master regulator of integrative physiology and behavior, including feeding, by controlling fundamental and pleiotropic regulatory processes of energy and glucose homeostasis. Further, sensory perception is altered in obesity and type 2 diabetes, and childhood obesity correlates with early sensory deficit. Along this line, the discovery of the developmental origins of health and diseases revealed that metabolic diseases have recognized roots in the very early stages of life and can be predisposed to by changes in the perinatal hormonal and nutritional environments, such as occur in cases of maternal obesity and unhealthy diet. In this context, an accumulating body of evidence suggests that maternal health and nutrition could negatively impinge on the development of sensory perception, and subsequently, on the lifelong regulation of sensory-dependent control of metabolic, physiological, and behavioral regulatory processes. This innovative research program consists of four autonomous but complementary projects aimed at (1) deciphering the exact central regulatory processes mediating sensory control of feeding behavior and glucose homeostasis, (2) uncovering the influence of maternal health and nutrition on lifelong sensory regulation of metabolism, and (3) & (4) investigating two independent, yet synergistic, mechanisms that could mediate developmental programming of sensory metabolic regulation. This research program will employ a technology framework of physiological, behavioral, and developmental analyses in mice in concert with state-of-the-art systems neuroscience approaches, including optogenetics, chemogenetics, and in vivo calcium imaging. Collectively, the overarching goals of this research program are to provide new insights into the precise regulatory processes of sensory metabolic regulation and to shed light on critical basic mechanisms underlying the developmental programming of metabolic diseases.

Project End Date: **31-MAY-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802825	**EnDeCAD**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. MINNA KAIKKONEN-MÄÄTTÄ**
Host Institution: Ita-Suomen Yliopisto, FI

Enhancers Decoding the Mechanisms Underlying CAD Risk

In recent years, genome-wide association studies (GWAS) have discovered hundreds of single nucleotide polymorphisms (SNPs) which are significantly associated with coronary artery disease (CAD). However, the SNPs identified by GWAS explain typically only small portion of the trait heritability and vast majority of variants do not have known biological roles. This is explained by variants lying within noncoding regions such as in cell type specific enhancers and additionally 'the lead SNP' identified in GWAS may not be the 'the causal SNP' but only linked with a trait associated SNP. Therefore, a major priority for understanding disease mechanisms is to understand at the molecular level the function of each CAD loci. In this study we aim to bring the functional characterization of SNPs associated with CAD risk to date by focusing our search for causal SNPs to enhancers of disease relevant cell types, namely endothelial cells, macrophages and smooth muscle cells of the vessel wall, hepatocytes and adipocytes. By combination of massively parallel enhancer activity measurements, collection of novel eQTL data throughout cell types under disease relevant stimuli, identification of the target genes in physical interaction with the candidate enhancers and establishment of correlative relationships between enhancer activity and gene expression we hope to identify causal enhancer variants and link them with target genes to obtain a more complete picture of the gene regulatory events driving disease progression and the genetic basis of CAD. Linking these findings with our deep phenotypic data for cardiovascular risk factors, gene expression and metabolomics has the potential to improve risk prediction, biomarker identification and treatment selection in clinical practice. Ultimately, this research strives for fundamental discoveries and breakthrough that advance our knowledge of CAD and provides pioneering steps towards taking the growing array of GWAS for translatable results.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803526	**BARINAFLD**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. DANNY BEN-ZVI**
Host Institution: The Hebrew University Of Jerusalem., IL

Using Bariatric Surgery to Discover Weight-Loss Independent Mechanisms Leading to the Reversal of Fatty Liver Disease

Non-Alcoholic Fatty Liver Disease (NAFLD), a disease characterized by accumulation of lipid droplets in the liver, is the major precursor for liver failure and liver cancer, and constitutes a global health challenge. An estimated 25% of the adult population suffers from NAFLD, but no FDA approved drugs are available to treat this condition. Obesity is a major NAFLD risk factor and weight-loss improves disease severity in obese patients. Bariatric surgeries are an effective treatment for obesity when lifestyle modifications fail and often lead to improvement in NAFLD and type 2 diabetes.

The overreaching objective of this proposal is to combine bariatric surgery in mice and humans with advanced molecular and computational analyses to discover novel, weight-loss independent mechanisms that lead to NAFLD alleviation, and harness them to treat NAFLD.

In preliminary studies, I discovered that bariatric surgery clears lipid droplets from the livers of obese db/db mice without inducing weight-loss. Using metabolic and computational analysis, I found that bariatric surgery shifts hepatic gene expression and blood metabolome of post-bariatric patients to a new trajectory, distinct from lean or sick patients. Data analysis revealed the transcription factor Egr1 and one-carbon and choline metabolism to be key drivers of weight-loss independent effects of bariatric surgery.

I will use two NAFLD mouse models that do not lose weight after bariatric surgery to characterize livers of mice post-surgery. Human patients do lose weight following surgery, therefore I will use computational methods to elucidate weight-independent pathways induced by surgery, by comparing livers of lean patients to those of NAFLD patients before and shortly after bariatric surgery. Candidate pathways will be studied by metabolic flux analysis and manipulated genetically, with the ultimate goal of reaching systems-levels understanding of NAFLD and identifying surgery-mimetic therapies for this disease.

Project End Date: **31-OCT-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804135	**INVADERS**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. BENOIT CHASSAING**
Host Institution: Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

Mucus-Penetrating Microbiota: Characterization, Mechanism and Therapeutic in Metabolic Disease

Mucus-Penetrating Microbiota: Characterization, Mechanism and Therapeutic in Metabolic Disease

Humanity is facing an epidemic of inter-related metabolic disorders, including obesity, insulin resistance, hyperglycemia, hyperlipidemia, and hepatic steatosis, that altogether have major impact on the promotion of cardiovascular diseases. The increasing incidence of these complex metabolic disorders and their highly morbid, chronic and costly downstream diseases threatens to overwhelm the world's health care systems and economies, making it a top public health priority in dire need of investigation.

The intestinal tract is inhabited by a large and diverse community of bacteria, collectively referred to as the intestinal microbiota. When stably maintained at an appropriately safe distance from the epithelial cell monolayer, the microbiota provides important benefits to its host. However, disturbance of the microbiota-host relationship, promoted by genetic or non-genetic factors, can alter intestinal homeostasis and drive chronic low-grade intestinal inflammation, ultimately leading to metabolic abnormalities. We previously reported that a ubiquitous class of food additives, emulsifiers, detrimentally impact the microbiota resulting in its encroachment into the mucus layer that associated with low-grade inflammation and development of metabolic disorders.

The central goal of this proposal is to investigate the hypothesis that bacteria that penetrate the inner part of the mucus layer, referred as invaders, promote development of metabolic alterations.

We herein propose to identify mucus-invaders, in preclinical models and clinical conditions, and investigate mechanisms by which they promote inflammatory and metabolic abnormalities. Furthermore, we propose to define original approaches to modulate the intestinal microbiota in order to counteract microbiota encroachment and protect against associated metabolic abnormalities.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
805201	**METANICHE**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. ANJALI KUSUMBE**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Regulation of bone metastases by age-associated angiocrine signals

Blood vessels form a versatile transport network and provide inductive signals called angiocrine factors to regulate tissue-specific functions. Blood vessels in bone are heterogeneous with distinct capillary subtypes that exhibit remarkable alterations with age. Bone is the most prevalent site of metastasis, and ageing is linked to the reactivation of dormant tumor cells (dorTCs) and metastatic relapse. Bone remodeling processes are also associated with metastatic relapse. Here, I propose to gain mechanistic insights into the role of blood vessels in regulating bone remodeling. Further, I hypothesize that distinct blood vessel subtypes differentially regulate the fate of disseminated tumor cells (DTCs) and age-related changes in the bone vasculature drive the reactivation of dorTCs. Therefore, I will define the role of distinct vascular niches in regulating the fate of DTCs in bone. Finally, I will unravel the age-related angiocrine factors and identify key angiocrine signals that drive the reactivation of dorTCs. I will employ a powerful combination of advanced 3D, intravital, and whole body imaging, cell specific-inducible mouse genetics, transcriptional profiling, bioinformatics, and secretome analysis in an unprecedented manner to achieve my goals. New cutting-edge techniques such as advanced 3D and 4D bone imaging are important aspects of my proposal. I will also define the role of highly promising novel candidate age-related angiocrine signals with sophisticated inducible endothelial-specific humanised mouse models. My work will break new ground by unraveling a repertoire of age-related angiocrine factors and will contribute to a wider scientific community in bone, blood, and age-related diseases. This interdisciplinary work at the frontiers of bone, cancer and vascular biology will provide the first conceptual link between vascular ageing and bone metastasis and will contribute towards the development of therapeutic strategies for targeting DTCs in bone.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
805225	**VESSEL CO-COPTION**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. GIORGIO SEANO**
Host Institution: Institut Curie, FR

Vessel co-option and radioresistance in glioblastoma

Glioblastoma (GBM) is one of the deadliest types of human cancer. Despite a very aggressive treatment regime – including resection of the tumor, radiation and chemotherapy – its estimated recurrence rate is more than 90%. Recurrence is mostly caused by the regrowth of highly invasive cells spreading from the tumor bulk, which are not removed by resection. To develop an effective therapeutic approach, we need to better understand the underlying molecular mechanism of radiation resistance and tumor spreading in GBM.

Radioresistance in GBM is attributed to glioma stem cells (GSCs), a fraction of perivascular, self-renewing, multipotent and tumor-initiating cells. Growing evidence highlights the perivascular space as a niche for GSC survival, resistance to therapy, progression and dissemination. The unknown factor is the dynamics of GSCs, how they end up in the vascular niche and how this impacts on radioresistance.

My overall hypothesis is that GSCs reach the perivascular niche through vessel co-option - the directional migration of tumor cells towards vessels - and that targeting vessel co-option has the potential to radiosensitize GBM.

With this project, we aim to uncover the exact molecular and cellular connections among vessel co-option, GSCs, the vascular niche and radioresistance. Using multiple strategies, such as multiphoton intravital microscopy, orthotopic models of GBM, organotypic cultures, screenings and survival studies, we will investigate and mechanistically change the dynamics of GSC and differentiated GBM cells in order to understand the role of their interaction with brain vessels and whether this confers resistance to radiotherapy.

These studies will provide clinically relevant insights into the involvement of GSCs, the vascular niche and vessel co-option in the resistance of GBM to therapy. Since all GBM patients receive radiotherapy, many would benefit from therapeutic strategies aimed at increasing its efficacy.

Project End Date: **31-JUL-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
805338	**PedSarc**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. ANA BANITO**
Host Institution: Deutsches Krebsforschungszentrum, DE

Targeting genetic and epigenetic mechanisms in pediatric sarcomas.

Sarcomas are an extremely heterogeneous group of mesenchymal tumors that arise in a multitude of tissues from many different cell types. Several genetic events have been identified in different sarcoma sub-types, but very few models were developed to study their role in tumorigenesis aiming at exploiting them as therapeutic vulnerabilities. As a result, the treatment of sarcoma has extremely limited advancement in therapeutic options compared to other cancers. Therefore, the generation of faithful in vitro and in vivo models for sarcoma research is urgently needed to provide insights into the pathobiology of these tumors and discover novel vulnerabilities in these lethal but yet understudied disease. Many types of soft tissue sarcomas arising in children and young adults have a unifying underlying genetic mechanism, where chromosomal translocations generate fusion oncoproteins that serve as drivers of the disease. Exploiting this genetic simplicity provides an exceptional opportunity to develop effective and specific therapies. My past research has applied cutting edge technology to define epigenetic vulnerabilities associated with the SS18-SSX gene fusion, the defining event in synovial sarcoma (one subgroup of pediatric sarcomas), and to study its chromatin occupancy genome-wide. In this proposal my team will combine a toolbox consisting of CRISPR/Cas9, RNAi technology and expertise in mouse models to systematically elucidate key genetic and epigenetic mechanisms in the pathobiology of pediatric sarcomas along three main aims: 1) Develop strategies to target SS18-SSX-driven sarcomas, 2) Study the role of non-canonical polycomb repressive complexes in childhood sarcomas and 3) model sarcoma gene fusions and their cancer-related dependencies in vivo. This work will help to understand key players in epigenetic deregulation in pediatric sarcomas, generate new sarcoma models to assist clinical translation, and identify new therapeutic targets for these deadly diseases.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818858	**LymphMap**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. KARINA YANIV**
Host Institution: Weizmann Institute Of Science, IL

Navigating lymphatic formation and function in health and disease

For many years, lymphatic vessels have been viewed as inert fluid conduits whose open structure allows for passive flow of antigens, proteins and cells from peripheral tissues to lymphoid organs. Yet, recent discoveries highlighting novel functions and heterogeneous origins of the lymphatic endothelium, call for reevaluation of the passive lymphatic-vessel paradigm. During the past decade, we have used the zebrafish (ZF) to detail the cellular and molecular events underlying the development of the lymphatic system. Our discoveries have greatly contributed to our understanding of the origins, specification and mechanisms of formation of lymphatic endothelial cells (LECs) in the developing embryo. In line with our past achievements, we now aim towards novel directions- to transform the adult ZF into an equally convenient model for the study of lymphatic diversity. The overall goal of LymphMap is to reveal the multiple regulatory levels that coordinate the formation and functionality of lymphatic vessels in health and disease. To this end, we will carry out a comprehensive research program characterizing four distinct aspects of lymphatic biology:

1.Cellular origins and molecular signature of LECs
2.Formation and specialization of organotypic lymphatics
3.Lymphatic vessels during organ regeneration
4.Lymphatic involvement in human disease

Our experimental strategy involves the combination of high-resolution imaging, global expression profiling and regeneration models in adult ZF, with analyses of human-derived LECs in various clinical settings. The important and unique aspects of our approach are the focus on in vivo dynamics, and the cross-organ comparative analysis, which will likely provide the much-needed knowledge on lymphatic diversity in health and disease. When completed, we anticipate that this work will be part of a new paradigm – no longer perceiving lymphatics as passive bystanders, but rather as orchestrators of tissue morphogenesis and regeneration.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819543	**MetaboSENS**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. GANNA PANASYUK**
Host Institution: Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

Metabolic integration by nutrient SENSing

Nutrient sensing enables metabolic homeostasis by matching energy use with fuel availability. The vast body of knowledge on pro-anabolic nutrient sensors, such as insulin and class 1 phosphoinositol-3 kinase (PI3K) signalling exposed the missing links in molecular coordination of catabolism. The cellular catabolism relies on mitochondrial activities and on lysosomal pathway of autophagy, both paced by the biological clock. However, how pro-catabolic nutrient sensors synchronize these catabolic activities is not well understood. We discovered that class 3 PI3K, the only PI3K present in all eukaryotes, is essential for catabolic homeostasis in vivo, but the mechanisms of its metabolic functions are still lacking. We found novel roles for class 3 PI3K in metabolic adaptation to fasting and mitochondrial activity, beyond its established functions in autophagy and endosomal trafficking. These findings form the basis of our innovative interdisciplinary research program that will investigate the molecular bases of Metabolic integration in vivo by a nutrient SENSing pathway of class 3 PI3K (MetaboSENS). In the MetaboSENS research program, we seek to identify transcription factor networks and regulatory complexes of class 3 PI3K that serve its catabolic integrator function. We aim to reveal the physiological oscillation of class 3 PI3K signalling and its reciprocal impact on metabolic timekeeping. Finally, the MetaboSENS project will combine patient analyses and the medical expertise of my team to reveal, for the first time, genetic alterations in class 3 PI3K signalling in inborn metabolic disease. The new mechanisms that we discover may provide therapeutic targets that we will test in the pre-clinical models. Altogether, the MetaboSENS project will redefine our view of systemic catabolism.

Project End Date: **31-OCT-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819600	**FIRM**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. MICHELANGELO CAMPANELLA**
Host Institution: The Royal Veterinary College, UK

Form and Function of the Mitochondrial Retrograde Response

The molecular communication between mitochondria and nucleus is an integrated bi-directional crosstalk - anterograde (nucleus to mitochondria) and retrograde (mitochondria to nucleus) signalling pathways. The mitochondrial retrograde response (MRR) is driven by defective mitochondrial function, which increases cytosolic reactive oxygen species (ROS) and Ca2+. Metabolic reprogramming is a key feature in highly proliferative cells to meet the energy needs for rapid growth by generating substrates for cellular biogenesis. In these mitochondria retro-communicate with the nucleus to induce wide-ranging cytoprotective effects exploited to develop resistance against treatment and sustain uncontrolled growth. Recently, the mitochondrial management of cholesterol-derived intermediates for the synthesis of steroids has been demonstrated as a determinant in the oncogenic reprogramming of cellular environment.

We hypothesise that cholesterol-enriched domains facilitate the communication between remodelled mitochondria and nucleus to expedite MRR. This mechanism may be exploited during abnormal cell growth in which cholesterol metabolism and associated molecules are increased.

This application capitalizes on expertise in cell signalling and metabolism to interrogate core pathways and unveil molecular sensors and effectors that define form and function of the MRR by:

I. Elucidating the mechanism of metabolic regulation of MRR, describing the role exerted by cholesterol trafficking;

II. Unveiling microdomains for mito-nuclear communication established by remodelled, autophagy escaped, mitochondria;

III. Validating protocols to modulate and target MRR for diagnostic and therapeutic benefit;

The experimental plan will (i) define a molecular signalling axis that currently stands uncharacterized, (ii) provide mechanistic knowledge for preventive, and (iii) therapeutic applications to counteract deficiencies associated with stressed, dysregulated mitochondria.

Project End Date: **31-MAR-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833440	**IMMUNOTHROMBOSIS**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. STEFFEN MASSBERG**
Host Institution: Ludwig-Maximilians-Universitaet Muenchen, DE

Cross-talk between platelets and immunity - implications for host homeostasis and defense

The overall aim of the IMMUNOTHROMBOSIS project is to clarify the mechanisms underlying the recently identified synergism between thrombosis and inflammation. Thrombus formation and inflammation are vital host responses that ensure homeostasis, but can also drive cardiovascular disease, including myocardial infarction and stroke, the major causes of death in Europe. My group and others discovered, that thrombosis and inflammation are not to be considered separate processes. They are tightly interrelated and synergize in immune defence, but also in inflammatory and thrombotic diseases in a process we termed immunothrombosis. Targeting this synergism has great potential to identify innovative and unconventional strategies to more specifically prevent undesired activation of thrombotic and inflammatory pathways. However, this requires a deeper mechanistic understanding of immunothrombosis. I recently identified two ground-breaking novel immunothrombotic principles: I discovered that platelets have the ability to migrate autonomously, which assists immune cells in fighting pathogens. Further, I revealed that immune cells play a central role in controlling the production of platelets from their megakaryocyte precursors. The physiological and pathophysiological relevance of both processes is unclear. This is the starting point and focus of the IMMUNOTHROMBOSIS project. My aim is to define how platelets use their ability to migrate to support immune cells in protection of vascular integrity (objective 1) and to identify the contribution of platelet migration to different cardiovascular diseases involving immunothrombotic tissue damage (objective 2). Finally, I will clarify how inflammatory responses feedback to the production of thrombotic effectors and dissect inflammatory mechanisms that control platelet production (objective 3). IMMUNOTHROMBOSIS will identify new options for specific prevention or treatment of thrombotic and inflammatory cardiovascular diseases.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850622	**MOLEC ANTI-ARRHYT**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. SARA LIIN**
Host Institution: Linkopings Universitet, SE

Resilience and Trigger Factors in Cardiac Arrhythmia: Risk Stratification and Drug Design

Up to 30% of individuals with inherited cardiac arrhythmias such as Long QT syndrome are not protected from sudden cardiac death despite state-of-the-art treatment. A major hurdle for effective risk stratification and treatment of inherited cardiac arrhythmias is the poor correlation between genetic variant and clinical manifestations. Affected individuals, who harbour the same arrhythmia-causative mutation, paradoxically display a spectrum of clinical phenotypes ranging from a lifelong asymptomatic state to sudden death in infancy. Up to 40% of genotype-positive individuals, depending on type of arrhythmia, do not display clinical manifestation. Based on our unpublished observations, I propose that an important, yet unexplored, underlying cause of the diverse clinical manifestations are endogenous resilience and trigger factors, which interact with mutated cardiac ion channels to alter arrhythmia severity. MOLEC ANTI-ARRHYT utilizes front-line experimental and computational approaches and the cardiac IKs potassium channel, which is strongly linked to lethal arrhythmias and sudden cardiac death, as a prototype. We aim to: (i) identify major classes of endogenous ligands with therapeutic (resilience factors) or pathological (trigger factors) effects on the IKs channel, (ii) provide proof of mechanism for how the effect of resilience and trigger factors is determined by arrhythmia-causative mutations in the IKs channel, (iii) utilize resilience mechanisms to develop a fundamentally novel concept of anti-arrhythmic drug development: Resilience-Mimetic Drug Development. The successful completion of this project will open up new avenues for personalized risk stratification and clinical management, which ultimately will improve the clinical outcome for individuals with inherited arrhythmias.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852343	**EPICAMENTE**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. SARA SDELCI**
Host Institution: Fundacio Centre De Regulacio Genomica, ES

At the epigenetics-cancer metabolism interface

Epigenetic regulation and metabolism are of great interest in cancer research. However, physical and functional connections between these two areas remain largely unexplored. While it is commonly believed that metabolites can randomly distribute inside the cell, recent evidence rather favors the hypothesis that production of certain metabolites in specific subcellular compartments orchestrates different cellular processes. EPICAMENTE aims at exploring whether the localization of enzymatic activities on chromatin can integrate cancer metabolism with chromatin remodeling to control epigenetic regulation and tumor progression. First, I aim at providing a dataset of chromatin-bound metabolic enzymes in a comprehensive panel of cancer cell lines. By combining a chromatin fluorescent reporter cell line strategy with epigenomic approaches, I will define the epigenetic and transcriptional scenarios orchestrated by chromatin-bound metabolic enzymes, and investigate their relevance in cancer cell proliferation. Performing genetic screenings with the chromatin fluorescent reporter cell lines will allow the identification of genetic interactors mediating the epigenetic role of chromatin-bound metabolic enzymes. In parallel, I aim to screen for small molecules able to counteract the epigenetic states mediated by those metabolic enzymes. Finally, I will validate my results in in vivo cancer models, thus adding an important translational aspect to the project, and opening up new opportunities for cancer therapy. The success of this project can impact our fundamental understanding of cellular and cancer biology. In most cases, the belief is that intracellular materials reside inside steady-state membrane-based compartments, which limit the interactions between different molecular pathways. By describing the role of chromatin-bound metabolic enzymes and discovering direct connections between cancer metabolism and epigenetic regulation, I will scrutinize this belief.

Project End Date: **31-OCT-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852742	**PROTEOFIT**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. ALEXANDER BARTELT**
Host Institution: Ludwig-Maximilians-Universitaet Muenchen, DE

Adapting protein fate for muscle function and fitness

Muscle function is essential for motion, exercise, and shivering, whereas physical inactivity is causally related to reduced metabolic fitness in animal models and humans. A critical requirement for muscle function is that proteins are properly produced and, if necessary, degraded to adapt the proteome to meet metabolic demands. However, there is a fundamental, open gap in understanding how challenges to muscle proteostasis are sensed and how protein fate is subsequently adapted to enhance muscle function in exercise or, conversely, how it is compromised in obesity. I hypothesize that protein fate is highly adaptive and can be fine-tuned to promote proteostasis, the integrity of muscle cells, and metabolic health. Identifying novel key regulators of these mechanisms in muscle may hold great therapeutic promise for targeting metabolic fitness to combat obesity and associated disorders. In this innovative project I want to define new mechanisms of muscle adaptation in humans and preclinical mouse models, with the ultimate goal of using this knowledge to improve muscle function and fitness in obesity. I will identify exercise- and obesity-specific substrates of the proteasome by ubiquitomics in human and mouse muscle and define how the ubiquitination and turnover of these proteins dictates muscle cell function. In a complementary approach, I will use novel loss- and gain-of-function mouse models allowing for precise muscle-specific manipulation of Nfe2l1, an adaptive regulator of proteasomal protein degradation, to define the biological and therapeutic significance of this pathway for muscle function in exercise and obesity. In summary, this novel work will provide a transformative molecular understanding of muscle adaption to metabolic challenges and provide insight into how this translates into metabolic fitness and the development of obesity and associated disorders in humans.

Project End Date: **30-NOV-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852761	**ONco-Energetics_OFF**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. MOHAMED ELGENDY**
Host Institution: Technische Universitaet Dresden, DE

Dissection of Bioenergetic Plasticity of Tumors

Tumors reprogram their metabolism to fuel rapid growth. Glycolysis and oxidative phosphorylation "OXPHOS" are the main energy-producing pathways. For decades, metabolic reprogramming of tumors was perceived as only increased glycolysis (Warburg effect). This dogma has recently been revised as we started to realize the importance of OXPHOS in tumor metabolism. We are now entering a new era as metabolomics studies show that tumor metabolism is more heterogeneous than initially assumed. In the preparatory phase of this proposal, using an integrated transcriptional and metabolic profiling, a panel of cancer cell lines was first classified according to the bioenergetic pathway they predominantly utilize (glycolysis or OXPHOS). Second, the response of glycolytic and OXPHOS-dependent cells to the inhibition of their wired bioenergetic program was assessed. My findings show that regardless of their dependency at baseline, cancer cells can be collectively categorized according to their adaptability into "bioenergetically-committed" to one of the two pathways or "bioenergetically-plastic" cells which are able to switch from one to the other upon metabolic challenges. This proposal uses an integrated system approach to dissect the molecular signature, regulation and implications of bioenergetic plasticity. We will answer three key questions:
1-Why some cancer cells are bioenergetically-plastic while others are committed? What are the differences in metabolic machineries and oncogenic switches between both?
2-How heterogeneous tumor cell subpopulations are in terms of bioenergetic plasticity? Does metabolic crosstalk contribute to bioenergetic plasticity of tumors?
3-What are the implications of bioenergetic plasticity in drug resistance and metastasis and finally how to design approaches to target this plasticity?
Only handful drugs targeting tumor energetics have made it to clinical use. ONco-Energetics_OFF has a realistic and immediate translational potential.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
853057	**InflaPML**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. CARLOTTA GIORGI**
Host Institution: Universita Degli Studi Di Ferrara, IT

Promyelocytic leukemia protein (PML) outside the tumor: a new player in the control of inflammation

Local sterile inflammation arise in many pathologic states, including several diseases of the nervous system as brain stroke, neurodegenerative diseases and epilepsy. The persistent and de-regulated inflammatory response sustains these neurological pathologies worsening their prognosis. Different molecular players, as NLRP3 and P2X7 have been shown to contribute to the progression of these illnesses triggering the release of IL-1β and recruiting cellular components of the immune response at the neurodegeneration site. Consistently, brain penetrant P2X7 antagonists are clinically used to treat epilepsy and neurodegenerative diseases, while the pharmacological modulation of IL-1β is still unsuccessful. Unfortunately, the molecular mechanism underlying neuroinflammation and NLRP3 inflammasome assembly remains elusive. Here we propose that different neuroinflammatory diseases can be linked together in a common disease pathway, of which damaged function should be targeted for therapy. Specifically we propose a new mechanism acting on IL-1β regulation: we hypothesize the existence of a new activity of PML outside tumour environment, acting at the endoplasmic reticulum-mitochondria interfaces (MAMs) as modulator of NLRP3 inflammasome. On these bases, I propose a project in which PML activity at MAMs can be the key link of different neuroinflammatory diseases. Our goals are as follow: 1) to demonstrate that PML post-transcriptionally controls NLRP3 activity at the ER/MAMs compartments and thus IL-1β release via P2X7; 2) to prove that IL-1β release have a strong influence on neuronal environment and survival, and might represent a prognostic factor; 3) to develop new drugs targeting PML/NLRP3/P2X7 axis to overcome the unexpected failure of anti-IL-1 therapies.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
853425	**ANIMATE**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. DENNIS WOLF**
Host Institution: Universitaetsklinikum Freiburg, DE

Adaptive Immunity in Human Atherosclerosis: Understanding its Cellular Basis to Define Novel Immunomodulatory Therapies

Atherosclerosis is a chronic immune disease of arteries that causes vessel-narrowing atherosclerotic plaques. Its acute complications, myocardial infarction and stroke, are the leading causes of death worldwide. Atherosclerosis is accompanied by an inflammatory and autoimmune response with CD4+ T-helper cells that recognize self-antigens, including ApoB-100 (ApoB), the main protein in low-density lipoprotein (LDL) cholesterol. Although their existence has been inferred from indirect evidence, the existence and function of atherosclerosis-specific, self-reactive CD4+ T cells on a single-cell level remains elusive. In particular, it is unclear whether these are pro- or anti-inflammatory.

Preliminary data suggest the existence of a natural pool of ApoB-reactive T-helper cells that share properties with atheroprotective T-regulatory cells but transform into pathogenic T-effector cells in the natural course of disease. This proposal aims to explore this loss of protective immunity on a cellular and function level. It employs novel tools to detect antigen-specific T cells in vivo by MHC-II multimers, mass cytometry (CyTOF), single cell RNA-sequencing (scRNA-seq), lineage-tracing mouse models, and live cell imaging. Based on the anticipated findings, this study will define a map of auto-reactive T-helper cell phenotypes in a temporal, spatial, and functional dimension. These insights will be used to identify novel immunomodulatory strategies to therapeutically stabilize the population of protective ApoB-specific T-helper cells, or to prevent their transformation into pathogenic T cell phenotypes by adoptive cells transfers, vaccination, or cytokine-blockade. In clinical association studies, a direct correlation of auto-immunity and clinical atherosclerosis will be tested.

This proposal will decipher traits of protective immunity in atherosclerosis and help to build the conceptual framework to define novel therapeutic strategies for patients.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864499	**SecondCANCERinKIDS**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. RUBEN VAN BOXTEL**
Host Institution: Prinses Maxima Centrum Voor Kinderoncologie Bv, NL

What causes therapy-related malignancies in childhood cancer survivors? Dissecting the etiology of second cancers

Therapy-related malignancies are a major cause of long-term mortality among childhood cancer survivors. However, it is unclear how exposure to chemo- and/or radiotherapy early in life induces carcinogenesis. My aim is to determine the mechanisms and rate-limiting steps underlying the genesis of second malignancies in childhood cancer survivors. For this, we will focus on studying the etiology of therapy-related myeloid malignancies (t-MNs). I have pioneered methods to characterize mutation accumulation in single stem cells and study clonal lineages in the human hematopoietic system. My lab is embedded in Europe's largest childhood cancer center, providing the opportunity to apply our techniques to unique patient material. In Objective 1, we will dissect the life history of t-MN and study its cellular origin. Our key question is: Was the original t-MN clone already present before chemotherapy exposure, or generated as a consequence thereof? We will address this by tracking back clonal lineages in the hematopoietic tissue of patients using the mutations present in their second cancers. In Objective 2, we will study the mutational consequences of chemotherapy in normal hematopoietic cells of children before and after they received treatment. Our key question is: Is enhanced mutagenesis rate limiting for t-MN development? To address this, we will perform in-depth mutational analyses and in vitro validations. In Objective 3, we will determine phenotypic effects of chemotherapy on population dynamics of blood. Our key question is: how does chemotherapy affect selection dynamics and clonal composition of blood? To address this, we will integrate clonal histories and lineage contributions using somatically acquired mutations. Our unique methodology and anticipated novel insights will not contribute to improved survival of children with cancer, but also to increased fundamental knowledge on the origin of cancer.

Project End Date: **31-MAR-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864522	**Retina Rhythm**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator:	**Dr. MATTHEW CAMPBELL**
Host Institution:	The Provost, Fellows, Foundation Scholars & The Other Members Of Board Of The College Of The Holy & Undivided Trinity Of Queen Elizabeth Near Dublin, IE

Investigating the role of the inner retina in age-related macular degeneration (AMD)

Age-related macular degeneration (AMD) is the leading cause of irreversible central blindness in the world. The number of people with AMD is predicted to be 196 million by 2020, with an estimated 1 in 10 people over the age of 55 already showing early signs of the condition. Identifying those individuals at greater risk of disease progression is challenging and robust animal models of disease are delaying the development of therapeutics.

We have recently discovered that the blood vessels of the inner retina are highly dynamic and our data suggest that they play a central role in AMD development. I hypothesize, in contrast to studies to date, that the inner retina may be critical to the early stages of AMD onset. We have discovered that circadian regulation of the inner blood-retina barrier (iBRB) allows for replenishment and renewal of components of photoreceptor outer segments on a daily basis by a process we have termed Retinal Interstitial Kinesis (RIK).

Here, I propose that circadian mediated regulation of the inner retinal blood vessels is paramount in the early stages of AMD pathology. Our preliminary data suggests that circadian-mediated changes in the permeability of the iBRB can lead to an AMD-like phenotype in mice and non-human primates. I propose that re-establishing the dynamic cycling of the iBRB may represent a novel therapeutic strategy for the prevention and treatment of AMD.

Over the next 5 years, the central aims of Retina-Rhythm are to:

1. Develop and characterize newly established mouse and non-human primate models of AMD by disrupting circadian cycling of the iBRB.
2. Develop a novel AAV based vector with the ability to re-establish dynamic circadian cycling of the iBRB and treat AMD.
3. Prove that dysregulated circadian-mediated iBRB cycling mediates AMD pathology in human subjects.

Our goal: To determine the key early initiators of AMD and to develop the next generation of therapies for this devastating form of blindne

Project End Date: **30-JUN-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864759	**ALTER-brain**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. MANUEL VALIENTE**
Host Institution: Fundacion Centro Nacional De Investigaciones Oncologicas Carlos Iii, ES

Metastasis-associated altered molecular patterns in the brain

Organ colonization is the most inefficient step of metastasis. However, once a few cancer cells manage to re-initiate their growth in the brain, the initial naïve microenvironment, which was not favouring and even actively limiting the number of potential metastasis initiating cells, is slowly rewired into a different ecosystem with pro-metastatic properties. In this project (ALTER-brain), we will study the biology of microenvironment reprogramming to explore innovative ways of treating metastasis.

Microenvironment reprogramming relies on altered molecular patterns that emerge in specific brain cell types simultaneously to the outgrowth of metastases. Dissecting the biology of these emerging patterns and their functional consequences could provide the basis to prevent metastasis but also to treat advances lesions. A key objective of ALTER-brain is the identification of newly established functional networks among previously non-connected components of the microenvironment that are critical to nurture tumour growth.

This research proposal focuses on metastasis in the brain given its rising incidence, poor therapeutic options and short survival rates upon diagnosis. ALTER-brain will use novel (i.e. spontaneous metastasis) and clinically relevant (i.e. relapse after therapy) experimental mouse models of brain metastasis combined with genetically engineered mice in which we will target specific components of the microenvironment. In addition, we will apply novel lineage tracing technologies to understand the origin and emerging heterogeneity of the reprogrammed microenvironment. Given the clinical relevance of our research, human brain metastasis provided by our clinical network will be used to validate key findings.

ALTER-brain will identify key principles underlying the unknown biology of the brain under a specific pathological pressure that might be translated to other highly prevalent disorders affecting this organ in the future.

Project End Date: **30-JUN-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864788	**MacinNASH**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. MYRIAM AOUADI**
Host Institution: Karolinska Institutet, SE

Revealing the contribution of liver macrophage populations to NASH in insulin resistance

Non-alcoholic steatohepatitis (NASH), the most common chronic liver disease worldwide, is an unmet medical need with no approved therapies and debilitating consequences for patients. Obesity-associated insulin resistance is a high-risk factor for the development of NASH. The prevailing paradigm is a multiple hit process, whereby lipid accumulation in the liver of obese patients leads to oxidative stress and increased production of inflammatory cytokines by macrophages. However, my research group's comprehensive investigations in mice and humans have revealed that liver macrophages (LMs) contribute to insulin resistance and oxidative stress independently of their inflammatory status. I thereby propose that LMs predispose insulin resistant patients to NASH independently of their inflammatory status. In this ambitious multidisciplinary project, we will use a novel platform encompassing multiple single cell and in situ omics technologies tailored by my research group to characterize the phenotype of LM populations in healthy individuals and insulin resistant patients with or without NASH. We will strengthen this approach with functional validation in animal models as well as human liver organoids using a patented technology that I have developed to specifically manipulate gene expression in macrophages. We will then decipher how hepatic insulin resistance creates a spatiotemporal environment facilitating NASH. My group's unique access to patient material combined with cutting-edge methodologies to reveal the phenotype of single LMs provides an exceptional starting point from which to identify genes and pathways involved in the development of NASH in obese insulin resistant patients. This project will set the stage for a paradigm-shift in studying and treating life-threatening liver diseases.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865408	**RENOPROTECT**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. MATIAS SIMONS**
Host Institution: Universitaetsklinikum Heidelberg, DE

Targeting tubular reabsorption for kidney protection

Many forms of chronic kidney disease are featured by the loss of protein into the urine (proteinuria). When the cause of proteinuria lies within the glomerulus, such as in diabetic kidney disease, then the protein overload in the tubular lumen may lead to damage of the downstream tubular cells. Particularly vulnerable are proximal tubular cells (PTCs), because these cells are specialized in protein reabsorption and have a high metabolic demand. Dysfunction of the main albumin uptake receptor cubilin (encoded by the CUBN gene) leads to the reduction of albumin uptake and albuminuria. Here, we hypothesize that genetic variants in CUBN are key for providing a cell-to-cell variability that is beneficial for PTC homeostasis and resistance against proteinuric kidney disease. This hypothesis is based on our recent findings that 1.) CUBN mutations are well tolerated by humans despite their proteinuric effects and that 2.) the CUBN locus shows signatures of balancing selection during human evolution. To address this hypothesis, we will first functionally validate common CUBN variants and haplotypes in a humanized Drosophila model and test whether they provide protection against renal disease in mice. Second, we will explore monoallelic CUBN expression and partial cryptic exon inclusion as two possible genetic mechanisms by which CUBN variants could promote proximal tubule fitness and tissue repair. Finally, taking advantage of cubilin dysfunction as a “safe” means to avoid PTC overload, we will target PTC protein uptake in proteinuric mice with the help of a nanoparticle delivery method. Altogether, our integrative translational approach will combine human genetics and experimental studies to explore a new mechanism of proximal tubule homeostasis that may also be applicable to other tissues. Based on evolutionary genetics, we aim to establish a novel paradigm for kidney protection with high relevance for the diagnosis, prognosis and treatment of proteinuric kidney disease.

Project End Date: **31-JUL-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866240	**EXPLOSIA**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. JACOB BENTZON**
Host Institution: Aarhus Universitet, DK

EXpansion and Phenotype Loss Of SMCs In Atherosclerosis: Causal effects and therapeutic possibilities

Atherosclerosis is considered an inflammatory disease caused by the accumulation, modification and immune cell recognition of low-density lipoproteins in the arterial wall. Plaque macrophages are held to be the main drivers of disease activity, whereas smooth muscle cells (SMCs) have traditionally been considered protective by forming fibrous tissue that stabilises plaques from undergoing rupture and causing thrombosis.

In the present project, we challenge this dichotomous view of cellular villains and heroes in atherosclerosis. Using lineage tracking techniques in mice, we and others have uncovered a large population of SMCs in plaques, which has escaped detection because the cells completely lose conventional SMC phenotype. Strikingly, we have found that the entire plaque SMC population derives from only few founder SMCs that undergo massive clonal expansion and phenotypic modulation during lesion formation. We hypothesise that the balance between the different modulated SMC subtypes and the functions they carry are central to lesion progression.

In EXPLOSIA we will address this hypothesis in 3 steps. First, we will conduct a comparative analysis of clonal structure in mice, minipigs, and humans. Second, we will determine links between SMC subtypes, their gene expression programs, and atherosclerotic disease activity by combining single-cell transcriptomics with novel techniques to alter atherosclerotic disease activity in gene-modified mice and minipigs. Third, we will develop techniques for manipulating genes in modulated plaque SMCs and test the causal role of perturbing SMC subtypes and function for lesion progression.

The aim of the project is to answer the following key questions for a deeper understanding of atherosclerosis:

- What is the clonal architecture of SMCs in human atherosclerosis?
- What is the SMC gene expression signature of atherosclerotic disease activity?
- Can interventions targeting SMCs prevent dangerous lesion development?

Project End Date: **31-JUL-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866548	**Hemstem**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. CLAUDIA LENGERKE**
Host Institution: Universitaet Basel, CH

Targeting leukaemia by modulating hematopoietic stem cell competitiveness

Human acute myeloid leukemia (AML) remains a devastating disease with less than 30% of patients surviving five years after diagnosis. Despite decades of research and detailed mo-lecular insights provided by mutational profiling, curative treatment still requires high-intensity chemotherapy and the crude approach of allogeneic stem cell transplantation – an effective, yet non-specific immunotherapy that is costly to the patient because of its severe side effects. One reason why the wealth of molecular and experimental knowledge has so far been unable to revolutionize treatments is the fact that AML is driven by small subpopulations of so-called leukemic stem cells (LSCs), which survive chemotherapy and immune surveillance. LSCs have growth advantages induced by oncogenic mutations, but are in many ways similar to healthy hematopoietic stem cells (HSCs). This similarity makes it difficult to target LSCs without simultaneously eradicating HSCs and healthy hematopoiesis derived from these cells. Like HSCs, LSCs home to protective bone marrow (BM) niches promoting stemness and therapy resistance and modify them to displace HSCs and promote their own expansion. This proposal explores strategies to target LSCs based on understanding these interactions. In Aim 1 we investigate how WNT signaling, an evolutionary conserved pathway governing stem cell self-renewal, regulates interactions between leukemic and healthy hematopoietic (stem) cells. In Aim 2, we propose to inhibit the in vivo expansion of LSCs by enhancing self-renewal and niche affinity in their natural competitors, the healthy stem cells with inborn BM homing ability. Aim 3 uses zebrafish to visualize LSC-HSC interactions and screens for molecules supporting healthy instead of (pre-) malignant hematopoiesis. Our studies will im-prove the knowledge on the complex interactions between LSCs and HSCs and provide a rationale for novel treatments that might lead to a paradigm-shift in the clinical management of AML.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695295	**C.NAPSE**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. JEAN-LOUIS BESSEREAU**
Host Institution: Universite Lyon 1 Claude Bernard, FR

TOWARDS A COMPREHENSIVE ANALYSIS OF EXTRACELLULAR SCAFFOLDING AT THE SYNAPSE

Synaptic scaffolding molecules control the localization and the abundance of neurotransmitter receptors at the synapse, a key parameter to shape synaptic transfer function. Most characterized synaptic scaffolds are intracellular, yet a growing number of secreted proteins appear to organize the synapse from the outside of the cell. We recently demonstrated in C. elegans that an evolutionarily conserved protein secreted by motoneurons specifies the excitatory versus inhibitory identity of the postsynaptic domains at neuromuscular synapses. We propose to use this system as a genetically tractable paradigm to perform a comprehensive characterization of this unforeseen synaptic organization.

Specifically, this project will pursue 4 complementary aims:

1) Identify and characterize a comprehensive set of genes that organize and control the formation and maintenance of these scaffolds through a series of genetic screens based on the direct visualization of fluorescent acetylcholine and GABA receptors in living animals.

2) Solve the spatial synaptic organization of these scaffolds at a nanoscale resolution using super-resolutive and correlative light and electron microscopy, and analyze their dynamic behavior in vivo by implementing Single Particle Tracking imaging in living worms.

3) Decipher the role of the synaptomatrix in the organization of synaptic extracellular scaffolds and evaluate its functional contribution at the physiological and molecular levels using a candidate gene strategy and innovative imaging.

4) Analyze the formation and decline of these scaffolds at the lifetime scale and evaluate the role of synaptic activity and aging in these processes by taking advantage of the possibility to follow identified synapses over the entire life of C. elegans.

Using powerful genetics in combination with cutting-edge in vivo imaging and electrophysiology, we anticipate to identify new genes and new mechanisms at work to regulate normal and pathological synaptic function.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715043	**CholAminCo**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. BALAZS HANGYA**
Host Institution: Institute Of Experimental Medicine - Hungarian Academy Of Sciences, HU

Synergy and antagonism of cholinergic and dopaminergic systems in associative learning

Neuromodulators such as acetylcholine and dopamine are able to rapidly reprogram neuronal information processing and dynamically change brain states. Degeneration or dysfunction of cholinergic and dopaminergic neurons can lead to neuropsychiatric conditions like schizophrenia and addiction or cognitive diseases such as Alzheimer's. Neuromodulatory systems control overlapping cognitive processes and often have similar modes of action; therefore it is important to reveal cooperation and competition between different systems to understand their unique contributions to cognitive functions like learning, memory and attention. This is only possible by direct comparison, which necessitates monitoring multiple neuromodulatory systems under identical experimental conditions. Moreover, simultaneous recording of different neuromodulatory cell types goes beyond phenomenological description of similarities and differences by revealing the underlying correlation structure at the level of action potential timing. However, such data allowing direct comparison of neuromodulatory actions are still sparse. As a first step to bridge this gap, I propose to elucidate the unique versus complementary roles of two "classical" neuromodulatory systems, the cholinergic and dopaminergic projection system implicated in various cognitive functions including associative learning and plasticity. First, we will record optogenetically identified cholinergic and dopaminergic neurons simultaneously using chronic extracellular recording in mice undergoing classical and operant conditioning. Second, we will determine the postsynaptic impact of cholinergic and dopaminergic neurons by manipulating them both separately and simultaneously while recording consequential changes in cortical neuronal activity and learning behaviour. These experiments will reveal how major neuromodulatory systems interact to mediate similar or different aspects of the same cognitive functions.

Project End Date: **30-APR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
726280	**Spontaneous ZeBrain**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. GERMAN SUMBRE**
Host Institution: Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

Whole-brain dynamics underlying self-generated behaviour

The first behavioural theories conceived the organism as primarily driven by external sensory stimuli. However, the energy associated with momentary demands of the environment represent ~1% of the brain's total energy budget, implying that the intrinsic activity represents a major aspect of the brain's function. Indeed, more recent theories such as cognitivism and embodiment describe the organisms as capable of generating complex behaviours emerging from the brain's intrinsic dynamics.

Past and current studies that investigated the neuronal basis self-generated behaviours mainly focus on the readiness potential (RP) signal, a build-up ramping activity in the premotor cortex, occurring ~ 2 sec before the movement's onset. However, the neuronal mechanisms underlying the generation of self-generated behaviours (how RPs are generated), the involvement of other regions, and how the brain codes the impending movements (activity predictive of the onset and type of movement), still remain poorly understood.

The combination of light-sheet microscopy, optogenetics, and the zebrafish larva model enables monitoring whole-brain dynamics in an intact behaving vertebrate. Moreover, the diverse yet limited and well described repertoire of motor behaviours will enable to perform experiments in more natural unconstrained conditions, in comparison to previous studies, which were structured in trials and limited to one or two behavioural choices. These advantages will allow us to go beyond the current state-of-the-art in the field. More specifically, we propose to investigate the following specific aims:

1) Whole-brain dynamics basis and mechanisms underlying self-generated behaviours.

2) A comparison between the neuronal pathways underlying the initiation of self-generated and sensory
induced behaviours.

3) The internal and external modulation of self-generated behaviours.

Project End Date: **30-APR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
740427	**BrainEnergy**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. DAVID ATTWELL**
Host Institution: University College London, UK

Control of cerebral blood flow by capillary pericytes in health and disease

Pericytes, located at intervals along capillaries, have recently been revealed as major controllers of brain blood flow. Normally, they dilate capillaries in response to neuronal activity, increasing local blood flow and energy supply. But in pathology they have a more sinister role. After artery block causes a stroke, the brain suffers from the so-called "no-reflow" phenomenon - a failure to fully reperfuse capillaries, even after the upstream occluded artery has been reperfused successfully. The resulting long-lasting decrease of energy supply damages neurons. I have shown that a major cause of no-reflow lies in pericytes: during ischaemia they constrict and then die in rigor. This reduces capillary diameter and blood flow, and probably degrades blood-brain barrier function. However, despite their crucial role in regulating blood flow physiologically and in pathology, little is known about the mechanisms by which pericytes function.

By using blood vessel imaging, patch-clamping, two-photon imaging, optogenetics, immunohistochemistry, mathematical modelling, and live human tissue obtained from neurosurgery, this programme of research will:
(i) define the signalling mechanisms controlling capillary constriction and dilation in health and disease;
(ii) identify the relative contributions of neurons, astrocytes and microglia to regulating pericyte tone;
(iii) develop approaches to preventing brain pericyte constriction and death during ischaemia;
(iv) define how pericyte constriction of capillaries and pericyte death contribute to Alzheimer's disease;
(v) extend these results from rodent brain to human brain pericytes as a prelude to developing therapies.

The diseases to which pericytes contribute include stroke, spinal cord injury, diabetes and Alzheimer's disease. These all have an enormous economic impact, as well as causing great suffering for patients and their carers. This work will provide novel therapeutic approaches for treating these diseases.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758604	**ENTRAINER**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. RAFAEL POLANIA**
Host Institution: Eidgenoessische Technische Hochschule Zurich, CH

Enhancing brain function and cognition via artificial entrainment of neural oscillations

Neural oscillations are ubiquitous in the human brain and have been implicated in diverse cognitive functions to support both neural communication and plasticity. Their functional relevance is further supported by a large number of studies linking various cognitive deficits (e.g., attention deficit hyperactivity disorder, ADHD) with abnormal neural oscillations. However, this field of research faces two important problems: First, there is only correlative, but no causal evidence linking cognitive deficits to abnormal neural oscillations in humans. Second, there is virtually no theory-driven mechanistic approach that generates insights into how oscillations within and across neural networks are linked to human behavior. In this project, I propose to take decisive steps to provide a long-needed neurophysiological characterization—via (1) computational modelling, (2) electrophysiological measures, and (3) novel non-invasive manipulations of cortical rhythms—on how neural oscillations contribute to two types of cognitive processes that are fundamental for many aspects of human behavior: attention and short-term memory. I will go a step further by demonstrating that it is possible to augment performance in these cognitive functions with the design of non-invasive brain stimulation protocols individually tailored to the theory-driven neurocomputational characterizations and electrophysiological signatures of each individual. This will result in the applied goal of deriving new neuro-computational assays that can detect deviant network interactions causally related to cognitive functions, which is key for then renormalizing those functions in neuropsychological conditions such as ADHD. Thus, if successful, my proposed work will ultimately result in novel, low-cost, and painless non-invasive neural interventions for a wide range of neuropsychological disorders tied to abnormal neural oscillations.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
770244	**CMTaaRS**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. ERIK STORKEBAUM**
Host Institution: Stichting Katholieke Universiteit, NL

Defective protein translation as a pathogenic mechanism of peripheral neuropathy

Familial forms of neurodegenerative diseases are caused by mutations in a single gene. It is unknown whether distinct mutations in the same gene or in functionally related genes cause disease through similar or disparate mechanisms. Furthermore, the precise molecular mechanisms underlying virtually all neurodegenerative disorders are poorly understood, and effective treatments are typically lacking.

This is also the case for Charcot-Marie-Tooth (CMT) peripheral neuropathy caused by mutations in five distinct tRNA synthetase (aaRS) genes. We previously generated Drosophila CMT-aaRS models and used a novel method for cell-type-specific labeling of newly synthesized proteins in vivo to show that impaired protein translation may represent a common pathogenic mechanism.

In this proposal, I aim to determine whether translation is also inhibited in CMT-aaRS mouse models, and whether all mutations cause disease through gain-of-toxic-function, or alternatively, whether some mutations act through a dominant-negative mechanism. In addition, I will evaluate whether all CMT-aaRS mutant proteins inhibit translation, and I will test the hypothesis, raised by our unpublished preliminary data shown here, that a defect in the transfer of the (aminoacylated) tRNA from the mutant synthetase to elongation factor eEF1A is the molecular mechanism underlying CMT-aaRS. Finally, I will validate the identified molecular mechanism in CMT-aaRS mouse models, as the most disease-relevant mammalian model.

I expect to elucidate whether all CMT-aaRS mutations cause disease through a common molecular mechanism that involves inhibition of translation. This is of key importance from a therapeutic perspective, as a common pathogenic mechanism allows for a unified therapeutic approach. Furthermore, this proposal has the potential to unravel the detailed molecular mechanism underlying CMT-aaRS, what would constitute a breakthrough and a requirement for rational drug design for this incurable disease.

Project End Date: **31-MAY-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
770951	**CLAUSTRUM**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. AMI CITRI**
Host Institution: The Hebrew University Of Jerusalem., IL

The Claustrum: A Circuit Hub for Attention

Our senses face a constant barrage of information. Hence, understanding how our brain enables us to attend to relevant stimuli, while ignoring distractions, is of increasing biomedical importance. Recently, I discovered that the claustrum, a multi-sensory hub and recipient of extensive neuromodulatory input, enables resilience to distraction.

In my ERC project, I will explore the mechanisms underlying claustral mediation of resilience to distraction and develop novel approaches for assessing and modulating attention in mice, with implications for humans. Transgenic mouse models that I identified as enabling selective access to claustral neurons overcome its limiting anatomy, making the claustrum accessible to functional investigation. Using this novel genetic access, I obtained preliminary results strongly suggesting that the claustrum functions to filter distractions by adjusting cortical sensory gain.

My specific aims are: 1) To delineate the mechanisms whereby the claustrum achieves sensory gain control, by applying in-vivo cell-attached, multi-unit and fiber photometry recordings from claustral and cortical neurons during attention-demanding tasks. 2) To discriminate between the functions of the claustrum in multi-sensory integration and implementation of attention strategies, by employing multi-sensory behavioral paradigms while modulating claustral function. 3) To develop validated complementary physiological and behavioral protocols for adjusting claustral mediation of attention via neuromodulation.

This study is unique in its focus and aims: it will provide a stringent neurophysiological framework for defining a key mechanism underlying cognitive concepts of attention, and establish a novel platform for studying the function of the claustrum and manipulating its activity. The project is designed to achieve breakthroughs of fundamental nature and potentially lead to diagnostic and therapeutic advances relevant to attention disorders.

Project End Date: **28-FEB-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772395	**Acclimatize**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. JAN SIEMENS**
Host Institution: Universitaetsklinikum Heidelberg, DE

Hypothalamic mechanisms of thermal homeostasis and adaptation

Mammalian organisms possess the remarkable ability to maintain internal body temperature (Tcore) within a narrow range close to 37°C despite wide environmental temperature variations. The brain's neural "thermostat" is made up by central circuits in the hypothalamic preoptic area (POA), which orchestrate peripheral thermoregulatory responses to maintain Tcore. Thermogenesis requires metabolic fuel, suggesting intricate connections between the thermoregulatory centre and hypothalamic circuits controlling energy balance. How the POA detects and integrates temperature and metabolic information to achieve thermal balance is largely unknown. A major question is whether this circuitry could be harnessed therapeutically to treat obesity.

We have recently identified the first known molecular temperature sensor in thermoregulatory neurons of the POA, transient receptor potential melastatin 2 (TRPM2), a thermo-sensitive ion channel. I aim to use TRPM2 as a molecular marker to gain access to and probe the function of thermoregulatory neurons in vivo. I propose a multidisciplinary approach, combining local, in vivo POA temperature stimulation with optogenetic circuit-mapping to uncover the molecular and cellular logic of the hypothalamic thermoregulatory centre and to assess its medical potential to counteract metabolic syndrome.

Acclimation is a beneficial adaptive process that fortifies thermal responses upon environmental temperature challenges. Thermoregulatory neuron plasticity is thought to mediate acclimation. Conversely, maladaptive thermoregulatory changes affect obesity. The cell-type-specific neuronal plasticity mechanisms underlying these changes within the POA, however, are unknown.

Using ex-vivo slice electrophysiology and in vivo imaging, I propose to characterize acclimation- and obesity-induced plasticity of thermoregulatory neurons. Ultimately, I aim to manipulate thermoregulatory neuron plasticity to test its potential counter-balancing effect on obesity.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772452	**nanoAXON**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. JANOS SZABADICS**
Host Institution: Institute Of Experimental Medicine - Hungarian Academy Of Sciences, HU

Nano-physiology of small glutamatergic axon terminals

We will reveal the neuronal mechanisms of fundamental hippocampal and axonal functions using direct patch clamp recordings from the small axon terminals of the major glutamatergic afferent and efferent pathways of the dentate gyrus region. Specifically, we will investigate the intrinsic axonal properties and unitary synaptic functions of the axons in the dentate gyrus that originate from the entorhinal cortex, the hilar mossy cells and the hypothalamic supramammillary nucleus. The fully controlled access to the activity of individual neuronal projections allows us to address the crucial questions how upstream regions of the dentate gyrus convey physiologically relevant spike activities and how these activities are translated to unitary synaptic responses in individual dentate gyrus neurons. The successful information transfers by these mechanisms ultimately generate specific dentate gyrus cell activity that contributes to hippocampal memory functions. Comprehensive mechanistic insights are essential to understand the impacts of the activity patterns associated with fundamental physiological functions and attainable with the necessary details only with direct recordings from individual axons. For example, these knowledge are necessary to understand how single cell activities in the entorhinal cortex (carrying primary spatial information) contribute to spatial representation in the dentate (i.e. place fields). Furthermore, because the size of these recorded axon terminals matches that of the majority of cortical synapses, our discoveries will demonstrate basic biophysical and neuronal principles of axonal signaling that are relevant for universal neuronal functions throughout the CNS. Thus, an exceptional repertoire of methods, including recording from anatomically identified individual small axon terminals, voltage- and calcium imaging and computational simulations, places us in an advantaged position for revealing unprecedented information about neuronal circuits.

Project End Date: **31-MAR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
786467	**MiCaBra**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. GIOVANNI MARSICANO**
Host Institution: Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

Mitochondrial Cannabinoid Receptors in the Brain

Brain activity critically depends on the high energetic support provided by mitochondria, the cell organelles transforming energy sources into molecularly usable ATP. The pathological effects of chronic mitochondrial dysfunctions in the brain are under scrutiny, but the impact of physiological modulation of mitochondrial activity on ongoing brain functions is almost unknown. Cannabinoid type-1 receptors (CB1) are amongst the G Protein-Coupled receptors (GPCR) expressed at highest levels in the brain, and they are key regulators of behaviour. We recently showed that CB1 receptors are present at brain mitochondrial membranes (mtCB1), where they regulate bioenergetic processes, thereby mediating amnesic effects of cannabinoids. Thus, the physiological roles of the brain endocannabinoid system formed by CB1 receptors and endogenous ligands, and the pharmacological effects of cannabinoid drugs (e.g. the psychotropic compound of the plant cannabis sativa, Δ9-tetrahydrocannabinol) partially rely on the regulation of brain mitochondrial activity. Using a bottom-up approach at micro-, meso- and macro-scale levels, MiCaBra will reveal cell biological features, signalling properties and behavioural impact of mtCB1 receptors in the brain. First, we will address the cell biology of mtCB1 receptors, determining the structural and molecular requirements for their mitochondrial trafficking. To define how this GPCR modulate mitochondrial activity and what are the functional consequences of these effects, we will study downstream intra-mitochondrial signalling of mtCB1 receptors and the eventual impact on cellular processes controlled by the organelle. Finally, we will tackle the role of mtCB1 receptors in the (endo)cannabinoid control of brain circuits and behaviour. Thus, MiCaBra has the ambitious aim to understand the impact of regulation of bioenergetic processes on ongoing brain functions, thereby determining a novel framework in the study of behavioural pathophysiology.

Project End Date: **31-OCT-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
786949	**HOWPER**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. EHUD AHISSAR**
Host Institution: Weizmann Institute Of Science, IL

An open or closed process: Determining the global scheme of perception

Despite decades of intensive research, there is no agreement about the general scheme of perception: Is the external object a trigger for a brain-internal process (open-loop perception, OLP) or is the object included in brain dynamics during the entire perceptual process (closed-loop perception, CLP)? HOWPER is designed to provide a definite answer to this question in the cases of human touch and vision. What enables this critical test is our development of an explicit CLP hypothesis, which will be contrasted, via specific testable predictions, with the OLP scheme. In the event that CLP is validated, HOWPER will introduce a radical paradigm shift in the study of perception, since almost all current experiments are guided, implicitly or explicitly, by the OLP scheme. If OLP is confirmed, HOWPER will provide the first formal affirmation for its superiority over CLP.

Our approach in this novel paradigm is based on a triangle of interactive efforts comprising theory, analytical experiments, and synthetic experiments. The theoretical effort (WP1) will be based on the core theoretical framework already developed in our lab. The analytical experiments (WP2) will involve human perceivers. The synthetic experiments (WP3) will be performed on synthesized artificial perceivers. The fourth WP will exploit our novel rat-machine hybrid model for testing the neural applicability of the insights gained in the other WPs, whereas the fifth WP will translate our insights into novel visual-to-tactile sensory substitution algorithms.

HOWPER is expected to either revolutionize or significantly advance the field of human perception, to greatly improve visual to tactile sensory substitution approaches and to contribute novel biomimetic algorithms for autonomous robotic agents.

Project End Date: **31-MAY-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787157	**FunctionalProteomics**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. ZOLTAN NUSSER**
Host Institution: Institute Of Experimental Medicine - Hungarian Academy Of Sciences, HU

Proteomic fingerprinting of functionally characterized single synapses

Our astonishing cognitive abilities are the consequence of complex connectivity within our neuronal networks and the large functional diversity of excitable nerve cells and their synapses. Investigations over the past half a century revealed dramatic diversity in shape, size and functional properties among synapses established by distinct cell types in different brain regions and demonstrated that the functional differences are partly due to different molecular mechanisms. However, synaptic diversity is also observed among synapses established by molecularly and morphologically uniform presynaptic cells on molecularly and morphologically uniform postsynaptic cells. Our hypothesis is that quantitative molecular differences underlie the functional diversity of such synapses. We will focus on hippocampal CA1 pyramidal cell (PC) to mGluR1α+ O-LM cell synapses, which show remarkable functional and molecular heterogeneity. In vitro multiple cell patch-clamp recordings followed by quantal analysis will be performed to quantify well-defined biophysical properties of these synapses. The molecular composition of the functionally characterized single synapses will be determined following the development of a novel postembedding immunolocalization method. Correlations between the molecular content and functional properties will be established and genetic up- and downregulation of individual synaptic proteins will be conducted to reveal causal relationships. Finally, correlations of the activity history and the functional properties of the synapses will be established by performing in vivo two-photon Ca2+ imaging in head-fixed behaving animals followed by in vitro functional characterization of their synapses. Our results will reveal quantitative molecular fingerprints of functional properties, allowing us to render dynamic behaviour to billions of synapses when the connectome of the hippocampal circuit is created using array tomography.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
789054	**Myel-IN-Crisis**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. DAVID HENRY ROWITCH**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

Myelin at the crossroads of Development and Disease

The oligodendrocyte, the largest cell in mammalian biology, greatly enables central nervous system (CNS) function through production of a single substance: myelin. Oligodendrocytes undergo a dramatic 1-2 day metamorphosis during myelination, increasing their cell surface area ~6500-fold with proteolipid extensions to nerve axons in the CNS white matter. How is this synthetic feat accomplished? We lack a comprehensive understanding of machinery that precisely coordinates transcription, translation, lipid synthesis and energy production. Moreover, how do these mechanisms become so intensively upregulated during myelination? Does this extraordinary transient state put the myelinating oligodendrocyte at risk of death in diseases of white matter? These questions underlie the Aims of the proposal "Myel-IN-crisis."

I propose (Aim 1) testing whether an "Integrated Synthetic Programme (ISP)" controls oligodendrocyte differentiation, metabolic and synthetic requirements of developmental myelination. In Aim 2, I will investigate roles for "smart sensor" oxygen (HIF) and nutrient (mTOR) pathways in regulating initiation and termination of the ISP. During development, extrinsic white matter injury in preterm infants leads to cerebral palsy, while intrinsic defects in myelin protein PLP1 cause the fatal human leukodystrophy, Pelizaeus-Merzbacher disease (PMD). Preliminary studies indicate transcriptional and translational dysregulation in human PLP1-mutant oligodendrocytes, which become iron overloaded leading to apoptotic cell death. In Aim 3, I propose that either extrinsic (e.g., hypoxia) or intrinsic (e.g., PLP1 mutation) factors promote a "Universal Stress Response (USR)" in the pre-myelinating oligodendrocyte that leads to toxic dysregulation of the ISP. Finally, in Aim 4 we will identify the key pathways of the USR to generate strategies for rescue of myelination with potential translational impact in cerebral palsy and leukodystrophy, multiple sclerosis and stroke.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802305	**RecoverInFlame**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. ARTHUR LIESZ**
Host Institution: Ludwig-Maximilians-Universitaet Muenchen, DE

T cell-driven inflammatory mechanisms promote recovery after acute brain injury

The overall goal of this project is to investigate T cells as “Trojan horses” to improve recovery from brain injuries – we will gain novel insights on how T cells promote neurologic recovery by modulating the cerebral micromilieu and how these pathomechanisms can be therapeutically targeted.
Inflammation is a common response to acute brain injuries, which are a leading cause of morbidity and mortality. I have recently identified continuous cerebral T cell recruitment as a hallmark of a long-lasting and profound neuroinflammation after acute brain injury. While a detrimental effect of T cells in the acute phase has been well documented, the pathophysiological consequences and therapeutic potential of T cell-driven chronic inflammation for recovery after brain injury are unknown. Interestingly, my recent findings indicate that T cell fate is orchestrated in the gut via modulation of commensal bacteria and that T cells potently promote stroke recovery. Building up on these recent findings, I hypothesize that T cells contribute substantially to the recovery after brain injury by inflammation-driven remodeling. Using several innovative methodologies applied for the first time to recovery after brain injury, we will firstly investigate the contribution of T cells on cortical connectivity, spine plasticity and mechanisms of glial responses. Next, we will analyze the contribution of the gut microbiota to modulate the chronic neuroinflammatory response via a pro-regenerative polarization of T helper cells. Finally, we will test the generalizability and translational robustness of our findings in models of various acute brain injuries and common comorbidities. Results from this project are likely to open up a new research field on T cell-driven neurologic recovery after brain injury, thereby revolutionizing our pathomechanistic understanding and provide novel therapeutic strategies for one of the most pressing medical problems.

Project End Date: **31-OCT-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802371	**DisConn**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. ALESSANDRO GOZZI**
Host Institution: Fondazione Istituto Italiano Di Tecnologia, IT

Neural drivers of functional disconnectivity in brain disorders

A rapidly expanding approach to understanding neural organization is to map patterns of spontaneous neural activity as an index of functional communication and connectivity across brain regions. Fostered by the advent of neuroimaging methods like resting-state fMRI (rsfMRI), this approach has revealed that functional connectivity is almost invariably disrupted in severe psychiatric disorders, such as autism or schizophrenia. However, the neural basis of such functional disconnectivity remains mysterious. What drives brain-wide functional synchronization? And are there shared pathophysiological mechanisms leading to impaired large-scale neural coupling?

This project aims to elucidate the neural drivers of macroscale functional connectivity, as well as its breakdown in brain connectopathies. To achieve this goal, I propose a multi-scale perturbational approach to establish causal relationships between specific neural events and brain-wide functional connectivity via a novel combination of rsfMRI and advanced neural manipulations and recordings in the awake mouse.

By directionally silencing functional hubs as well as more peripheral cortical regions, I will provide a hierarchical description of spontaneous network organization that will uncover regional substrates vulnerable to network disruption. I will also manipulate physiologically-distinct excitatory or inhibitory populations to probe a unifying mechanistic link between excitatory/inhibitory imbalances and aberrant functional connectivity. Finally, to account for the hallmark co-occurrence of synaptic deficits and functional disconnectivity in developmental disorders, I will link cellular mechanisms of synaptic plasticity and learning to the generation of canonical and aberrant spontaneous activity patterns. These studies will pave the way to a back-translation of aberrant functional connectivity into interpretable neurophysiological events and models that can help understand, diagnose or treat brain disorders.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802531	**EvolutioNeuroCircuit**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. LUCIA PRIETO GODINO**
Host Institution: The Francis Crick Institute Limited, UK

Cellular and genetic bases of neural circuits evolution

Sensory systems encode the world around us to produce context-dependent appropriate behaviours. However, we know little about the way new sensory evoked behaviours arise as neural circuits are re-shaped during evolution. Tackling this question requires a deep understanding of the circuits underlying specific behaviours and integration of this knowledge with tools from other fields, including evolutionary and developmental biology. Recent technological advancements on neural circuit interrogation and genome editing have put progress on this fundamental biological question within reach.

The olfactory system of the larval stage of the fly Drosophila melanogaster and related species is an ideal model for investigating these questions because (i) D. melanogaster has pioneered both the fields of population genetics and neurogenetics and (ii) its olfactory system is one of the best-characterised neural circuits. We will address the question of how olfactory circuits evolve by studying four species with divergent odour-guided behaviours through the following multidisciplinary aims:

1. Which olfactory pathways are targeted in the evolution of ecological specialisation? – Combining high-throughput behavioural assays, optogenetics and calcium imaging in the larva of all four species we will determine whether/which olfactory pathways have switched valences or sensitivity.
2. How have central neural circuits diverged? – We will address this question at unprecedented resolution through whole-brain calcium imaging and serial electron microscopy reconstruction.
3. What are the molecular and genetic bases of neural circuits rewiring during evolution? – Using transcriptomic profiling we will identify differentially expressed genes in conserved and divergent circuits across species, and functionally probe selected candidates to establish causality.
4. How do evolutionary forces shape olfactory circuits? – We will investigate this question using field studies and population genetics

Project End Date: **29-FEB-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803589	**RECENT-TO-REMOTE**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. INBAL GOSHEN**
Host Institution: The Hebrew University Of Jerusalem., IL

Remote Memory Consolidation Based on Activity, Connectivity and Stability; Contribution of Neurons and Astrocytes.

Our remote memories, weeks to decades long, define who we are and how we experience the world, yet almost nothing is known about the neuronal ensembles encoding them, or the mechanisms underlying the transition from recent to remote memory.

I propose a novel hypothesis explaining the selection of the ensembles supporting remote memories based on their activity, connectivity and stability. I further suggest that 'systems consolidation', underlying the transition from recent to remote memory, is implemented by ongoing interactions between brain regions. Finally, I propose a novel role for astrocytes in recent and remote memory.

My Specific Objectives are to: 1) Provide multi-dimensional characterization of the neuronal ensembles supporting recent and remote memory, by using activity-based tagging to show how recent and remote recall ensembles differ in activity, connectivity and stability. 2) Perturb the functional connectivity underlying 'systems consolidation' by employing connectivity-based tagging to label specific hippocampal and cortical projection neurons, image their activity during recent and remote memory, and causally demonstrate their functional significance to systems consolidation. 3) Determine the role of astrocytes in recent and remote memory consolidation and retrieval. We will manipulate astrocytes to show their role in recent and remote memory, ensemble allocation, and long-distance communication between neuronal populations. We will image astrocytic activity during a memory task to test if they can independently encode memory features, and how their activity corresponds to that of the neurons around them.

This pioneering ERC project, comprised of innovative and ambitious experiments going far and beyond the state of the art in the field, will drive considerable progress to our contemporary understanding of the transition from recent to remote memory, identifying ensemble dynamics and critical projections and how they are modulated by astrocytes.

Project End Date: **31-OCT-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803870	**AXPLAST**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. JAN GRUNDEMANN**
Host Institution: Universitaet Basel, CH

Deep brain imaging of cellular mechanisms of sensory processing and learning

Learning and memory are the basis of our behaviour and mental well-being. Understanding the mechanisms of structural and cellular plasticity in defined neuronal circuits in vivo will be crucial to elucidate principles of circuit-specific memory formation and their relation to changes in neuronal ensemble dynamics.

Structural plasticity studies were technically limited to cortex, excluding deep brain areas like the amygdala, and mainly focussed on the input site (dendritic spines), whilst the plasticity of the axon initial segment (AIS), a neuron's site of output generation, was so far not studied in vivo. Length and location of the AIS are plastic and strongly affects a neurons spike output. However, it remains unknown if AIS plasticity regulates neuronal activity upon learning in vivo.
We will combine viral expression of AIS live markers and genetically-encoded Ca2+-sensors with novel deep brain imaging techniques via gradient index (GRIN) lenses to investigate how AIS location and length are regulated upon associative learning in amygdala circuits in vivo. Two-photon time-lapse imaging of the AIS of amygdala neurons upon fear conditioning will help us to track learning-driven AIS location dynamics. Next, we will combine miniature microscope imaging of neuronal activity in freely moving animals with two-photon imaging to link AIS location, length and plasticity to the intrinsic activity as well as learning-related response plasticity of amygdala neurons during fear learning and extinction in vivo. Finally, we will test if AIS plasticity is a general cellular plasticity mechanisms in brain areas afferent to the amygdala, e.g. thalamus.

Using a combination of two-photon and miniature microscopy imaging to map structural dynamics of defined neural circuits in the amygdala and its thalamic input areas will provide fundamental insights into the cellular mechanisms underlying sensory processing upon learning and relate network level plasticity with the cellular level.

Project End Date: **30-NOV-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804581	**BrainNanoFlow**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. JUAN VARELA**
Host Institution: The University Court Of The University Of St Andrews, UK

Nanoscale dynamics in the extracellular space of the brain in vivo

Aggregates of proteins such as amyloid-beta and alpha-synuclein circulate the extracellular space of the brain (ECS) and are thought to be key players in the development of neurodegenerative diseases. The clearance of these aggregates (among other toxic metabolites) is a fundamental physiological feature of the brain which is poorly understood due to the lack of techniques to study the nanoscale organisation of the ECS. Exciting advances in this field have recently shown that clearance is enhanced during sleep due to a major volume change in the ECS, facilitating the flow of the interstitial fluid. However, this process has only been characterised at a low spatial resolution while the physiological changes occur at the nanoscale. The recently proposed “glymphatic” pathway still remains controversial, as there are no techniques capable of distinguishing between diffusion and bulk flow in the ECS of living animals. Understanding these processes at a higher spatial resolution requires the development of single-molecule imaging techniques that can study the brain in living animals. Taking advantage of the strategies I have recently developed to target single-molecules in the brain in vivo with nanoparticles, we will do “nanoscopy” in living animals. Our proposal will test the glymphatic pathway at the spatial scale in which events happen, and explore how sleep and wake cycles alter the ECS and the diffusion of receptors in neuronal plasma membrane. Overall, BrainNanoFlow aims to understand how nanoscale changes in the ECS facilitate clearance of protein aggregates. We will also provide new insights to the pathological consequences of impaired clearance, focusing on the interactions between these aggregates and their putative receptors. Being able to perform single-molecule studies in vivo in the brain will be a major breakthrough in neurobiology, making possible the study of physiological and pathological processes that cannot be studied in simpler brain preparations.

Project End Date: **30-NOV-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818996	**DEVMEM**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. FRANCESCA CACUCCI**
Host Institution: University College London, UK

Learning to remember: the development of the neural mechanisms supporting memory processing.

The ability to form and store memories allows organisms to learn from the past and imagine the future: it is a crucial mechanism underlying flexible and adaptive behaviour. The aim of this proposal is to identify the circuit mechanisms underlying our ability to learn and remember, by tracking the ontogenesis of memory processing. Importantly, we are not born with a fully functioning memory system: generally, adults cannot recollect any events from before their third birthday ('infantile amnesia'). There are several accounts as to the source of this mnemonic deficit, each placing emphasis on impairments of specific processes (encoding, consolidation, retrieval). However, a general weakness in the study of memory ontogeny is the lack of neural data describing the activity of memory-related circuits during development. To directly address this knowledge gap, we propose to study the ontogeny of brain-wide hippocampus-centred memory networks in the rat. We will study to which extent memory expression relies on spatial signalling, delineate the role of sleep in memory consolidation, determine how hippocampal planning-related neuronal activity influences memory processing, understand whether the rapid forgetting observed in development is due to interference, and explore interactions between the hippocampus, pre-frontal and striatal circuits in orchestrating memory emergence. We are best placed to deliver this ambitious experimental plan due to our extensive experience of in vivo recording in developing rats which we will couple with the application of recently emerged technologies (2-photon imaging, high density electrophysiology, chemogenetic manipulation of neural activity). As our studies of the development of hippocampal spatial representations have delivered powerful insights into their adult function, we expect the work outlined here to critically advance our understanding not only of development, but also of healthy memory processing in adulthood.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819814	**RememberEx**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. BRYAN STRANGE**
Host Institution: Universidad Politecnica De Madrid, ES

Human Subcortical-Cortical Circuit Dynamics for Remembering the Exceptional

Our memory system is optimised for remembering the exceptional over the mundane. We remember better those events that violate predictions generated by the prevailing context, particularly because of surprise or emotional impact. Understanding how we form and retrieve long-term memories for important or salient events is critical for combating the rapidly growing incidence of pathologies associated with memory dysfunction with huge socio-econonomic burden. Human lesion and non-invasive functional imaging data, motivated by findings from animal models, have identified subcortical structures that are critical for upregulating hippocampal function during salient event memory. However, mechanistic understanding of these processes in humans remains scarce, and requires better experimental approaches such as direct intracranial recordings from, and focal electrical stimulation of, these subcortical structures.

This project will characterise human subcortico-cortical neuronal circuit dynamics associated with enhanced episodic memory for salient stimuli by studying direct recordings from human hippocampus, amygdala, nucleus accumbens, ventral midbrain and cortex. Within this framework, I will elucidate the electrophysiological mechanisms underlying amygdala-hippocampal-cortical coupling that lead to better memory for emotional stimuli, extend the hippocampal role in detecting unpredicted stimuli to define its role in orchestrating cortical dynamics in unpredictable contexts, and discover the neuronal response profile of the human mesolimbic dopamine system during salient stimulus encoding. The predicted results, based on my own preliminary data, will offer several conceptual breakthroughs, particularly regarding hippocampal function and the role of dopaminergic ventral midbrain in memory. The knowledge gained from this project is a fundamental requirement for designing therapeutic interventions for patients with memory deficits and other neuropsychiatric disorders.

Project End Date: **30-APR-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833964	**REPLAY_DMN**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. FRANCESCO BATTAGLIA**
Host Institution: Stichting Katholieke Universiteit, NL

A theory of global memory systems

Spontaneous activity accounts for most of what the brain does and is likely to be key for information processing in the brain, but its function is still quite mysterious. Two key spontaneous activity processes are the Default Mode Network, a set of areas that are most markedly connected and active during behavioural idleness, and memory replay, the spontaneous reactivation of neural patterns occurring during experience.

I will test the hypothesis that the DMN plays a key role in memory replay processes. This theory, if confirmed, would bring important conceptual advances: to memory studies, as it would provide a mechanism supporting the formation and consolidation of complex memory representations. To the Default Mode Network field, as replay can be used as the “Rosetta Stone” to decipher the computations the DMN performs, moving beyond the connectivity, dynamics, and cognitive correlates, typical focus of DMN research.

I will explore this theory by an experimental study of spontaneous neural activity over the whole mouse cortex, going from large field-of-view 2-photon imaging and high-volume electrophysiology for the single neuron scale, to voltage sensitive imaging and electrocorticography, to resting state fMRI, in animals running memory tasks.

I will characterize the network dynamics and the encoding and replay of memories by quantifying conveyed information and assessing its nature (e.g. about simple percepts vs. complex events, remote vs. memories). I will also measure critical behaviour in these networks, and test whether neuronal avalanches, that occur in spontaneous activity, play a role in conveying information across distant brain areas.

I will model the consequences of these mechanisms for computation by formulating a machine learning based model of memory formation and consolidation, endowing a deep network with critical properties and memory replay.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
834682	**CELLPHASE_AD**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. BART DE STROOPER**
Host Institution: Vib, BE

Genetics to understand cellular components of Alzheimer Disease pathogenesis

Alzheimer disease (AD) is a major health problem worldwide. New therapies require an accelerated translation of genetic information into mechanistic insights. Given limitations of rodent models, fully humanized models are needed to capture the complexity of the disease process.
Human stem cells (iPS) provide great possibilities but are largely investigated in vitro with associated limitations. Many of the novel genetic risk factors for AD are expressed in microglia and astroglia, which remains an understudied population in this classically neuron-centric field. We propose here mouse-human chimeric mouse models to test the effects of AD-associated genetic risk factors on the phenotypes of transplanted microglia and astroglia derived from patients and from genomic engineered, isogenic stem cells. The cells will be followed during disease progression in brain of wild type and of mice developing Aβ- and Tau- pathology. Using single cell transcriptomics, a dynamic view of the cell states over time is generated. In a first arm of the project, we investigate how the genetic makeup of patient derived stem cells with high and low polygenic risk scores influences pathological cell states. In the second arm of the project, we generate inducible Crisper/CAS9 iPS isogenic cell lines to manipulate rapidly and specifically the expression of 4 selected AD associated genes linked to a putative cholesterol pathway but also affecting inflammation. These cell lines will be used also in the second phase of the project when validating hypotheses generated from the extensive bioinformatics analysis of the 600.000 single human cell profiles generated. We expect to identify and validate >5 novel drug targets in the astroglia-microglia axis of AD pathogenesis.
Our work provides humanized models for AD, an answer on how genetic makeup affects microglia and astroglia in an AD relevant context, and establishes a highly versatile platform to explore human genetics in human cells in vivo.

Project End Date: **31-OCT-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850820	**SynLink**	**LS5** Neurosciences and Neural Disorders

Principal Investigator:	**Dr. JONATHAN ELEGHEERT**
Host Institution:	Centre National De La Recherche Scientifique, FR

Molecular Structure and Engineering of Synaptic Organizer Proteins in Health and Disease

Synapses are the specialized cellular junctions that form the basic units of communication between neuronal cells. Given the variety of network-dependent functions that synapses need to support, a fundamental question is how their properties are specified at the molecular level. Membrane-anchored and soluble “synaptic organizer proteins” form adhesive interactions that mediate synapse formation and differentiation. However, a structural and mechanistic understanding of how they recruit and organize the molecular machinery for neurotransmission is largely lacking. Simultaneously, dysfunction of synapses and loss of neurons are hallmarks of neurodegenerative disease that underlie a persistent deterioration of cognitive functions. The properties of synaptic organizer proteins to form and functionalize synapses could be exploited as a mechanism for synaptic repair to reverse neuronal degeneration.

The aims of this proposal are (i) to reveal the structural basis for trans-synaptic molecular nanocolumn formation by determining the complex structures of synaptic organizer proteins and neurotransmitter receptors, and (ii) to leverage insights into the structure and function of soluble synaptic organizers for generating engineered variants that can remodel synapses with the potential for restoring neuronal circuitry and cognition in animal models of Alzheimer’s disease (AD), the most common form of dementia associated with early defects in synaptic function.

To achieve these aims, I will combine techniques of structural biology (X-ray crystallography, cryo-electron microscopy and biophysical interaction analysis), protein engineering (combinatorial screening using yeast surface display), and cellular neuroscience (neuronal culture, electrophysiology, advanced imaging and mouse models). Our results will elucidate fundamental principles of synaptic signalling and pave the way for disease-modifying therapies that focus on recovery of synaptic connectivity and function.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852086	**AGEMEC**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. JEROME MERTENS**
Host Institution: Universitaet Innsbruck, AT

Age-dependent mechanisms of sporadic Alzheimer's Disease in patient-derived neurons

Sporadic Alzheimer's Disease (AD) accounts for the overwhelming majority of all AD cases and exclusively affects people at old age. However, mechanistic links between aging and AD pathology remain elusive. We recently discovered that in contrast to iPSC models, direct conversion of human fibroblasts into induced neurons (iNs) preserves signatures of aging, and we have started to develop a patient-based iN model system for AD. Our preliminary data suggests that AD iNs show a neuronal but de-differentiated transcriptome signature. In this project, we first combine cellular neuroscience assays and epigenetic landscape profiling to understand how neurons in AD fail to maintain their fully mature differentiated state, which might be key in permitting disease development. Next, using metabolome analysis including mass spec metabolite assessment, we explore a profound metabolic switch in AD iNs that shows surprisingly many aspects of aerobic glycolysis observed also in cancer. While this link might represent an interesting connection between two age-dependent and de-differentiation-associated diseases, it also opens new avenues to harness knowledge from the cancer field to better understand sporadic AD. We further focus on identifying and manipulating key metabolic regulators that appear to malfunction in an age-dependent manner, with the ultimate goal to define potential targets and treatment strategies. Finally, we will focus on early AD mechanisms by extending our model to mild cognitive impairment (MCI) patients. An agnostic transcriptome and epigenetic landscape approach of glutamatergic and serotonergic iNs will help to determine the earliest and probably most treatable disease mechanisms of AD, and to better understand the contribution of neuropsychiatric risk factors. We anticipate that this project will help to illuminate the mechanistic interface of cellular aging and the development of AD, and help to define new strategies for AD.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852173	**PRYSM**	**LS5** Neurosciences and Neural Disorders

Principal Investigator:	**Dr. YNTE RUIGROK**
Host Institution:	Universitair Medisch Centrum Utrecht, NL

Early recognition of intracranial aneurysms to PRevent aneurYSMal subarachnoid hemorrhage

Intracranial aneurysms usually go undetected until rupture occurs leading to aneurysmal subarachnoid hemorrhage (ASAH), a type of stroke with devastating effects. Early detection and preventive treatment of aneurysms fall short as we do not know who is it at risk and why, as we have insufficient insight in the contribution and interplay of genetic, environmental and intermediate phenotypic risk factors. Given the rarity of the disease, there is a paucity of large and rich cohorts to study risk factors separately with sufficient power. To add to the problem, my preliminary findings suggest disease heterogeneity with subgroup specific risk factors for aneurysms. The sex-related heterogeneity is most eminent in the disease with 2/3 of patients being women. I aim to advance disease understanding to allow early recognition of intracranial aneurysms to prevent ASAH.
I have established a new conceptual approach that integrates genetic and environmental risk factors with imaging markers as intermediate phenotypes for genetic factors. With data reduction and machine-learning approaches I will for the first time address disease heterogeneity and aneurysm risk with adequate power. I will develop and validate a tool to automatically detect new imaging markers predicting aneurysm development applying feature-learning models. Next I will elucidate the genetic basis underlying differential imaging risk patterns (imaging genetic factors). I will apply a new hypothesis-free strategy to detect and validate yet unknown environmental risk factors predicting aneurysm presence. I will assess the contribution to disease of all factors detected according to sex. All risk factors will be combined in an aneurysm prediction risk model to understand relative contribution of different risk factors in different subgroups. It will advance disease understanding and individualized risk prediction of aneurysms leading to precision medicine in early aneurysm detection to reduce the burden of ASAH.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852869	**CN Identity**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. ZHENYU GAO**
Host Institution: Erasmus Universitair Medisch Centrum Rotterdam, NL

Comprehensive anatomical, genetic and functional identification of cerebellar nuclei neurons and their roles in sensorimotor tasks

How does the brain integrate diverse sensory inputs and generate appropriate motor commands? Our cerebellum is a key region for such a sensorimotor processing, empowered by its sophisticated neural computation and constant communication with other brain regions. The well-timed cerebellar information is integrated and funneled to other brain regions through the cerebellar nuclei (CN). Yet, how CN circuitry contributes to the cerebellar control of sensorimotor processing is unclear. My recent work indicates that the CN activity serves various functions ranging from the online motor control, the amplitude amplification of cerebellar outputs to the control of motor planning. Given these advances, I am now in a unique position to decipher the properties of CN neurons and identify their specific roles in different forms of sensorimotor processing. It is my central hypothesis that depending on the specific demands of the task, CN neurons can either facilitate or suppress the activity of downstream regions with millisecond precision; and the anatomical, genetic and functional properties of CN neurons are tailored to the particular task involved. To test this hypothesis, I will 1) identify the activity patterns of different CN modules during the acquisition and execution of two sensorimotor tasks and characterize the relevant extra-cerebellar inputs to these modules; 2) identify the connectivity-transcription logic of different CN modules and link them to their task-specific outputs; and 3) examine the impacts of manipulating anatomically and/or genetically defined CN neurons on the downstream regions during different sensorimotor tasks. I will accomplish these key objectives by developing various novel electrophysiological, optogenetic, molecular and imaging techniques. My research is likely to break new ground, demonstrating that the identity of CN neurons is determined by their differential temporal demands of sensorimotor tasks controlled by different brain structures.

Project End Date: **31-OCT-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
853251	**ONACSA**	**LS5** Neurosciences and Neural Disorders

Principal Investigator:	**Dr. SAMUEL WASS**
Host Institution:	University Of East London, UK

Oscillatory neural and autonomic correlates of social attunedness during early life: new mechanistic insights into how we learn to learn from one another

We are a social species. Most infants, and young children, spend the majority of their early waking lives in the company of others. But, for practical reasons, almost everything that we know about how the brain subserves early attention and learning comes from studies that examined brain function in one individual at a time. This means that we understand lots about how children attend and learn from information presented while they are alone, viewing a computer screen - but little about how attention is shared between people during social interaction. ONASCA will develop new techniques to look, for the first time, at how two brains dynamically interact with one another during early learning exchanges. The project will determine how children's active, participatory bids during learning lead to reactive changes in both members of the dyad – and how these changes, in turn, influence both partners' subsequent attention, and learning. It will also determine how, and why, some infants, and some parents, show greater sensitivity during social exchanges than others. And, using targeted interventions, it will investigate whether social sensitivity can be improved. The question of how two brains dynamically influence one another during learning exchanges has been described as the 'dark matter' of social neuroscience. Yet nobody has looked at these questions before from the perspective of early learning. Our results may help us to move beyond viewing children primarily as passive recipients of information during learning exchanges, to a perspective that better appreciates children's role as active participants in learning. Our findings may also have practical implications for educationalists, and clinicians.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
853413	**ExpectBG**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. MARCUS STEPHENSON-JONES**
Host Institution: University College London, UK

Elucidating the Basal Ganglia Circuits for Reward Expectation

Predicting future outcomes is fundamental for adaptive behaviour. Reward-predicting stimuli evoke a state of expectation, which informs motivation, guides attention, and drives preparatory motor behaviour. Reward expectations are crucial for learning since they serve as a comparison to actual outcomes. This comparison allows animals to determine if there is a prediction error (i.e. if an outcome was better or worse than expected). Even though reward expectation signals are observed in many areas of the brain how they are computed remains unknown. The main reason for lack of progress is the absence of a clear understanding of where expectation is generated and which circuits are involved in its computation. Consequently, we are missing the prerequisite knowledge for determining where reward expectation arises, how it is computed, and how expectations are learnt. We hypothesize, based on preliminary data and prior literature, that specific circuits within the basal ganglia are crucial for computing reward expectation. We will utilize cutting edge viral methods, combined with electrophysiological recordings and calcium imaging techniques, to identify the specific circuits and cell-types within the basal ganglia nuclei that compute reward expectation. The causal role these identified circuits play in learning will be determined using cell-type specific manipulations in mice performing reinforcement learning tasks. Finally, we will pioneer approaches to manipulate elements of the basal ganglia circuit, while simultaneously recording from specific cell types in the ventral tegmental area, that are involved in computing reward prediction error. Together, this work will uncover how specific basal ganglia cell types causally contribute to the computation of reward expectation and the calculation of reward prediction error. This will provide a foundation for understating how reward expectation influences adaptive behaviour and is perturbed in psychiatric disease.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864552	**SocialNAc**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. CAMILLA BELLONE**
Host Institution: Universite De Geneve, CH

Circuit and synaptic plasticity mechanisms of approach and avoidance social behavior.

Social behavior is defined as any modality of communication and interaction between two or more conspecifics. These behaviors, which include affiliative and antagonistic interactions, are exhibited by all sexually reproducing species, they are characterized by high-level complexity of communication through multiple sensory modalities and they are essential for survival. Humans and other animals living in groups continuously experience situations in which they need to select appropriate behavioral responses upon exposure to conspecifics. At the very basis of this social behavior, an individual needs to decide for example whether to approach (positive or appetitive) or avoid (negative or aversive) other individuals. Here, using mice, we will investigate the brain circuits and synaptic mechanisms involved in conspecific approach and avoidance behavior. The Nucleus Accumbens (NAc) is a key region of the mesocorticolimbic circuits for evaluating appetitive and aversive information. Recent studies have revealed the importance of NAc in social behavior, but which neurons within this structure are relevant and how they contribute to conspecific interaction is largely unknown. We hypothesize that different populations of neurons within the NAc orchestrate and integrate different types of socially relevant information to initiate the appropriate behavioral response. Using in vivo and ex vivo recordings and circuit-specific optogenetic manipulations in specific social interaction conditions, we will investigate how the NAc integrates information about conspecifics and how it incorporates learned associations to initiate conspecific approach or avoidance. This study will thus identify and functionally characterize the circuit and synaptic mechanisms controlling socially appetitive and aversive stimuli, and hence pave the way for a causal understanding of the processes underlying disruption of complex social behaviors in psychiatric disorders.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864912	**EscapeVector**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. TIAGO BRANCO**
Host Institution: University College London, UK

Circuit and cellular mechanisms for computing spatial vectors to shelter during escape

Executing actions that move the body across space to reach goals is a task that animals constantly perform. In some cases, the goal is within direct reach of sensory systems, but in others the goal location has to be retrieved from memory and requires moving towards to a memorised point in space. Previous work has identified neural circuits that represent space, and devised models for transforming object-centred spatial representations into body-centred coordinates, but we do not know the mechanisms by which actions are computed to reach memorised locations. Our goal is to uncover these mechanisms, by investigating instinctive escape to shelter in mice. Recent work has shown that escape to shelter is a goal-directed action that relies on memory of the shelter location, and which is controlled by a midbrain defensive circuit encompassing the superior colliculus and the periaqueductal gray. These circuit nodes can elicit the entire flight sequence to shelter, providing a unique entry point for investigating how spatial representations are converted into goal-directed actions. We aim to explain at the cellular and circuit level how the spatial vector to the shelter is encoded and transformed into shelter-directed flight actions.

Our experimental strategy is to use loss-of-function approaches to identify circuit nodes that project to the superior colliculus and are necessary for escaping to the correct location, and perform neural activity recordings with high-density silicon probes and calcium imaging to determine how the spatial vector to the shelter is encoded and transferred to midbrain effector circuits. At the single neuron level, we will use whole-cell recordings to investigate connectivity and the biophysics of synaptic integration in circuits controlling the execution of flight. The results from this project will produce mechanistic models of how neurons encode information about a goal in space, and compute appropriate motor actions to reach the goal.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865157	**MyeRIBO**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. ASHWIN WOODHOO**
Host Institution: Asociacion Centro De Investigacion Cooperativa En Biociencias, ES

Deconstructing the Translational Control of Myelination by Specialized Ribosomes

The myelin sheath is essential for neuronal function and health: myelinating glial cells speed up propagation of axonal potentials, fuel the energetic demands and regulate the ionic environment of neurons. Lesions to the myelin sheath thus result in devastating neurological disorders that include multiple sclerosis, diabetic neuropathy and Charcot-Marie-Tooth disease. Myelination involves a striking expansion of the glial cell membrane that relies on an exceptional increase in protein and lipid synthesis rates. Decades of dedicated research has uncovered a complex transcriptional program that drives this process, whereas translational control mechanisms, on the other hand, have received little attention. There is emerging evidence, enabled by modern techniques, that ribosomes, typically viewed as invariant, passive molecular machines, may instead be heterogeneous in composition, with particular ribosomal components having a 'specialized' regulatory capacity for preferential translation of specific mRNAs. In MyeRIBO, I propose that translation control by specialized ribosomes is a novel layer of regulation that shapes the proteome of the myelinating glial cell. I will exploit advances in cryo-EM and quantitative proteomics analyses to discover the nature and diversity of ribosomes in myelinating cells, employ genome-wide ribosome profiling to obtain mechanistic insights into selective mRNA translation by heterogeneous ribosomes, and generate genetic mouse models to determine the functional consequences of this specialization for myelination in vivo. Notably, I will study the implication of this mechanism in pathogenesis of injury-induced demyelination and diabetic neuropathy, and evaluate the targeting of specialized ribosomal components as a preclinical strategy. MyeRIBO will push further the boundaries of our current understanding of the molecular control of myelination, which could have a profound impact for understanding neural development and myelin disorders.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865592	**GliomaSignals**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. GILLES HUBERFELD**
Host Institution: Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

Oncometabolitic control of tumor growth and epileptogenesis in IDH mutated gliomas: D2HG signaling mechanism.

Dysregulated growth processes of gliomas interact with pro-epileptic plasticity of brain circuits in such a way that the excitatory transmitter glutamate promotes autocrine tumor invasion as well as epileptic synchrony in surrounding cortical regions. Most low-grade gliomas are associated with mutations of Isocitrate DesHydrogenase (IDH) genes which lead to an excess of the oncometabolite D-2-Hydroxyglutarate (D2HG). With a structure mimicking glutamate, D2HG is thought to participate in both epileptogenic and oncologic processes. Importantly, while epileptic activity is accentuated, tumor prognosis is improved in affected people. My preliminary data now suggest a dual function for D2HG, acting as a glutamatergic agonist at high levels, but as an antagonist in the presence of glutamate. Solving this paradox will be a step forward in glioma science. The GliomasSignals project will examine the role of D2HG in the neurobiology of gliomas bringing electrophysiology concepts and tools to neuro-oncology, seeking to transform our understanding. It seeks to better understand how D2HG modulates glutamatergic signaling, affects neuronal excitability and tumor growth, and to detect the extent to which tumor infiltration colocalizes with epileptic remodeling. In vivo and in vitro work mostly on human tissue will aim at: 1- Map biomarkers of epileptic activity / tumor infiltration by cortical recordings during surgery using unique next generation Neurogrid electrodes. 2- Correlate D2HG levels, glutamate concentrations and tumor infiltration with recordings in peritumoral cortex at an unprecedented resolution. 3- Identify D2HG effects on glutamate signaling in human tissue slices producing epileptic activities and in a rodent model. 4- Explore D2HG long-term effects on epileptic activity and tumor growth / infiltration in co-cultures of tumors with surrounding peritumoral cortex by exploiting our unique capabilities for long-term human cortex organotypic cultures.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865617	**CELPRED**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. GEORG KELLER**
Host Institution: Friedrich Miescher Institute For Biomedical Research Fondation, CH

Circuit elements of the cortical circuit for predictive processing

One promising theoretical framework to explain the function of cortex is predictive processing. It postulates that cortex functions by maintaining an internal model, or internal representation, of the world through a comparison of predictions based on this internal model with incoming sensory information. Implementing predictive processing in a cortical circuit would require a set of distinct functional cell types. These would include neurons that compute a difference between top-down predictions and bottom-up input, referred to as prediction error neurons, and a separate population of neurons that integrate the output of prediction error neurons to maintain an internal representation of the world. This research proposal will test the framework of predictive processing and identify different putative circuit elements and cell types that are thought to form the circuit in mouse visual cortex. We will use a combination of physiological recordings, optogenetic manipulations of neural activity, and gene expression measurements to determine the cell types that have functional responses consistent with different prediction errors, as well as those coding for the internal representation. Identifying the circuit elements underlying predictive processing in cortex may reveal a strategy to bias processing either towards top-down or bottom-up drive when the balance between the two is perturbed, as may be the case in neuropsychiatric disorders.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865618	**MicroSynCom**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. MARTIN FUHRMANN**
Host Institution: Deutsches Zentrum Fuer Neurodegenerative Erkrankungen Ev, DE

Mechanisms of Microglia Synapse Communication

Microglia are the resident tissue macrophages of the brain and represent cells of the innate immune system. Looking at microglia from the immunological perspective, much is known about their role during inflammatory processes, factors that activate them and how they response e.g by releasing cytokines to mount an inflammatory response. This response has been shown to be detrimental during disease processes and lead to pruning/loss of synapses, a task microglia carry out also during development. Although microglia obviously play an important role in synaptic pruning and loss, it remains an open question, whether microglia are involved in the process of synapse formation under physiologic conditions. Therefore, the main hypothesis of MicroSynCom is that microglia represent the mediator of synapse formation or linker between pre- and post-synapse: sensing neurotransmitter release at highly active pre-synaptic sites and actively orchestrating the formation of new spines from the dendrite. I propose to investigate and reveal the underlying mechanisms of this tripartite microglia synapse communication process. Therefore, we will use two-photon stimulated emission depletion microscopy (2P-STED), novel viral and genetically encoded sensors for neurotransmitters, as well as optogenetic and chemogenetic manipulation tools. These methods will be combined with behavior test in freely moving, but also head-fixed mice to visualize microglia mediated synapse formation in awake mice. This will allow us for the first time to visualize, investigate and reveal the mechanisms establishing this novel role of microglia as the mediator of synapse formation in life animals and relate it to physiologically relevant neuronal network rewiring.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
884281	**SynapseBuild**	**LS5** Neurosciences and Neural Disorders

Principal Investigator:	**Dr. VOLKER HAUCKE**
Host Institution:	Forschungsverbund Berlin Ev, DE

Mechanisms of Presynaptic Biogenesis and Dynamic Remodeling

Our ability to move, to process sensory information or to form, store and retrieve memories crucially depends on the function of neuronal synapses. Synapses comprise a presynaptic compartment harboring the machinery for neurotransmitter release and an associated postsynaptic compartment that processes the neurotransmitter signal. During decades of research we have acquired a wealth of knowledge regarding the mechanisms of neurotransmitter release and information processing in the postsynaptic compartment. In great contrast, we know surprisingly little about the pathways that direct the formation, transport, and assembly of the complex molecular machines that make up a functional presynapse. In particular, it is unclear where and how synaptic vesicle (SV) precursors are formed in the neuronal cell body, in which form they are transported along the axon, and which maturation steps occur to allow their assembly into functional units for neurotransmitter release. How cytoplasmically synthesized presynaptic active zone (AZ) proteins that organize SV release sites are transported and assembled is equally unclear. Here, we combine genome engineering in stem cell-derived neurons and genetically altered mice with proteomic, high-resolution imaging and systems biology approaches to identify the origin and composition of SV and AZ precursors, dissect the mechanisms of their axonal transport and integration into developing synapses and unravel the pathway that controls axonal transport and presynaptic assembly of newly made SV and AZ proteins to set synaptic weight. Our high risk/ high gain studies will yield groundbreaking insights into the mechanisms that mediate the formation, maintenance, and dynamic remodeling of the presynaptic compartment during development and thereby fill a crucial knowledge gap in neuroscience. Furthermore, they may pave the way for the future development of therapeutics to cure nerve injury or neurological disorders linked to synapse dysfunction.

Project End Date: **31-OCT-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
885069	**SYNAPTOME**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. SETH GRANT**
Host Institution: The University Of Edinburgh, UK

Synaptome architecture of the single neuron

Synapses participate in all our thoughts and actions and are damaged in over 100 genetic brain disorders. Synapses are the hallmark of brain complexity, being present in vast numbers and containing thousands of different proteins. Unravelling this complexity to get at the functional logic embedded within is a major challenge in neuroscience. We recently characterised excitatory synapse molecular diversity across the whole mammalian brain, revealing a remarkable 3D organisation of synapse types across the different regions – the 'synaptome architecture'. This architecture is reorganised in genetic diseases, is important in structural and functional connectivity across the brain, and provides a mechanism for the storage and recall of information. But what of the fundamental, functional cellular building block of this architecture – the single neuron and its dendritic tree? Crucially, very little is known about the distribution of synapse types on individual neurons and what this actually means for brain function. The overarching goal of SYNAPTOME is to define single-neuron synaptome architecture (SNSA). We will develop new genetic labelling and computational approaches to systematically map SNSA in the mouse brain. We will identify the SNSA of specific functional types of neurons and determine whether neurons share a canonical SNSA. We will reveal how the SNSA is built during development and how it is relevant to the connections between neurons and their physiological properties and functional output. We will ask if the SNSA can direct us to the specific synapses damaged in genetic disorders. These studies will uncover fundamental design principles inherent in the building blocks of the brain that link genome, proteome and synaptome with the architecture and function of individual neurons and their organisation into brain-wide networks. The new tools, resources and knowledge that SYNAPTOME will bring will have wide application in neuroscience and disease research.

Project End Date: **31-JUL-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715182	**Baby DCs**	**LS6** Immunity and Infection

Principal Investigator: **Dr. BARBARA SCHRAML**
Host Institution: Ludwig-Maximilians-Universitaet Muenchen, DE

Age-dependent Regulation of Dendritic Cell Development and Function

Early life immune balance is essential for survival and establishment of healthy immunity in later life. We aim to define how age-dependent regulation of dendritic cell (DC) development contributes to this crucial immune balance. DCs are versatile controllers of immunity that in neonates are qualitatively distinct from adults. Why such age-dependent differences exist is unclear but newborn DCs are considered underdeveloped and functionally immature.

Using ontogenetic tracing of conventional DC precursors, I have found a previously unappreciated developmental heterogeneity of DCs that is particularly prominent in young mice. Preliminary data indicate that distinct waves of DC poiesis contribute to the functional differences between neonatal and adult DCs. I hypothesize that the neonatal DC compartment is not immature but rather that DC poiesis is developmentally regulated to create essential age-dependent immune balance. Further, I have identified a unique situation in early life to address a fundamental biological question, namely to what extent cellular function is pre-programmed by developmental origin (nature) versus environmental factors (nurture).

In this proposal, we will first use novel models to fate map the origin of the DC compartment with age. We will then define to what extent cellular origin determines age-dependent functions of DCs in immunity. Using innovative comparative gene expression profiling and integrative epigenomic analysis the cell intrinsic mechanisms regulating the age-dependent functions of DCs will be characterized. Because environmental factors in utero and after birth critically influence immune balance, we will finally define the impact of maternal infection and metabolic disease, as well as early microbial encounter on DC poiesis. Characterizing how developmentally regulated DC poiesis shapes the unique features of early life immunity will provide novel insights into immune development that are vital to advance vaccine strategies.

Project End Date: **31-MAY-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716718	**ALLERGUT**	**LS6** Immunity and Infection

Principal Investigator:	**Dr. CASPAR OHNMACHT**
Host Institution:	Helmholtz Zentrum Muenchen Deutsches Forschungszentrum Fuer Gesundheit Und Umwelt Gmbh, DE

Mucosal Tolerance and Allergic Predisposition: Does it all start in the gut?

Currently, more than 30% of all Europeans suffer from one or more allergic disorder but treatment is still mostly symptomatic due to a lack of understanding the underlying causality. Allergies are caused by type 2 immune responses triggered by recognition of harmless antigens. Both genetic and environmental factors have been proposed to favour allergic predisposition and both factors have a huge impact on the symbiotic microbiota and the intestinal immune system. Recently we and others showed that the transcription factor ROR(γt) seems to play a key role in mucosal tolerance in the gut and also regulates intestinal type 2 immune responses.
Based on these results I postulate two major events in the gut for the development of an allergy in the lifetime of an individual: First, a failure to establish mucosal tolerance or anergy constitutes a necessity for the outbreak of allergic symptoms and allergic disease. Second, a certain 'core' microbiome or pathway of the intestinal microbiota predispose certain individuals for the later development of allergic disorders. Therefore, I will address the following aims:
1) Influence of ROR(γt) on mucosal tolerance induction and allergic disorders
2) Elucidate the T cell receptor repertoire of intestinal Th2 and ROR(γt)+ Tregs and assess the role of alternative NFκB pathway for induction of mucosal tolerance
3) Identification of 'core' microbiome signatures or metabolic pathways that favour allergic predisposition

ALLERGUT will provide ground-breaking knowledge on molecular mechanisms of the failure of mucosal tolerance in the gut and will prove if the resident ROR(γt)+ T(reg) cells can function as a mechanistic starting point for molecular intervention strategies on the background of the hygiene hypothesis. The vision of ALLERGUT is to diagnose mucosal disbalance, prevent and treat allergic disorders even before outbreak and thereby promote Public Health initiative for better living.

Project End Date: **30-JUN-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757743	**MalPar.NET**	**LS6** Immunity and Infection

Principal Investigator: **Dr. NETA REGEV-RUDZKI**
Host Institution: Weizmann Institute Of Science, IL

Malaria Parasite Networking: Discovering Modes of Cell-Cell Communication

Malaria, caused by Plasmodium falciparum, is a devastating parasitic disease effecting hundreds of millions of people worldwide. The parasite's transmission cycle between humans and mosquitoes involves a remarkable series of morphological transformations. While it is clear that, for such a complex journey, the parasites must develop means to sense their host and coordinate their actions; these modes of communication remain one of the greatest mysteries in malaria biology. In fact, since an individual parasite is enclosed by three membranes inside its human host, the red blood cell (RBC), they were not thought to possess any communication ability. However, we discovered that these parasites, despite the multiple barriers, are able to communicate and exchange episomal genes by releasing exosome-like vesicles, thereby opening the exciting new field of malaria parasite communication. Our initial data demonstrate that these vesicles serve as a secure tool for the delivery of remarkable components.

The overarching goal of this proposal is to take an innovative look at this under-investigated area of parasite sensing and signalling pathways and to decipher the multiple layers of parasite and host signalling networks. Specifically, we will determine the biological roles of Plasmodium exosome cargo components in: parasite-parasite communication - exploring parasite coordination traits in cell-density growth and sexual development (Objective 1); and parasite-host communication - unravelling the mutual communication of the parasite and its hosts, the red blood and immune cells (Objective 2). Simultaneously, we will exploit our experience in cell communication research to investigate the complementary, yet-to-be-explored mode of parasite communication via the secretion of small molecules (Objective 3).

Our project will provide a holistic view of parasite communication networking while potentially providing, in the long term, novel targets for malaria therapeutics.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
773153	**IMMUNO-PEPTALK**	**LS6** Immunity and Infection

Principal Investigator: **Dr. CYRIL ZIPFEL**
Host Institution: Universitaet Zuerich, CH

Regulation of plant receptor kinase-mediated immunity by endogenous peptides and their receptors

Plant receptor kinases are major pattern recognition receptors (PRRs) that function as part of dynamic multimeric complexes to perceive pathogen-associated molecular patterns or host-derived damage-associated molecular patterns at the plasma membrane (PM). Our long-term objective is to decipher the molecular basis of plant innate immunity and to understand how plant receptor kinases work.

Our recent findings point to an important role of endogenous peptides in the regulation of plant innate immune signaling. The main aim of this proposal is to understand how these endogenous peptides and their corresponding receptors regulate plant innate immune signaling. The central hypotheses of this research are that: (i) a subset of plant endogenous peptides are perceived by receptor kinases to fine-tune dynamically plant innate immune signaling, and thus act as 'phytocytokines'; (ii) these phytocytokines and their receptors regulate the formation of active immune-signaling nanoclusters at the PM; and (iii) phytocytokine receptors participate in the sensory continuum represented by the plant PM and the cell wall to respond dynamically to environmental challenges.

We will pursue the following specific objectives:

(1) decipher the regulation, function, and perception of RALF peptides by malectin-like receptor kinases during immunity;

(2) elucidate the formation, composition, and function of PM immune receptor nanoclusters;

(3) reveal the function of the receptor kinase MIK2 and its ligand(s) in immunity.

Through a balanced combination of straight-forward and high risk/high gain biochemical, biophysical, bioimaging, and genetics approaches, this project will provide groundbreaking insights into the molecular mechanisms underlying the establishment and regulation of plant innate immune signaling, but also into the general mechanisms that control plant receptor kinase functions and by which the myriad endogenous peptides encoded by plant genomes control environmental sensing.

Project End Date: **31-MAY-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
786602	**ENVISION**	**LS6** Immunity and Infection

Principal Investigator:	**Dr. SØREN RIIS PALUDAN**
Host Institution:	Aarhus Universitet, DK

Novel mechanisms of early defense against virus infections

Virus-induced type I interferons (IFN) have classically been considered to constitute the first line of defense against virus infections However, recent work by us and others has identified early antiviral actions that occur independently of inducible type I and III IFN expression and sometimes even prior to IFN action (e.g. Iversen,...., Paludan. Nature Immunology, 2016; Paludan. Trends in Immunology, 2016). These discoveries challenge the current thinking in the field that IFNs constitute the first line of defense. Hence, there is an urgent need for more detailed understanding of the immediate antiviral defense mechanisms. Most importantly, we remain to identify key players in IFN-independent antiviral responses, we completely lack insight into the mechanisms that govern these responses, and we also lack information on the importance of this layer of defense in mice and humans. In accord with this, my proposal follows four aims: (i) Identification of mechanisms of virus detection at epithelial surfaces, (ii) elucidation of the role of tonic IFN signaling in antiviral defense, (iii) identification and characterization of novel restriction factors, and (iv) deciphering the mechanisms that govern induction of the first wave of IFNs at epithelial surfaces. In addition, I will also explore the interactions between the early antiviral actions. To achieve the goals, I will combine unbiased genome-wide screens with hypothesis-driven approaches, and will integrate molecular biology/genetics/biochemistry with advanced cell culture systems, animal science and analysis of patient material. Strong preliminary data have been generated for all four aims, and world-leading collaborations are in place, hence minimizing the risks, and allowing fast progress. Our findings will (i) change the thinking in innate immunology by uncovering a novel layer of antiviral defense and (ii) provide new avenues for therapeutic modulation of immune responses.

Project End Date: **30-NOV-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788516	**SEXinMALARIA**	**LS6** Immunity and Infection

Principal Investigator:	**Dr. OLIVER BILLKER**
Host Institution:	Umea Universitet, SE

Sex in malaria parasites – from basic biology to targets for transmission blocking interventions.

Sexual development in malaria parasites is critical for disease transmission between infected individuals, and is therefore a major target for the malaria elimination agenda. However, there are currently no effective drugs or vaccines that block parasite transmission to mosquitoes, and we currently do not understand the molecular mechanisms involved. This is primarily because Plasmodium genetics has been slow, with the majority of the genome unexplored. I here propose to conduct the first genome-scale screen for male and/or female fertility genes by leveraging a game-changing genetic system we have developed and recently validated through the first genome-scale in vivo gene KO screen in any parasite. Using simultaneous phenotyping of barcoded mutants, we will conduct the first genome-scale screen for male and/or female fertility genes. My team will systematically map specific biological roles for hundreds of parasite genes, ranging from sex determination to zygote differentiation. We will also overcome the next hurdle in Plasmodium genetics by developing a method for massive parallel phenotyping, using the power of single cell transcriptomics to validate the screen and reveal molecular mechanisms at previously intractable points in the Plasmodium life cycle. This approach has clear translational implications, as it will identify both drug and vaccine candidates. This proposal builds firmly on my outstanding track records in delivering large reverse genetics projects and making ground-breaking discoveries in Plasmodium transmission biology. Its unprecedented breadth and depth will mark a turning point in how gene functions are studied in this important model parasite. I am relocating from the UK to Umeå University, a centre of excellence for pathogen research and innovative genetics, so retaining this important research in the EU of 27 will depend critically on ERC funding.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802773	**MitoGuide**	**LS6** Immunity and Infection

Principal Investigator: **Dr. PING-CHIH HO**
Host Institution: Universite De Lausanne, CH

Integration and adaptation of impaired mitochondrial fitness in orchestrating T cell dysfunction in the tumor microenvironment

Cancer immunotherapies harnessing the tumoricidal activity of tumor-reactive T cells represent a major breakthrough in the current paradigm for treating cancer patents. However, the highly immunosuppressive tumor microenvironments found in solid tumors present challenges by restricting the tumoricidal functions and metabolic fitness of infiltrating tumor-reactive T cells. Given that the activation-induced metabolic switch is tightly intertwined with T cell activities, restoring the metabolic fitness of T cells represents a promising strategy for strengthening anti-tumor immunity. However, the success of this strategy relies on our understanding of the underlying mechanisms utilized by tumor cells to abolish the metabolic fitness of T cells, and of how metabolic programming controls T cell functions. Based on our preliminary results, we postulate that tumor cells disrupt the mitochondrial dynamics of tumor-infiltrating T cells by interrupting mitophagy. This causes a metabolic crisis for the infiltrating T cells in sustaining their metabolic fitness and flexibility. Furthermore, we hypothesize that declined mitochondria-derived retrograde signals resulted from mitochondrial dysfunction may lead to T cell dysfunction/exhaustion and altered immune responses through epigenetic reprogramming and altered proteome-metabolic regulatory circuits. The objectives of this proposal are to delineate how tumor cells influence the mitochondrial dynamics of T cells and define the unexplored immunometabolic regulations of T cell functions that are controlled by mitochondria. Lastly, we aim to new methods to restore missing retrograde signals in T cells, which could allow them to prevent mitochondrial dysfunction-induced epigenetic and transcriptomic changes. This work represents an entirely new perspective on control of T cell functions by the immunosuppressive tumor microenvironment, and it may reveal new dimensions of immunometabolic regulation.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802878	**FunDiT**	**LS6** Immunity and Infection

Principal Investigator: **Dr. ONDREJ STEPANEK**
Host Institution: Ustav Molekularni Genetiky Akademie Ved Ceske Republiky Verejna Vyzkumna Instituce, CZ

Functional Diversity of T cells

T cells have a central role in most adaptive immune responses, including immunity to infection, cancer, and autoimmunity. Increasing evidence shows that even resting steady-state T cells form many different subsets with unique functions. Variable level of self-reactivity and previous antigenic exposure are most likely two major determinants of the T-cell diversity. However, the number, identity, and biological function of steady-state T-cell subsets are still very incompletely understood. Receptors to ligands from TNF and B7 families exhibit variable expression among T-cell subsets and are important regulators of T-cell fate decisions. We hypothesize that pathways triggered by these receptors substantially contribute to the functional diversity of T cells.The FunDiT project uses a set of novel tools to systematically identify steady-state CD8+ T cell subsets and characterize their biological roles. The project has three complementary objectives.

(1) Identification of CD8+ T cell subsets. We will identify subsets based on single cell gene expression profiling. We will determine the role of self and foreign antigens in the formation of these subsets and match corresponding subsets between mice and humans.

(2) Role of particular subsets in the immune response. We will compare antigenic responses of particular subsets using our novel model allowing inducible expression of a defined TCR. The activity of T-cell subsets in three disease models (infection, cancer, autoimmunity) will be characterized.

(3) Characterization of key costimulatory/inhibitory pathways. We will use our novel mass spectrometry-based approach to identify receptors and signaling molecules involved in the signaling by ligands from TNF and B7 families in T cells.

The results will provide understanding of the adaptive immunity in particular disease context and resolve long-standing questions concerning the roles of T-cell diversity in protective immunity and tolerance to healthy tissues and tumors.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802899	**VIRUSES AND RNA**	**LS6** Immunity and Infection

Principal Investigator: **Dr. TROELS KASPER HØYER SCHEEL**
Host Institution: Kobenhavns Universitet, DK

RNA regulation during viral infection

Viral infections are responsible for significant morbidity and mortality and frequency and impact of epidemics are expected to increase. Thorough understanding of basic virology is critical for informed development of prevention and control. Most systematic studies of virus-host interactions have focused on proteins, however, with recent methodological advances the intersecting fields of viral infection and RNA biology hold great promise for basic and therapeutic exploration. The goal of this application therefore is to discover and dissect RNA-based virus-host interactions and related regulatory mechanisms of gene expression.

Micro-RNAs (miRNAs) fine-tune gene expression by repressing mRNA targets. However, cellular miRNAs increase translation and replication of certain viruses. Thus, hepatitis C virus (HCV) critically depends on the liver specific miR-122, which emerged as a therapeutic target. Further, HCV sequesters enough miR-122 to indirectly regulate cellular gene expression. I hypothesize that this RNA-based mechanism contributes to virus induced liver cancer, and aim to address this using our recently developed rodent model for HCV infection (Aim 1). Better understanding of viral RNA (vRNA) interactions could significantly contribute to basic infection biology and novel therapeutics. I therefore aim to systematically identify vRNA interactions with other cellular RNAs and proteins (Aim 2). I expect to identify interactions of value for functional regulation and therapeutic targeting. I finally hypothesize that translation of certain cellular mRNAs – similarly to viruses – increase upon miRNA binding, and aim to systematically screen for such virus-like alternative regulation, with potential to change understanding of post-transcriptional regulation (Aim 3).

In conclusion, this high-risk high-gain project has potential to shape novel dogmas for virus and RNA biology and to identify novel RNA-based therapeutic targets; a promising upcoming field of discovery.

Project End Date: **30-JUN-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803087	**ENTRI**	**LS6** Immunity and Infection

Principal Investigator: **Dr. CHRISTOPH KLOSE**
Host Institution: Charite - Universitaetsmedizin Berlin, DE

Enteric-nervous-system-mediated regulation of intestinal inflammation

Environmental and internal stimuli are constantly sensed by the body's two large sensory units, the nervous system and the immune system. Integration of these sensory signals and translation into effector responses are essential for maintaining body homeostasis. While some of the intrinsic pathways of the immune or nervous system have been investigated, how the two sensory interfaces coordinate their responses remains elusive. We have recently investigated neuro-immune interaction at the mucosa of the intestine, which is densely innervated by the enteric nervous system (ENS). Our research has exposed a previously unrecognized pathway used by enteric neurons to shape type 2 immunity at mucosal barriers. Cholinergic enteric neurons produce the neuropeptide Neuromedin U (NMU) to elicit potent activation of type 2 innate lymphoid cells (ILC2s) via Neuromedin U receptor 1, selectively expressed by ILC2s. Interestingly, NMU stimulated protective immunity against the parasite Nippostrongylus brasiliensis but also triggered allergic lung inflammation. Therefore, the NMU-NMUR1 axis provides an excellent opportunity to study how neurons and immune cells interact to regulate immune responses and maintain body homeostasis. We propose to generate and use elegant genetic tools, which will allow us to systematically investigate the consequences of neuro-immune crosstalk at mucosal surfaces in various disease models. These tools will enable us to selectively measure and interfere with neuronal and ILC2 gene expression and function, thereby leading to an unprecedented understanding of how the components of neuro-immune crosstalk contribute to parasite immunity or allergic disease development. Furthermore, we will progress into translational aspects of NMU-regulated immune activation for human immunology. Therefore, our research has the potential to develop basic concepts of mucosal immune regulation and such discoveries could also be harnessed for therapeutic intervention.

Project End Date: **30-JUN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
805500	**RiboInflam**	**LS6** Immunity and Infection

Principal Investigator: **Dr. EMILIANO RICCI**
Host Institution: Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

Assessing the role of ribosomes and mRNA translation in shaping the inflammatory response

Inflammation is a highly regulated process that acts as a first line of defense against pathogens infections. Triggered by cellular pattern recognition receptors (PRRs) that recognize specific microbial components and endogenous or exogenous non-microbial components, activation of inflammation induces a dynamic and coordinated gene expression program that leads to the production of cytokines and chemokines to attract effector cells to the site of infection. Although a robust inflammatory response is required for efficient clearance of pathogens, uncontrolled or prolonged inflammation can lead to inflammatory disorders such as septic shocks or to autoimmune diseases like lupus.

Most studies have focused so far on the transcriptional control of the inflammatory gene expression program. However, post-transcriptional regulatory mechanisms involving mRNA splicing, mRNA decay or translation have also been described to control the inflammatory response. Among these, regulation of mRNA translation allows for rapid and reversible modulation of gene expression but its precise role and control mechanisms in the inflammatory response remain poorly understood.

Using innovative technologies, our project aims at characterizing the role of ribosomes and mRNA translation in regulating the inflammatory response. In particular, we propose to identify the complete set of of ribosome accessory proteins and to determine their role in the context of “specialized ribosomes” with specific regulatory activities. We will also study the cross-talks between ribosomes and other cellular processes such as mRNA decay and uncover the role of mRNA editing in regulating translation during the inflammatory response.

From this work, we expect to identify new regulatory mechanisms that orchestrate inflammation as well as cellular factors that could represent new therapeutic targets for the design of drugs modulating inflammation.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
817533	**PRinTERs**	**LS6** Immunity and Infection

Principal Investigator: **Dr. MONIKA WOLKERS**
Host Institution: Stichting Sanquin Bloedvoorziening, NL

Post-transcriptional regulation of effector function in T cells by RNA binding proteins

CD8+ T cells are critical to fight infections and to clear tumor cells through the production of inflammatory cytokines and cytotoxic molecules. These effector molecules must be tightly controlled: too little leads to the inability to control the pathogen, and too much can result in a life-threatening cytokine storm and tissue damage. While transcriptional control of effector genes is well-studied, regulation at the levels of RNA stability and translation efficiency by RNA-binding proteins (RBPs) has remained underappreciated. We recently found that several cytokines are tightly regulated through these processes, and we identified ZFP36L2 as one of the responsible RBPs. However, much is still to be learned about the underlying molecular mechanisms. Moreover, there are >1000 putative RBPs, and a systematic analysis of their regulatory activity in T cells is lacking, particularly with regard to the control of effector proteins.

Here, we will use a combination of mouse genetics, and molecular and cellular biology to gain a deep understanding of the control of cytokine production by RBPs, using ZFP36L2 as a paradigm. Next, we will take a novel, highly sensitive proteomics approach to systematically identify the RBP repertoire in resting and activated primary human T cells. Complementary functional screens will identify those RBPs that control specific effectors. Selected RBPs identified in these screens will be studied in-depth to understand their roles in T cell responses to acute infection and in tumor models. Lastly, we will define how RBPs can imprint and/or maintain the killer phenotype of human CD8+ T cells.
This research will significantly advance our understanding of post-transcriptional regulation of T cell effector activity, and it should help us to develop novel tools to drive effective T cell responses against pathogens and malignant cells.

Project End Date: **29-FEB-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819439	**ADIMMUNE**	**LS6** Immunity and Infection

Principal Investigator: **Dr. ERAN ELINAV**
Host Institution: Weizmann Institute Of Science, IL

Decoding interactions between adipose tissue immune cells, metabolic function, and the intestinal microbiome in obesity

Obesity and its metabolic co-morbidities have given rise to a rapidly expanding 'metabolic syndrome' pandemic affecting
hundreds of millions of individuals worldwide. The integrative genetic and environmental causes of the obesity pandemic
remain elusive. White adipose tissue (WAT)-resident immune cells have recently been highlighted as important factors
contributing to metabolic complications. However, a comprehensive understanding of the regulatory circuits governing their
function and the cell type-specific mechanisms by which they contribute to the development of metabolic syndrome is
lacking. Likewise, the gut microbiome has been suggested as a critical regulator of obesity, but the bacterial species and
metabolites that influence WAT inflammation are entirely unknown.
We propose to use our recently developed high-throughput genomic and gnotobiotic tools, integrated with CRISPR-mediated interrogation of gene function, microbial culturomics, and in-vivo metabolic analysis in newly generated mouse models, in order to achieve a new level of molecular understanding of how WAT immune cells integrate environmental cues into their crosstalk with organismal metabolism, and to explore the microbial contributions to the molecular etiology of WAT inflammation in the pathogenesis of diet-induced obesity. Specifically, we aim to (a) decipher the global regulatory landscape and interaction networks of WAT hematopoietic cells at the single-cell level, (b) identify new mediators of WAT immune cell contributions to metabolic homeostasis, and (c) decode how host-microbiome communication shapes the development of WAT inflammation and obesity.
Unraveling the principles of WAT immune cell regulation and their amenability to change by host-microbiota interactions
may lead to a conceptual leap forward in our understandingof metabolic physiology and disease. Concomitantly, it may
generate a platform for microbiome-based personalized therapy against obesity and its complications.

Project End Date: **29-FEB-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834302	**ImmUne**	**LS6** Immunity and Infection

Principal Investigator:	**Dr. THOMAS BOEHM**
Host Institution:	Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Towards identification of the unifying principles of vertebrate adaptive immunity

About 500 million years ago, the two sister groups of vertebrates independently evolved alternative forms of adaptive immunity, representing a striking example of convergent evolution. Whereas the components and functions of the immune system in jawed vertebrates (ranging from sharks to humans) are well characterized, much remains to be learned about adaptive immunity in jawless vertebrates (lampreys and hagfishes). Up to now, progress in understanding immunity in jawless fishes was hampered by their complex life-cycle, long generation time, and the difficulty of raising fish in the laboratory for extended periods, particularly after in vitro fertilization. Based on our recent methodological advances in aquatic husbandry and successful CRISPR/Cas9-mediated genetic modification, we propose to conduct a large-scale analysis of cellular immunity in lampreys laying the foundations for the identification of the unifying principles of vertebrate immunity. Our experiments will address the development and characteristics of different T cell subsets, the molecular basis of antigen receptor assembly, and the function of the two principal T cell lineages during the immune response. We will also examine the structure and function of the stromal microenvironment in the lamprey thymus equivalent, which is considered to be the site of T cell development. A particular focus will be on the functional analysis of a recently discovered MHC-like locus in the context of T cell development, and in the essential self/nonself discrimination mechanism(s) at play during the immune response. We expect that the identification of common design principles of adaptive immunity in vertebrates will provide us with an unprecedented view on immune functions in humans, potentially guiding the development of novel strategies for the treatment of failing immunity in patients with immunodeficiency and/or autoimmunity.

Project End Date: **31-MAY-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
835184	**RetroChrom**	**LS6** Immunity and Infection

Principal Investigator: **Dr. MONSEF BENKIRANE**
Host Institution: Centre National De La Recherche Scientifique, FR

Deciphering the molecular mechanisms of HIV DNA nuclear import and the impact of 3D genome organization on integration site selection

Chromosomes of eukaryotes adopt highly dynamic and complex hierarchical structures in the nucleus. The three-dimensional (3D) organization of chromosomes profoundly affects DNA functions, primarily transcription. During retroviral infection, histone-free viral DNA copy is synthesized from viral genomic RNA. vDNA will ultimately integrate into the host genome to ensure its maintenance and expression. Understanding retrovirus-host interactions at the genomic level, and the peculiar mechanisms by which lentiviruses, including HIV-1, and their related gene transfer vectors, are imported into the nucleus, loaded with nucleosomes, integrate in, and interact with, the human genome will provide valuable information about lentiviral replication and establish the basis for the development of safer and more efficacious lentiviral vectors for human gene therapy. Our objectives are: 1-To identify and characterize cellular proteins associated with the HIV-1 PIC, and determine their roles in nuclear import and/or integration. 2-To explore the role of the epigenome of unintegrated vDNA in HIV-1 gene expression from unintegrated and integrated vDNA. 3- To determine the impact of nuclear organization on integration site selection and on viral and host transcription. State of the art technologies will be applied to achieve these challenging objectives. If successful, this project will make an outstanding contributions not only to the field of HIV biology but also for the development of safe lentiviral vectors for gene therapy.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852452	**Bac2MUC**	**LS6** Immunity and Infection

Principal Investigator: **Dr. KARIN STRIJBIS**
Host Institution: Universiteit Utrecht, NL

Bacteria-mucin interactions – Shaping intestinal epithelial responses in health and disease

The intestinal microbiota consists of beneficial commensal bacteria and pathobionts that cause inflammation. The intestinal mucus layer dictates how specific members of the microbiota affect health and disease. The mucus layer consists of soluble mucins and epithelial transmembrane (TM) mucins that regulate host responses. The molecular mechanisms as to how the intestinal microbiota affect the functions of TM mucins is largely unknown. My recent work shows that TM mucin MUC1 is a key receptor for Salmonella invasion into polarized epithelial cells. We also discovered that MUC13 is a central regulator of epithelial barrier formation. I hypothesize that bacteria-mucin interactions shape epithelial responses by stimulating healthy barrier formation, driving inflammation or mediating bacterial invasion. My aim is to unravel molecular mechanisms via which distinct bacterial species regulate the functions of TM mucins MUC1 and MUC13 in the intestine. The key objectives of Bac2MUC are to: 1. Identify commensal and pathogenic bacteria that target TM mucins 2. Elucidate TM mucin signaling pathways activated by commensal and pathogenic bacteria 3. Determine the function of TM mucins during inflammation and invasion 4. Utilize bacteria-TM mucin interactions to unravel healthy epithelial barrier regulation I will use an innovative large-scale screening platform to identify novel bacteria-mucin interactions. TM mucin signaling pathways during bacterial interaction will be characterized by sortase technology. Cutting-edge technologies such as CRISPR/Cas9 genome editing and advanced microscopy will be applied in established bacterial infection assays with intestinal cell lines and organoids. Bac2MUC is an ambitious and ground-breaking project that will address, for the first time, the complex interplay between intestinal bacteria and TM mucins. This project will contribute to clinical strategies that prevent intestinal inflammation and improve mucosal barrier function.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865466	**REpAIR**	**LS6** Immunity and Infection

Principal Investigator: **Dr. SAMUEL HUBER**
Host Institution: Universitaetsklinikum Hamburg-Eppendorf, DE

Spatio-Temporal Regulation of Inflammation and Tissue Regeneration: Studying the immune system - tissue - microbiota communication to develop targeted therapies for immune-mediated diseases and cancer

Inflammation is fundamental to promote tissue regeneration upon injury, and in turn, the resolution of the immune response. Physiological tissue regeneration depends on fine-tuned interaction between the immune system, the tissue, and the microbiota. However, the complex communication between these three components and the molecules that mediate it are unclear. Understanding this is fundamental to prevent immune-mediated diseases and even cancer. This is particularly important at mucosal surfaces, where continued regeneration occurs. Therefore, we hypothesize that inflammatory bowel disease (IBD) and colorectal cancer (CRC) are a consequence of a miscommunication between these components.

Interleukin-22 (IL-22) is one key orchestrator of this communication: It is produced by immune cells and by acting on intestinal epithelial cells, it modulates the composition of the microbiota and promotes tissue regeneration. However, IL-22 can also promote both chronic inflammation and cancer. Exactly what regulates these paradoxical effects remains unclear. Of note, there is an endogenous inhibitor of IL-22, namely IL-22 binding protein (IL-22BP), which blocks IL-22 activity. We hypothesize that a misguided spatio-temporal regulation of the IL-22 – IL-22BP axis is the cause of pathogenic effects of IL-22.

In particular, we will analyse: (i) the location, and the functional and molecular heterogeneity; (ii) the origin and fate of IL-22 and IL-22BP producing immune cells; and (iii) the role of the microbiota in regulating them. To this end, we will use new transgenic and gnotobiotic mouse models, single cell RNA sequencing and human samples.

In short, by studying the IL-22 - IL-22BP axis, we will understand how the complex interactions between the immune system, the tissue, and the microbiota lead to either physiological or pathological tissue regeneration. This will provide the basis for therapies controlling inflammation and tissue regeneration in a spatio-temporal manner.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866222	**NICHEADAPT**	**LS6** Immunity and Infection

Principal Investigator: **Dr. PAMELA SCHNUPF**
Host Institution: Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

Deciphering the niche adaptations of a gut commensal involved in educating the host immune system

The gut microbiota plays an integral part in driving the postnatal maturation of the gut immune system and in protecting the host from pathogens. The commensal segmented filamentous bacteria (SFB) plays a critical role in these processes through its intimate attachment to the ileal epithelium using a unique pointed tip structure on its unicellular 'infectious' particle. SFB induces a broad pro-inflammatory immune activation, and notably a striking induction of IgA and Th17 cell responses, that fosters pathogen resistance but can also exacerbate disease severity in a number of autoimmune models, making SFB an important microbe in health and disease. SFB is found in many vertebrate species, including humans, and SFB monocolonization has allowed a detail study of its immunostimulatory potential. However, the unique and complex life-cycle of SFB and SFB's interaction with the host has remained poorly understood due to a lack of in vitro culturing techniques. We recently overcame this hurdle by establishing the first in vitro SFB-host cell co-culturing system. Using this system, unicellular SFB were discovered to be flagellated and to stimulate TLR5 signaling, revealing a missing link of immunological importance in the SFB life-cycle. This important developmental stage will now be further characterized and its immunological consequence assessed using gnotobiology. State-of-the-art microscopy techniques will be employed to characterize in detail the SFB life-cycle and novel structures discovered during in vitro growth. Unicellular SFB surface proteins will be identified using mass spectrometry, localized on the bacterium and tested for their ability to mediate host cell attachment. In addition, next generation sequencing and transcriptomics will be used to assess SFB genome evolution and SFB niche constraints. Together, this work will lead to a detailed view of the SFB life-cycle and how SFB has adapted to its unique replicative niche at the epithelial surface.

Project End Date: **31-DEC-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
637830	**Novel asthma therapy**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. OLIVIA MERKEL**
Host Institution: Ludwig-Maximilians-Universitaet Muenchen, DE

Biocompatible nanoparticles for T cell targeted siRNA delivery as novel asthma therapy

The aim of this proposal is to engineer biocompatible nanoparticles that deliver short interfering RNA (siRNA) to activated T cells (ATCs) for the downregulation of the Type 2 T helper cell (Th2) transcription factor GATA-3. By downregulating GATA-3 with siRNA, which regulates the secretion of proinflammatory cytokines in chronic inflammatory diseases such as asthma, the activation of their downstream inflammatory cascades can be prevented. However, T cells are hard-to-transfect cells which are not readily accessible for nucleic acid based therapeutics. I am the first to have demonstrated successful and targeted siRNA delivery to ATCs ex vivo and in vivo for specific GATA-3 knockdown without delivering siRNA to naive T cells. Thus, I can avoid general immune suppression. This was achieved by engineering targeted siRNA delivery systems based on low molecular weight polyethylenimine (LMW-PEI) which form nanoparticles with siRNA and successfully deliver the latter to ATCs. The targeting approach was realized by coupling transferrin to LMW-PEI and by optimizing the coupling chemistry. I have demonstrated specific delivery to ATCs in a mouse model of allergic asthma and have screened siRNA sequences for efficient GATA-3 knockdown. The nanoparticles were administered locally to the lung to prevent the first-pass effect in the liver. The LMW-PEI based nanocarriers were very well tolerated in healthy animals, however, potentially caused additional proinflammatory effects in the asthma model.

Therefore, I will engineer nanocarriers that do not only specifically deliver siRNA to ATCs but are also biocompatible in a diseased state of the lung. I will use oligospermines, which are tetramers and octamers of spermine, an endogenous polyamine, and apply the optimized coupling strategy to target the spermine based nanocarriers to ATCs for therapeutic GATA-3 knockdown. To obtain clinically relevant formulations, I will produce inhalable powders of these nanocarriers.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
671231	**HEPCIR**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator:	**Dr. THOMAS BAUMERT**
Host Institution:	Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

Cell circuits as targets and biomarkers for liver disease and cancer prevention

Chronic liver diseases such as liver cirrhosis and hepatocellular carcinoma (HCC) are major challenges for global health. HCC is the second leading and fastest rising cause of cancer death worldwide. The limited availability of therapeutic options reflects our poor understanding of the molecular and clinical mechanisms involved in progression of liver disease. Chronic hepatitis C virus (HCV) infection is a main risk factor for HCC. Although HCC may be avoided by addressing the underlying cause in early stage disease, strategies to prevent HCC in patients with established cirrhosis and advanced fibrosis, in which the risk of HCC persists despite treatment of the underlying cause are lacking. Indeed, even HCV cure does not eliminate the risk of HCC development when advanced fibrosis is already present. Since fibrosis/cirrhosis-driven carcinogenesis is the mechanism of HCC development common to all major etiologies, we propose to use HCV-induced liver disease as a model to decipher the pan-etiology sequence of molecular events underlying disease progression and HCC. Our own data provide solid evidence that HCV infection alters pathways implicated in liver disease progression, including cirrhosis deterioration, HCC development, and overall and liver-specific death. Thus, the molecular investigation of these pathways will identify key cell circuits for the understanding of the pathogenesis of liver disease and HCC in general, and as broadly applicable pan-etiology diagnostic and therapeutic targets. Using a novel patient-derived cell culture model system for liver disease biology combined with advanced functional genomics, novel animal models and clinical investigation, we aim to uncover the cell circuits that are of clinical relevance for liver disease progression and cancer. By providing novel targets and biomarkers for liver disease and HCC prevention, this proposal will have a marked impact on the management and prognosis of patients with liver disease and HCC.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714312	**RACE**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. ANNETTE VAN DER HELM**
Host Institution: Academisch Ziekenhuis Leiden - Leids Universitair Medisch Centrum, NL

Rheumatoid Arthritis Caught Early: investigating biological mechanisms preceding chronification of joint inflammation to identify patients prior to presentation of classic chronic arthritis

Rheumatoid Arthritis (RA) causes long lasting disability. At the time of clinically evident arthritis and diagnosis, the disease is already persisting, requiring long-term suppressive treatment. My overarching aim is to prevent chronic arthritis and RA by inhibiting the evolving auto-immune response in a pre-arthritis phase. Currently, identification of RA-patients before the classic presentation with clinically evident chronic arthritis is beyond the state of the art. I here aim to achieve this early recognition by increasing the mechanistic understanding of pre-arthritis phases.

I intend to study RA-specific auto-immune responses at the cellular and humoral level as well as markers reflecting local and systemic inflammation. These aspects are selected based on my world-wide validated rule to predict RA-development in early arthritis and on recent work on progression from Clinically Suspect Arthralgia (CSA) to clinical arthritis.

This project is now finally feasible, thanks to unique ‘pre-RA’ cohorts and cross-boundary preparatory work done with basic scientists, clinicians and engineers. My research concept is to integrate the products of separate trajectories in a longitudinal study and translate it to the clinic.

Patients with CSA will be studied serially in time. Using validated methods and novel techniques and insights we will: delineate molecular and predictive features of RA-specific auto-antibodies and auto-antibody secreting B-cells, identify improved markers of systemic inflammation and test and validate a computer-aided image analysis system to detect subclinical joint inflammation on MRI. Serial data will be combined to reveal interactions between markers and time relationships. Lastly a prediction model identifying imminent RA will be developed. The forefront position of my group allows national and international validation.

Together, this multidisciplinary and intersectorial project will open new horizons for preventive, targeted interventions.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714866	**REJUVENATION**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. GERARD BOINK**
Host Institution: Academisch Medisch Centrum Bij De Universiteit Van Amsterdam, NL

Repair of Junctional Atrioventricular Conduction and Impulse Formation

Background: To bypass hardware-related complication there have been substantial efforts to create biological pacemakers. Effective strategies have been identified and are now being refined for delivery of long-term function and clinical application. Yet, currently developed biological pacemakers only provide pacing to atrium or ventricle thereby aiming at ~20% of pacemaker patients. To unleash the full potential of biological pacing, targeting virtually every pacemaker patient, effective repair of atrio-ventricular (AV) conduction is crucial. With the arrival of advanced stem cell-based therapies, now is the time to meet this important challenge.

Objective: To develop a stem cell-based therapy that restores impulse formation and conduction at the interface between atrium and ventricle.

Approach: Human induced pluripotent stem cells (hiPSCs) will be used to produce cells with hallmark features of AV nodal cells. After in vitro testing, these cells will be implanted in vivo (together with biomaterials) to form AV bypass tracts in sheep that are in permanent AV block. In this setting, approaches will be tested for their ability to bridge electrical activity from the atrium to ventricle and protect the ventricle from atrial tachycardia. The final steps of this project focuses on the development of dedicated implantation catheters (in collaboration with Medtronic) and optimization of cellular constructs that are regulatory compliant and ready for clinical testing.

Impact: By developing novel therapies to re-establish AV impulse formation and conduction I will broaden the application area of biological pacing to nearly all patients. In Europe ~300.000 pacemakers are implanted annually representing cots of ~8 billion Euros. Five per cent of these implantations result in serious complications requiring re-implantation or other invasive treatments. Biological pacemakers are expected to reduce these complications, improve quality of life, and reduce healthcare costs.

Project End Date: **31-MAR-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715732	**STOP-HF**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. PETER VANDERMEER**
Host Institution: Academisch Ziekenhuis Groningen, NL

STEM CELL MODELS TO UNRAVEL THE SUSCEPTIBILITY AND RESILIENCE TO DEVELOP HEART FAILURE

The overarching objective of STOP-HF is to generate human induced pluripotent stem cells (hiPSC) derived cardiomyocytes from two specific forms of heart failure (HF) with a clear trigger to unravel common pathophysiological mechanisms involved in the early development of HF. The project is focused on two specific forms of HF, both with a clear trigger: pregnancy and anthracyclines. Better understanding of early molecular pathways leading to HF and knowledge about inter-individual susceptibility is needed. For detection of early changes on a molecular level cardiac tissue is needed. Generation of patient specific cardiac cells from skin fibroblasts (hiPSC technology) is a novel and innovative approach. SPECIFIC OBJECTIVES: 1. Fabrication and maturation of 3D cardiac tissue from hiPS derived cardiomyocytes. 2. Generate and characterize hiPS derived cardiomyocytes and endothelial cells from females with pregnancy induced HF and unravel differences on transcriptome level. 3. Generate and characterize hiPSC derived cardiomyocytes from patients with high susceptibility and resilience to develop anthracycline-induced HF and compare them on transcriptome level. 4. Integrate the results for coding and non-coding RNAs from objective 1+2 and identify overlapping pathways. 5. Validate discoveries on transcriptome level in vitro, in vivo and apply for the development of HF in the general population. WORKPACKAGES
WP1: Optimize fabrication and maturation of 3D cardiac tissue from hiPS derived cardiomyocytes; WP2A: Validate the model and compare hiPS derived cardiomyocytes and endothelial cells from PPCM and healthy sisters on transcriptome level; WP2B: Validate the model and compare hiPS derived cardiomyocytes from both patients with high susceptibility and resilience to develop HF after anthracyclins on transcriptome level; WP3: Integration of transcriptome data from WP 2A+2B; WP4: Validation of novel pathways in vitro, in vivo and new onset HF in the general population.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716063	**DrugComb**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. JING TANG**
Host Institution: Helsingin Yliopisto, FI

Informatics approaches for the rational selection of personalized cancer drug combinations

Making cancer treatment more personalized and effective is one of the grand challenges in our health care system. However, many drugs have entered clinical trials but so far showed limited efficacy or induced rapid development of resistance. We critically need multi-targeted drug combinations, which shall selectively inhibit the cancer cells and block the emergence of drug resistance. This project will develop mathematical and computational tools to identify drug combinations that can be used to provide personalized and more effective therapeutic strategies that may prevent acquired resistance. Utilizing molecular profiling and pharmacological screening data from patient-derived leukaemia and ovarian cancer samples, I will develop model-based clustering methods for identification of patient subgroups that are differentially responsive to first-line chemotherapy. For patients resistant to chemotherapy, I will develop network modelling approaches to predict the most potential drug combinations by understanding the underlying drug target interactions. The drug combination prediction will be made for each patient and will be validated using a preclinical drug testing platform on patient samples. I will explore the drug combination screen data to identify significant synergy at the therapeutically relevant doses. The drug combination hits will be mapped into signalling networks to infer their mechanisms. Drug combinations with selective efficacy in individual patient samples or in sample subgroups will be further translated into in treatment options by clinical collaborators. This will lead to novel and personalized strategies to treat cancer patients.

Project End Date: **31-MAY-22**

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Project ID:	Project Acronym:	Evaluation Panel:
724809	**iHEAR**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. MARY CANNON**
Host Institution: Royal College Of Surgeons In Ireland, IE

Investigating the meanings and mechanisms of psychotic experiences in young people: a novel, mixed-methods approach

Up to one fifth of young people have had the experience of psychotic symptoms, such as hearing voices when there is no-one around, or seeing visions. We now know that young people who experience these symptoms are at increased risk of developing psychotic disorders in adulthood. We also know that these young people are at higher risk of a range of co-morbid disorders such as depression and anxiety, and particularly suicidal behaviours. On the other hand, many of these young people will remain well and, for them, the psychotic experiences were merely a transitory phenomenon.

Childhood trauma is known to be associated with increased risk for psychotic symptoms and is a promising target for intervention. However we do not yet know enough about what types or timing of stressors are involved in the pathogenesis of psychotic symptoms, nor the mechanism by which early life stress may lead to changes in brain structure and function resulting in symptoms such as hallucinations. We also need to be able to identify those young people who will benefit most from intervention.

This ground-breaking, multi-disciplinary programme of work sets out to address these issues by drawing together epidemiology, social science, anthropology and neuroscience to devise a comprehensive programme of work examining the relationship between early life stress and psychotic symptoms among young people.

Designed as three inter-related work packages, this iHEAR programme will exploit a large population-based cohort and will capitalise on my existing unique cohort of young people, who were known to have experienced psychotic symptoms in childhood, as they enter young adulthood. This iHEAR programme will result in new information which will allow the development of innovative interventions to prevent or pre-empt severe mental illness in later life.

Project End Date: **31-MAY-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725051	**EVOLVE**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. MICHELE DE PALMA**
Host Institution: Ecole Polytechnique Federale De Lausanne, CH

Extracellular Vesicle-Internalizing Receptors (EVIRs) for Cancer ImmunoGeneTherapy

We are witnessing transformative results in the clinical application of both cancer immunotherapies and gene transfer
technologies. Tumor vaccines are a specific modality of cancer immunotherapy. Similar to vaccination against pathogens, tumor vaccines are designed to elicit a specific immune response against cancer. They are based on the administration of inactivated cancer cells or tumor antigens, or the inoculation of antigen-presenting cells (APCs) previously exposed to tumor antigens. In spite of significant development and testing, tumor vaccines have largely delivered unsatisfactory clinical results. Indeed, while some patients show dramatic and durable cancer regressions, many do not respond, highlighting both the potential and the shortcomings of current vaccination strategies. Hence, identifying and abating the barriers to effective cancer vaccines is key to broadening their therapeutic reach. The goal of EVOLVE (EVirs to Optimize and Leverage Vaccines for cancer Eradication) is to propel the development of effective APC-based tumor vaccines using an innovative strategy that overcomes several key hurdles associated with available treatments. EVOLVE puts forward a novel APC engineering platform whereby chimeric receptors are used to both enable the specific and efficient uptake of cancer-derived extracellular vesicles (EVs) into APCs, and to promote the cross-presentation of EV-associated tumor antigens for stimulating anti-tumor immunity. EVOLVE also envisions a combination of ancillary ‘outside of the box’ interventions, primarily based on further APC engineering combined with innovative pre-conditioning of the tumor microenvironment, to facilitate the deployment of effective APC-driven, T-cellmediated anti-tumor immunity. Further to preclinical trials in mouse models of breast cancer and melanoma, our APC platform will be used to prospectively identify novel human melanoma antigens and reactive T cell clones for broader immunotherapy applications.

Project End Date: **30-JUN-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725229	**EVICARE**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. JOOST SLUIJTER**
Host Institution: Universitair Medisch Centrum Utrecht, NL

Extracellular Vesicle-Inspired CArdiac Repair

More than 3.5 million people are newly diagnosed with heart failure every year in Europe with a long-term prognosis of 50% mortality within 4 years. There is a major need for more innovative, regenerative therapies that have the potential to change the course of disease. My hypothesis is that we can recondition heart failure by stimulating cardiac repair with extracellular vesicles that are derived from progenitor cells. In my laboratory, extracellular released vesicles containing a cocktail of stimulating factors, are amongst the most potent vectors for cardiac repair.

To achieve a sustainable and long-term therapeutic effect of these vesicles and enhance cardiac function by stimulating myocardial repair, we will 1) improve local cardiac delivery of progenitor cell-derived extracellular vesicles, 2) understand the mechanism of action of extracellular vesicles, and 3) stimulate extracellular vesicles release and/or production by progenitor cells.

These questions form the rationale for the current proposal in which we will co-inject extracellular vesicles and slow-release biomaterials into the damaged myocardium. By subsequent genetic tracing, we will determine fate mapping of injected vesicles in vivo, and perform further mechanistic understanding in in vitro culture models of targeted and identified myocardial cell types. Moreover, we will upscale the vesicles production by progenitor cells further via bioreactor culturing and medium-throughput screening on factors that stimulate vesicles release.

The use of stem cell-derived extracellular vesicles to stimulate cardiac repair will potentially allow for an off-the shelf approach, including mechanistic understanding and future clinical use. Additionally, since these vesicles act as a natural carrier system outperforming current artificial drug delivery, we might understand and mimic their characteristics to enhance local (RNA-based) drug delivery systems for cardiovascular application.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
741149	**Photoclin**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. PAUL BEARD**
Host Institution: University College London, UK

Advanced clinical photoacoustic imaging systems based on optical microresonator detection

Photoacoustic imaging is widely viewed as one of the most exciting and promising biomedical imaging techniques to have emerged in recent years. It offers major opportunities for increasing our understanding of basic biological processes at an anatomical, physiological and molecular level, and for improving the clinical diagnosis and treatment of cancer and other major diseases. The aim of this project is to develop and evaluate a new generation of advanced photoacoustic scanners for clinical photoacoustic imaging based on a novel, highly sensitive, optical microresonator ultrasound sensor. This type of sensor offers the prospect of a major step forward in terms of imaging performance by providing orders of magnitude higher sensitivity than equivalently sized conventional detectors with the necessary broadband frequency response and small element size for high image quality. As a consequence, it promises greater penetration depth and improved image quality than possible with current state-of-the-art photoacoustic scanners. This will pave the way for in vivo high resolution human imaging at depths currently unattainable, opening up entirely new clinical applications in oncology, cardiovascular medicine, regenerative medicine and other areas which have hitherto been impossible due to hardware limitations. The project will involve the development of novel polymer optical microresonator sensors, advanced parallelised optical read-out schemes for real-time image acquisition, and engineering complete imaging instruments for use in clinical studies. These instruments will then be evaluated in a variety of clinical contexts including the assessment of skin cancer, head and neck cancers, cardiovascular disease and reconstructive surgery.

Project End Date: **30-NOV-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
754365	**CuHypMECH**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. SHARON RUTHSTEIN**
Host Institution: Bar Ilan University, IL

New Nuclear Medicine Imaging Radiotracer 64Cu(II) for diagnosing Hypoxia Conditions Based on the Cellular Copper Cycle

Imaging of hypoxia is important in many disease states in oncology, cardiology, and neurology. Hypoxia is a common condition encountered within the tumour microenvironment that drives proliferation, angiogenesis, and resistance to therapy. Despite on-going efforts to identify hypoxia, until now there is no clinically approved imaging biomarker, due to both low tumour uptake, and a low signal to background (S/B) ratio that affects the imaging quality. Nuclear Medicine is using labelled radio-isotopes for PET/CT and SPECT imaging. These radio-tracers diagnose the metabolic processes in the body. Among these tracers, 18F-FDG is the most routinely used as a marker of glucose metabolism. However, not all tumours consume glucose, and glucose consumption is not specific only for malignant tumours, which limits its application. Copper is a nutritional metal, recently examined as a radiotracer for hypoxia, owing to its to the oxidising environment. Clinical and in-vivo studies on various 64Cu(II)-PET radiotracers resulted in controversial reports on the specificity of the current tracers for hypoxia imaging due to non-selective bio-distribution & low S/B ratio. This multidisciplinary proposal focuses on the discovery of comprehensive signal pathways of the cellular copper cycle using advanced biophysical methods and a proprietary design of 64Cu(II) radiotracer. This radiotracer will be incorporated in the cellular copper cycle, and will enable to selectively target the oxidising environment in tumours. The design of the new radiotracer is based on systematic structural & functional mapping of the copper binding sites to the various copper proteins and the visualisation of the transfer mechanism. This new copper tracer should increase the selectivity of tumour uptake, stability, and improve bio-distribution. This project assimilates cold and hot chemistry and biology, while emphasising the clinical unmet need in metal based radiotracer that form stable complexes.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757398	**NANONC**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. STEFAAN SOENEN**
Host Institution: Katholieke Universiteit Leuven, BE

Nanomaterials in Oncology: Exploiting the Intrinsic Cancer-Specific Toxicity of Nanoparticles.

In our current society, therapeutic strategies against cancer suffer from dose-limiting toxicity, lack of specificity and high morbidity. To overcome this, the use of nanomaterials (NMs) is rising, where several NM formulations are undergoing clinical trials or are used in clinics where the NMs are used as drug delivery vehicles or as mediators in physical anticancer methods (e.g. hyperthermia), where to date, the success rate is limited due to low tumor targeting efficacy, lack of specificity and frequent re-use of classical toxicity mechanisms.

To overcome these issues, this research program aims to exploit the intrinsic toxicity of certain types of metal-based, degradation-prone NMs (Fe-doped ZnO, Fe-doped CuO and Ag of different sizes and coatings) towards only cancer cells as a novel and generic anti-cancer tool with 1) improved efficacy against difficult to treat cancers such as multidrug-resistant cancer cells, 2) enhanced specificity and selectivity of the treatment by the intrinsic cancer cell-specific toxicity of NMs towards cancer cells. To overcome the issues related to selective delivery of the NMs, tumor-homing cells will be used that have been shown to efficiently home to primary tumors and their metastases. In practice, the NMs used show distinct degradation kinetics that primarily induce cancer-selective toxicity. To obtain efficient tumor targeting, suicide gene-expressing tumor-homing cells will be loaded with the NMs in their cytoplasm, hereby impeding premature NM degradation. The tumor homing efficacy of these cells will be monitored via optical imaging and once at the target site these cells will be chemically destroyed using the suicide gene strategy. This will release the NMs into the tumor site, where they can selectively destroy the cancer cells. This research program will be the first to explore the full potential of cancer-specific toxicity of NMs and the use of cytoplasmic loading of cells as biological carriers for efficient delivery.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758151	**CHIPS**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. MARIE PEDERSEN**
Host Institution: Kobenhavns Universitet, DK

Effects of Prenatal Exposure to Acrylamide on Health: Prospective Biomarker-Based Studies

Background: Acrylamide is a chemical formed in many commonly consumed foods and beverages. It is neurotoxic, crosses the placenta and has been associated with restriction of fetal growth in humans. In animals, acrylamide causes heritable mutations, tumors, developmental toxicity, reduced fertility and impaired growth. Therefore, the discovery of acrylamide in food in 2002 raised concern about human health effects worldwide. Still, epidemiological studies are limited and effects on health of prenatal exposure have never been evaluated.

Research gaps: Epidemiological studies have mostly addressed exposure during adulthood, focused on cancer risk in adults, and relied on questionnaires entailing a high degree of exposure misclassification. Biomarker studies on prenatal exposure to acrylamide from diet are critically needed to improve exposure assessment and to determine whether acrylamide leads to major diseases later in life.

Own results: I have first authored a prospective European study showing that prenatal exposure to acrylamide, estimated by measuring hemoglobin adducts in cord blood, was associated with fetal growth restriction, for the first time.
Objectives: To determine the effects of prenatal exposure to acrylamide alone and in combination with other potentially toxic adduct-forming exposures on the health of children and young adults.

Methods: Both well-established and innovative biomarker methods will be used for characterization of prenatal exposure to acrylamide and related toxicants in blood from pregnant women and their offspring in prospective cohort studies with long-term follow-up. Risk of neurological disorders, impaired cognition, disturbed reproductive function and metabolic outcomes such as obesity and diabetes will be evaluated.
Perspectives: CHIPS project will provide a better understanding of the impact of prenatal exposure to acrylamide from diet on human health urgently needed for targeted strategies for the protection of the health.

Project End Date: **30-JUN-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758657	**ImPRESS**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. KYRRE EEG EMBLEM**
Host Institution: Oslo Universitetssykehus Hf, NO

Imaging Perfusion Restrictions from Extracellular Solid Stress

Even the perfect cancer drug must reach its target to have an effect. The ImPRESS project main objective is to develop a novel imaging paradigm coined Restricted Perfusion Imaging (RPI) to reveal - for the first time in humans - vascular restrictions in solid cancers caused by mechanical solid stress, and use RPI to demonstrate that alleviating this force will repair the cancerous microenvironment and improve therapeutic response. Delivery of anti-cancer drugs to the tumor is critically dependent on a functional vascular bed. Developing biomarkers that can measure how mechanical forces in a solid tumor impair perfusion and promotes therapy resistance is essential for treatment of disease.

The ImPRESS project is based on the following observations; (I) pre-clinical work suggests that therapies targeting the tumor microenvironment and extracellular matrix may enhance drug delivery by decompressing tumor vessels; (II) results from animal models may not be transferable because compressive forces in human tumors in vivo can be many times higher; and (III) there are no available imaging technologies for medical diagnostics of solid stress in human cancers. Using RPI, ImPRESS will conduct a comprehensive series of innovative studies in brain cancer patients to answer three key questions: (Q1) Can we image vascular restrictions in human cancers and map how the vasculature changes with tumor growth or treatment? (Q2) Can we use medical engineering to image solid stress in vivo? (Q3) Can RPI show that matrix-depleting drugs improve patient response to conventional chemo- and radiation therapy as well as new targeted therapies?

The ImPRESS project holds a unique position to answer these questions by our unrivaled experience with advanced imaging of cancer patients. With successful delivery, ImPRESS will have a direct impact on patient treatment and establish an imaging paradigm that will pave the way for new scientific knowledge on how to revitalize cancer therapies.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759272	**STRATO**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. HENDRIK SAGER**
Host Institution: Deutsches Herzzentrum Munchen, DE

Stress as a modifier of atherosclerosis
- Novel mechanistic insights and therapeutic avenues -

Atherosclerosis and its complications such as acute coronary syndromes (myocardial infarction and unstable angina) are leading causes of death in the EU and worldwide. Mental stress is known to be a major trigger for the onset of acute coronary syndromes, even in patients with state-of-the-art medical treatment. How acute mental stress rapidly drives plaque destabilization causing acute coronary syndromes is poorly understood and consequently specific treatment, although urgently needed, is lacking. Mental stress is known to affect the immune system. Leukocytes, the effector cells of the immune system, are main instigators not only of plaque progression, but also of plaque destabilization. We hypothesize that acute mental stress rapidly aggravates plaque inflammation, which renders plaques more vulnerable and prone to rupture.

We aim to characterize the impact of stress on plaque inflammation in a mouse model of acute mental stress. We will explore the mechanisms by which acute mental stress drives plaque inflammation. Based on these findings, we aim to provide a novel treatment approach to mitigate stress exacerbated plaque inflammation. Further, we aim to translate our findings to stressed humans.

The STRATO study will be carried out in a multidisciplinary approach including basic and clinician scientists, immunologists, and psychosomatic specialists and will provide us with an unprecedented, comprehensive picture of how acute mental stress aggravates atherosclerosis. Our study will fill a gap in mechanistic knowledge and based on this will identify novel therapeutic measures with the aim to reduce acute mental stress related cardiovascular complications.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759585	**ToMeTuM**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. VOJTECH ADAM**
Host Institution: Vysoke Uceni Technicke V Brne, CZ

Towards the Understanding a Metal-Tumour-Metabolism

A tumour cell uses both genetic and protein weapons in its development. Gaining a greater understanding of these lethal mechanisms is a key step towards developing novel and more effective treatments. Because the metal ion metabolism of a tumour cell is not fully understood, we will address the challenge of explaining the mechanisms of how a tumour cell copes both with essential metal ions and platinum based drugs. The metal-based mechanisms help a tumour to grow on one side and to protect itself against commonly used metal-based drugs. On the other side, the exact description of these mechanisms, which are being associated with multi-drug resistance occurrence and failure of a treatment, still remains unclear. We will reveal the mechanism of the as yet not understood biochemical and molecularly-biological relationships and correlations between metal ions and proteins in a tumour development revealing the way how to suppress the growth and development of a tumour and to markedly enhance the effectiveness of a treatment.

To achieve this goal, we will focus on metallothionein and its interactions with essential metals and metal-containing anticancer drugs (cisplatin, carboplatin, and oxaliplatin). Their actions will be monitored both in vitro and in vivo. For this purpose, we will optimize electrochemical, mass spectrometric and immune-based methods. Based on processing of data obtained, new carcinogenetic pathways will be sought on cell level and proved by genetic modifications of target genes. The discovered processes and the pathways found will then be tested on two animal experimental models mice bearing breast tumours (MCF-7 and 4T1) and MeLiM minipigs bearing melanomas.

The precise description of the tumour related pathways coping with metal ions based on metallothioneins will direct new highly effective treatment strategies. Moreover, the discovery of new carcinogenetic pathways will open a window for understanding of cancer formation and development.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771112	**PhenoSwitch**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. YUVAL SHAKED**
Host Institution: Technion - Israel Institute Of Technology, IL

Phenotype switching: plasticity and/or differentiation of stromal cells and their progenitors within the tumour microenvironment regulate tumour fate.

The limited success of cancer therapy especially in advanced metastatic disease warrants a reassessment, especially given our limited understanding of the nature of cancer cells and the factors that allow them to proliferate and metastasise. Stromal cells of the tumour microenvironment, including fibroblasts, endothelial, immune, adipose and mesenchymal cells, significantly affect cancer cell characteristics and tumour fate; however, their sometimes dichotomous function in high- and low-aggressive tumours has not been thoroughly investigated. Here, we propose to elucidate the largely unknown role of haematopoietic stem and/or progenitor cells (HSCs) on tumour growth and metastases. We found that such cells reside in the tumour niche predominantly in non-aggressive tumours. We hypothesise that cancer cells trigger the differentiation of HSCs into haematopoietic tumour-supporting stromal cells, thereby inducing a phenotypic and functional switch that skews them towards a tumour-promoting phenotype, hence promoting tumour cell aggressiveness and metastases.

To test our hypothesis, we will use high-throughput technologies to track the lineage, differentiation and commitment of HSCs during tumour progression. Our specific aims are therefore:

(a) To systematically analyse tumour-promoting and tumour-restricting stromal phenotypes at the cellular and molecular levels.

(b) To characterise stromal cell plasticity and the contribution of tumour cells to the phenotype switch.

(c) To determine whether differentiated stromal cells and HSCs in cancer patients can predict clinical outcome.

(d) To screen for molecules that inhibit the tumour-promoting stromal switch.

Blocking the tumour-promoting phenotypic switch and maintaining a pre-mature tumour-restricting stromal microenvironment represent a novel strategy in the fight against cancer. This study will lead to the development of new tools to predict prognosis and pharmacological strategies to restrict tumour growth.

Project End Date: **31-MAR-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772345	**VENUSCANCER**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. CLAUDIA ALLEMANI**
Host Institution: London School Of Hygiene And Tropical Medicine Royal Charter, UK

Women's cancers: do variations in patterns of care explain the world-wide inequalities in survival and avoidable premature deaths?

Opening the World Cancer Congress in Paris in November 2016, President François Hollande insisted that women should be at the heart of cancer control, "because they are victims of inequality in access to prevention, treatment and screening in every country in the world."

Breast, ovarian and cervical cancers are a major public health problem world-wide. Each year, approximately 2.5 million women are diagnosed with one of these cancers, and 900,000 women die from them, mainly in low- and middle-income countries.

The CONCORD programme for global surveillance of cancer survival reported striking differences in survival from these three cancers. Population-based cancer survival is a key measure of the overall effectiveness of health systems in dealing with cancer, from early diagnosis to comprehensive investigation and optimal treatment. I will exploit the CONCORD data base, as follows:

• Access primary medical records in selected high- and low-income countries to collect more detailed data on stage at diagnosis, staging investigations, morphology, grade, prognostic bio-markers and treatment, for the most recent year during 2010-2014 for which data are available
• Analyse the distributions of stage and treatment ("patterns of care")
• Estimate 1- and 5-year survival trends by stage, histological group and/or molecular subtype
• Quantify inequalities in survival as the number of premature deaths that would be avoidable if survival in a given country (region) were equal to that in a neighbouring country with higher survival.

This ground-breaking work will show that it is possible (a) to collect high-quality, complete clinical information at population level even in low- and middle-income countries; (b) to explain the striking inequalities in women's cancer survival world-wide, and (c) to summarise these inequalities in a single number (avoidable deaths) as a powerful tool that motivates policymakers to reduce inequalities in survival.

Project End Date: **30-APR-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772970	**MicroC**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. FRANCESCA BUFFA**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Agent-Based Modelling of Gene Networks to model clonal selection in the tumour microenvironment and predict therapeutic resistance

The occurrence of therapeutic resistance is a major cause for the small effect on overall survival showed by targeted cancer therapies. Whilst experimental strategies to evaluate available treatments have been faced by an ever increasing number of possible combinations, computational approaches have been challenged by the lack of a framework able to model the multiple interactions encompassed by the three major factors affecting therapeutic resistance: selection of resistant clones, adaptability of gene signalling networks, and a protective and hypoxic tumour microenvironment.

Here I propose a novel modelling framework, Agent-Based Modelling of Gene Networks, which brings together powerful computational modelling techniques and gene networks. This combination allows biological hypotheses to be tested in a controlled stepwise fashion, and it lends itself naturally to model a heterogeneous population of cells acting and evolving in a dynamic microenvironment, which is needed to predict therapeutic resistance and guide effective treatment selection.

Using triple negative breast cancer (TNBC) as a testing case (15% of breast cancers, lacks validated), I propose to:

1. Develop a computational model of the TNBC tumour microenvironment using in-vitro and in-vivo, including patient-derived, models and data from clinical samples. 2. Validate the ability of the model to predict driver genes conferring a survival advantage to cancer cells in a hypoxic microenvironment. 3. Predict combinations of druggable targets to tackle TNBC therapeutic resistance. 4. Select most effective drug combinations and validate pre-clinically.

This project will deliver pre-clinically validated drug combinations, new therapeutic targets and a virtual environment to study individual tumours and predict therapeutic resistance. Complementing and empowering experimental models and assays, microC will offer a new powerful tool for diagnosis and therapy.

Project End Date: **31-MAY-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
785917	**PML-THERAPY**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. HUGUES DE THÉ**
Host Institution: Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

HARNESSING PML NUCLEAR BODIES FOR LEUKAEMIA THERAPY

In acute promyelocytic leukaemia (APL), retinoic acid (RA) and Arsenic trioxide (As) bind PML/RARA and promote its degradation. Exploring the mechanistic bases for APL response to the RA/As combination, we found that upon PML/RARA degradation the normal PML allele activates a PML/P53 checkpoint absolutely required for APL cure in mice or patients. Physiologically, PML behaves as an oxidative stress sensor and contributes to redox homeostasis. PML organizes nuclear bodies (NBs), domains that recruit multiple client proteins and may facilitate their post-translational modifications (PTM), particularly conjugation of SUMOs. This somehow controls multiple downstream pathways such as P53, but also RB, HIF1A or interferon (IFN). In APL, NB-disruption blunts P53-driven senescence, contributing to oncogenesis and therapy resistance. Critically, PML expression and/or NB-formation are lost upon many viral infections or during cancer development. The mechanism(s) underlying the selective pressure to loose PML expression in multiple cancers remains incompletely understood.

Our aim is to mechanistically dissect PML signalling in vivo and therapeutically restore it in malignancies where it is inactivated. We first propose a broad exploration of PML in mice to identify basal and stress-induced PML PTM and identify the repertoire of proteins sumoylated in a PML-dependent manner. We will generate a series of PML knock-in mutant mice and analyse their P53-regulated redox homeostasis. We will mechanistically explore PML/P53-driven senescence in three leukaemia models where we have evidence for basal or therapy-responsive NB-modulation: acute myeloid leukaemia expressing NPMc and IFN-sensitive Tax- or JAK2-driven leukaemias. We will screen chemical libraries for drugs modulating PML expression and/or NB biogenesis. Finally, we will integrate our findings to elaborate innovative therapeutic strategies based on restoration of the PML/P53 checkpoint in leukaemia with unmet medical needs

Project End Date: **31-MAR-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
786295	**EPIC**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. ZLATKO TRAJANOSKI**
Host Institution: Medizinische Universitat Innsbruck, AT

Enabling Precision Immuno-oncology in Colorectal cancer

Immunotherapy with checkpoints blockers is transforming the treatment of advanced cancers. Colorectal cancer (CRC), a cancer with 1.4 million new cases diagnosed annually worldwide, is refractory to immunotherapy (with the exception of a minority of tumors with microsatellite instability). This is somehow paradoxical as CRC is a cancer for which we have shown that it is under immunological control and that tumor infiltrating lymphocytes represent a strong independent predictor of survival. Thus, there is an urgent need to broaden the clinical benefits of immune checkpoint blockers to CRC by combining agents with synergistic mechanisms of action. An attractive approach to sensitize tumors to immunotherapy is to harness immunogenic effects induced by approved conventional or targeted agents.

Here I propose a new paradigm to identify molecular determinants of resistance to immunotherapy and develop personalized in silico and in vitro models for predicting response to combination therapy in CRC. The EPIC concept is based on three pillars: 1) emphasis on antitumor T cell activity; 2) systematic interrogation of tumor-immune cell interactions using data-driven modeling and knowledge-based mechanistic modeling, and 3) generation of key quantitative data to train and validate algorithms using perturbation experiments with patient-derived tumor organoids and cutting-edge technologies for multidimensional profiling. We will investigate three immunomodulatory processes: 1) immunostimulatory effects of chemotherapeutics, 2) rewiring of signaling networks induced by targeted drugs and their interference with immunity, and 3) metabolic reprogramming of T cells to enhance antitumor immunity.

The anticipated outcome of EPIC is a precision immuno-oncology platform that integrates tumor organoids with high-throughput and high-content data for testing drug combinations, and machine learning for making therapeutic recommendations for individual patients.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
786462	**HOPE**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. GOTTFRIED BAIER**
Host Institution: Medizinische Universitat Innsbruck, AT

Host Protective Engineering of Cancer Immunity by Targeting the Intracellular Immune Checkpoint NR2F6

Because of its biological complexity, cancer is still poorly understood. Chronic inflammation has been shown, both experimentally and epidemiologically, to be a predisposition to, and also an inseparable aspect of clinically prevalent cancer entities. Therefore, a detailed understanding of both tumour and immune cell functions in cancer progression is a prerequisite for more successful therapeutic startegies. My team was the first to reveal the lymphocyte-intrinsic PKC/NR2F6 axis as an essential signalling node at the crossroads between inflammation and cancer. It is the mission of this project to identify molecular signatures that influence the risk of developing tumours employing established research tools and state-of-the-art genetic, biochemical, proteomic and transcriptomic as well as large scale CRISPR/Cas9 perturbation screening-based functional genomic technologies. Defining this as yet poorly elucidated effector pathway with its profoundly relevant role would enable development of preventive and immune-therapeutic strategies against NSCLC lung cancer and potentially also against other entities. Our three-pronged approach to achieve this goal is to: (i) delineate biological and clinical properties of the immunological PKC/NR2F6 network, (ii) validate NR2F6 as an immune-oncology combination target needed to overcome limitations to "first generation anti-PD-1 checkpoint inhibitors" rendering T cells capable of rejecting tumours and their metastases at distal organs and (iii) exploit human combinatorial T cell therapy concepts for prevention of immune-related adverse events as well as of tumour recurrence by reducing opportunities for the tumour to develop resistance in the clinic. Insight into the functions of NR2F6 pathway and involved mechanisms is a prerequisite for understanding how the microenvironment at the tumour site either supports tumour growth and spread or prevents tumour initiation and progression, the latter by host-protective cancer immunity.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
801660	**TopSurgeons**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. ANTOINE DUCLOS**
Host Institution: Universite Lyon 1 Claude Bernard, FR

Understanding the influence of human and organizational factors on surgeon performance to enhance patient outcomes: experimental evaluation of a customized coaching program

Individual performance of surgeon is a core element of successful surgery that can vary greatly over career for poorly understood reasons. Solutions to optimize physical and mental condition of surgeon during operation have not been thoroughly explored so far, while this may represent basic foundation for delivering high quality surgery. This surgeon-centred outcome research pursues three successive goals: 1-Identifying the key determinants related to surgeon's human factor and operating room organization influencing his/her performance in terms of patient safety and care efficiency; 2-Developing a customized coaching program for surgeons based on the human and organizational factors previously discovered, which includes a charting system for individual parameters and surgical outcomes feedback, profiling of individual surgeon, and standardized modules of improvement; 3-Implementing and measuring the impact of this program on surgical outcomes of a randomized group of surgeons against a control group of non-exposed surgeons. Inspired from previous experiences in the aeronautic and sport arena to improve pilots and athletes performance, our approach will take place in real time at the point of care in close collaboration with front-line personnel. A particular attention will be paid to quantify the influence of several factors that may affect how the surgeon operates every day (physiological stress, sleep quality, physical activities, workload, team composition and unplanned events in operating room). Generated knowledge on these factors will be exploited for identifying deficiencies that, if corrected, could improve surgeon's functional capacity. Solutions to control these factors and achieve optimal outcomes will then be experimentally tested to establish evidence-based standards of surgical practice. Those standards will be adapted to each surgeon's needs and preferences, potentially leading to a certification model for surgeons complying with excellence criteria.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
801790	**MOBILIZE**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. SØREN T. SKOU**
Host Institution: Syddansk Universitet, DK

Improving health in people with multimorbidity: a paradigm shift in health care from disease-based curative models to personalized exercise therapy and self-management

The goal of this proposal is to support the paradigm shift in the health care of people with multiple chronic conditions in Europe from a focus on disease-based curative models to holistic person-centered self-care through personalized,supervised exercise therapy and education.
The problem:The impact of multimorbidity on the individual and society is massive and much greater than the impact of single chronic conditions alone. However, effective treatments are missing and research and health care reinforce an inefficient and burdensome single-disease framework.
The solution:Exercise has the potential to disrupt the 'vicious cycle' of systemic inflammation associated with chronic conditions and improve health in multimorbidity. A personalized exercise and education program aimed at supporting subsequent self-management by the individual will be developed in an interdisciplinary collaboration, building on evidence from biomarkers, patient involvement and methodological expertise. Self-reported,physiological and societal effects will be investigated in a randomized controlled trial comparing the personalized program with standard single-disease models of care. Scientific and public dissemination and implementation ensuring significant personal and societal benefit is fundamental to the proposal.
The proposal is associated with high risk, as the current disease-based curative models involve treatment by several highly specialized health care providers, while the new person-centered self-management model is centered on a personalized program delivered by one health care provider.
The ground-breaking nature of this proposal lies in its potential to revolutionize how health care is organized for people with multimorbidity, by giving them one primary care provider, and how we use non-surgical treatment in health care and science by bringing the concept of precision medicine into multimorbidity and utilizing it to improve treatment outcome with exercise therapy as the model.

Project End Date: **31-JUL-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
805361	**3DBIOLUNG**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. DARCY WAGNER**
Host Institution: Lunds Universitet, SE

Bioengineering lung tissue using extracellular matrix based 3D bioprinting

Chronic lung diseases are increasing in prevalence with over 65 million patients worldwide. Lung transplantation remains the only potential option at end-stage disease. Around 4000 patients receive lung transplants annually with more awaiting transplantation, including 1000 patients in Europe. New options to increase available tissue for lung transplantation are desperately needed.

An exciting new research area focuses on generating lung tissue ex vivo using bioengineering approaches. Scaffolds can be generated from synthetic or biologically-derived (acellular) materials, seeded with cells and grown in a bioreactor prior to transplantation. Ideally, scaffolds would be seeded with cells derived from the transplant recipient, thus obviating the need for long-term immunosuppression. However, functional regeneration has yet to be achieved. New advances in 3D printing and 3D bioprinting (when cells are printed) indicate that this once thought of science-fiction concept might finally be mature enough for complex tissues, including lung. 3D bioprinting addresses a number of concerns identified in previous approaches, such as a) patient heterogeneity in acellular human scaffolds, b) anatomical differences in xenogeneic sources, c) lack of biological cues on synthetic materials and d) difficulty in manufacturing the complex lung architecture. 3D bioprinting could be a reproducible, scalable, and controllable approach for generating functional lung tissue.

The aim of this proposal is to use custom 3D bioprinters to generate constructs mimicking lung tissue using an innovative approach combining primary cells, the engineering reproducibility of synthetic materials, and the biologically conductive properties of acellular lung (hybrid). We will 3D bioprint hybrid murine and human lung tissue models and test gas exchange, angiogenesis and in vivo immune responses. This proposal will be a critical first step in demonstrating feasibility of 3D bioprinting lung tissue.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
817884	**ViroPedTher**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. MARTA ALONSO**
Host Institution: Universidad De Navarra, ES

Oncolytic viruses for the treatment of pediatric brain tumors: An integrated clinical and lab approach

The overreaching goal of my lab is to improve the prognosis of patients with high-risk pediatric brain tumors. To this end, I propose to integrate clinical and lab-based research to develop tumor-targeted oncolytic adenoviruses with the capacity to elicit a therapeutic immune response in those tumors. Our research will use novel and relevant models to accomplish the experimental aims. We have previously worked with Delta-24-RGD (DNX-2401) a replication-competent adenovirus that has been translated to the clinical scenario. In 2017, the first clinical trial phase I with DNX-2401 for newly diagnosed Diffuse Intrinsic Pontine Gliomas (DIPG; a lethal pediatric brain tumor) opened propelled by my team. Preliminary results from the first trials revealed that the intratumoral injection of the virus instigated an initial phase of oncolysis followed by a delayed inflammatory response that ultimately resulted in complete regression in a subset of the patients without associated toxicities. I hypothesized that enhancement of the immune component of the DNX-2401-based therapy will result in the complete regression of the vast majority of pediatric brain tumors. In our specific approach, we propose to understand the immune microenvironment of DIPGs and the response to viral therapy in the context of the trial. Moreover, that knowledge will leverage the design of Delta-24-based adenoviruses to recruit lymphocytes to the tumor with the competence of different type of ligands to activate the tumor infiltrating lymphocytes. I expect that this combinatorial innovative treatment will efficiently challenge the profound and inherent tumor immunosuppression and, in turn, will elicit a robust anti-tumor immune response resulting in the significant improvement of the prognosis and quality of life of patients with pediatric brain tumors. This project has the potential to produce a vertical advance in the field of pediatric oncology.

Project End Date: **29-FEB-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
817908	**PROTONMBRT**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. YOLANDA PREZADO**
Host Institution: Centre National De La Recherche Scientifique, FR

Spatial fractionation of the dose in proton therapy: a novel therapeutic approach

Radiotherapy (RT) is one of the most frequently used methods for cancer treatment (above 50% of patients will receive RT). Despite remarkable advancements, the dose tolerances of normal tissues continue to be the main limitation in RT. Finding novel approaches that allow increasing normal tissue resistance is of utmost importance. This would make it possible to escalate tumour dose, resulting in an improvement in cure rate. With this aim, I propose a new approach, called proton minibeam radiation therapy (PROTONMBRT), which combines the prominent advantages of protons for RT and the remarkable tissue preservation provided by the use of submillimetric field sizes and a spatial fractionation of the dose, as in minibeam radiation therapy (MBRT). The main objectives of this project are to explore the gain of therapeutic index for radioresistant tumors, to disentangle the biological mechanisms involved and to evaluate the clinical potential of this novel approach. For this purpose, a method for minibeam generation adequate for patient treatments and a complete set of dosimetric tools will be developed. Then, tumour control effectiveness will be evaluated, and the possible biological mechanisms involved both in tumour and normal tissue responses will be disentangled. The gain in normal tissue recovery can foster one of the main applications of proton therapy, paediatric oncology, as well as open the door to an effective treatment of very radioresistant tumours, such as high-grade gliomas, which are currently mostly treated palliatively.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
817940	**METAPTPs**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. ESTEBAN GURZOV**
Host Institution: Universite Libre De Bruxelles, BE

PROTEIN TYROSINE PHOSPHATASES IN METABOLIC DISEASES: OXIDATION, DYSFUNCTION AND THERAPEUTIC POTENTIAL

Diabetes mellitus is characterised by hyperglycaemia caused by an absolute or relative insulin deficiency. The global prevalence of diabetes has reached more than 410 million individuals, underscoring the need for novel therapeutic strategies targeting the pathology as a multi-organ disease. Protein tyrosine phosphatases (PTPs) constitute a superfamily of enzymes that dephosphorylate tyrosine-phosphorylated proteins and oppose the actions of protein tyrosine kinases. My previous studies and preliminary data suggest that PTPs act as molecular switches for key signalling events in the development of diabetes, i.e. insulin/glucose/cytokine signalling. Dysregulation of these pathways results in metabolic consequences that are cell-specific. Oxidative stress abrogates the nucleophilic properties of the PTP active site and induces conformational changes that inhibit PTP activity and prevent substrate-binding. I have recently developed an innovative proteomic approach to quantify PTP oxidation in vivo and demonstrated that this occurs in liver/pancreas under pathological conditions, including obesity and inflammation. In this proposal, I aim to fully characterise the activity and oxidation status of PTPs in dysfunctional metabolic relevant cells in obesity and diabetes. Importantly, the crucial role of PTPs make them promising candidates for the treatment of metabolic disorders. I hypothesise that specific antioxidants, diets and/or adenovirus will restore PTP function and ameliorate the metabolic deleterious defects in pre-clinical studies. Over the next 5 years, I aim to:

- Identify the major oxidised PTPs in metabolic relevant tissues/cells in both obesity and diabetes.
- Determine the contribution of PTP inactivation in cellular responses to metabolic signalling in human samples.
- Assess the impact of tissue-specific PTP deficiency on the development of obesity and diabetes.
- Test novel therapeutic approaches targeting PTPs to prevent/reverse metabolic disorders.

Project End Date: **31-MAR-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818715	**SECRETE-HF**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. RUDOLF DE BOER**
Host Institution: Academisch Ziekenhuis Groningen, NL

SECRETED FACTORS IN CARDIAC REMODELING PROVOKE TUMORIGENESIS AND END ORGAN DAMAGE IN HEART FAILURE

The objective of SECRETE-HF is to demonstrate the effects of secreted factors from failing hearts to explain the etiology of multimorbidity in heart failure (HF). The project focuses on two co-morbid patterns: 1) the emerging susceptibility of HF patients for incident cancer, 2) the more established co-morbid conditions of renal, liver and pulmonary disease in HF. The rationale is:

• HF treatment has improved, yet morbidity and mortality remain high, which can be attributed to co-morbid conditions rather than pump failure alone.

• HF treatment is heart-oriented, neglecting the systemic effects that come with HF, and the associated morbidity and mortality.

• Using innovative experimental approaches such as organ transplant models, target finding, and deep phenotyping of clinical databases I will dissect HF-derived effects on tumor growth and organ damage.

OBJECTIVES

1. To establish the effects of HF, due to different etiologies, using the state-of-the-art heart transplantation murine model with (spontaneous) formation of colon and renal tumors, and phenotype tumor growth, as well as the main HF-affected organs: kidney, liver and lungs.
2. Identification of the cardiac secretome using unbiased approaches.
3. Integrate the results and identify overlapping and diverse factors from different HF forms, and their consequences for tumor growth and kidney/liver/lung remodeling.
4. Validate discoveries in human cohorts with data on incident HF, cancer and organ function.
5. Create clinical algorithms to detect, monitor and act on extra-cardiac disease.

WORKPACKAGES

WP 1: Create HF, murine heart transplantation models; phenotype tumor growth and organ involvement.

WP 2: Explore the proteomic, metabolomic and extracellular vesicle profiles from HF subforms.

WP 3: Validate secreted factors in vitro and in vivo.

WP 4: Validate human relevance in large population-based cohorts with unique phenotyping.

WP 5: Describe added value of novel markers and design clinical

Project End Date: **30-JUN-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818806	**TALE**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator:	**Dr. LUKAS JEKER**
Host Institution:	Universitaet Basel, CH

Therapeutic Allele Engineering: A novel technology for cell therapy

We are currently witnessing a revolution in cell therapies that are routed in decades of basic research in genetics, cell biology and immunology. A deep understanding of mammalian, and in particular immune, cells is currently being translated into highly efficient cell-based therapeutics. Technologic breakthroughs in genetic and genome engineering are further fueling the generation of customized, high precision therapies that are based on cells as “smart drugs”. For instance, reprogramming immune killer cells to recognize B cell leukemias resulted in unprecedented clinical responses in treatment-resistant and relapsed patients. However, currently only very few, highly selected patients benefit from these developments. A fundamental problem of today’s cell therapies is that transferred cells cannot be distinguished from host cells. We have developed “allele engineering”, a new technology that solves this challenge. Here, we outline how allele engineering will improve the safety and efficacy of cell therapies. We will 1) generate a non-viral, DNA-free safety/shielding switch 2) develop a radically new curative approach to acute myeloid leukemia 3) rationally design a safe allele engineering solution for human therapy and 4) use allele engineering as a curative therapy of scurfy syndrome, a lethal monogenic autoimmune disease. Allele engineering enables completely new treatment strategies and can be applied to any surface protein. Therefore, I anticipate that the results will have a major impact on the field.

Project End Date: **31-MAY-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818943	**UreaCa**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator:	**Dr. AYELET EREZ**
Host Institution:	Weizmann Institute Of Science, IL

Deciphering the metabolic roles of the urea-cycle pathway in carcinogenesis for improving diagnosis and therapy

Almost 100 years ago, Warburg described a metabolic change in energy flux that occurs during carcinogenesis. Since then, multiple studies have demonstrated how anabolic synthesis of macromolecules can be altered to support cancer cell progression. Yet, the potential effect of altered catabolic degradation of macromolecules on tumour carcinogenesis has been much less studied.

The urea cycle (UC) is the main catabolic pathway by which mammals excrete waste nitrogen. Although the complete UC pathway is liver-specific, most tissues express different combinations of UC enzymes according to the cellular needs. Surprisingly, we find that changes in expression of UC components causing UC dysregulation, (UCD) is a global phenomenon in cancer, metabolically augmenting net nitrogen usage for the synthesis of macromolecules by reducing nitrogen waste. This metabolic alteration is associated with poor patient prognosis. Thus, we hypothesise that UCD provides a major metabolic advantage to multiple aspects of carcinogenesis and as such, leads to specific, identifiable genomic and biochemical signatures, with implications for cancer diagnosis and therapy.

To pursue our hypothesis, we will incorporate state-of-the-art comparative genomic, peptidomic, metabolomic, and molecular approaches to explore this scientific "blind spot" of nitrogen metabolism in carcinogenesis. We will investigate how UCD causally affects carcinogenesis, by characterising tumour-specific functions of UC enzymes (Aim I), correlating tumour phenotypes with systemic biomarkers (Aim II), and testing the treatment efficacy of drug combinations targeting UCD in cancers (Aim III).

Our proposal, strengthened by my training as a physician scientist, harbours considerable potential for translational diagnostic and therapeutic utility of our findings, enabling us to i) identify new diagnostic biomarkers for monitoring cancer initiation and progression and ii) predict and enhance the therapeutic response.

Project End Date: **30-APR-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
820137	**CANCEREVO**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. MARCO GERLINGER**
Host Institution: The Institute Of Cancer Research: Royal Cancer Hospital, UK

Deciphering and predicting the evolution of cancer cell populations

The fundamental evolutionary nature of cancer is well recognized but an understanding of the dynamic evolutionary changes occurring throughout a tumour's lifetime and their clinical implications is in its infancy. Current approaches to reveal cancer evolution by sequencing of multiple biopsies remain of limited use in the clinic due to sample access problems in multi-metastatic disease. Circulating tumour DNA (ctDNA) is thought to comprehensively sample subclones across metastatic sites. However, available technologies either have high sensitivity but are restricted to the analysis of small gene panels or they allow sequencing of large target regions such as exomes but with too limited sensitivity to detect rare subclones. We developed a novel error corrected sequencing technology that will be applied to perform deep exome sequencing on longitudinal ctDNA samples from highly heterogeneous metastatic gastro-oesophageal carcinomas. This will track the evolution of the entire cancer population over the lifetime of these tumours, from metastatic disease over drug therapy to end-stage disease and enable ground breaking insights into cancer population evolution rules and mechanisms. Specifically, we will: 1. Define the genomic landscape and drivers of metastatic and end stage disease. 2. Understand the rules of cancer evolutionary dynamics of entire cancer cell populations. 3. Predict cancer evolution and define the limits of predictability. 4. Rapidly identify drug resistance mechanisms to chemo- and immunotherapy based on signals of Darwinian selection such as parallel and convergent evolution. Our sequencing technology and analysis framework will also transform the way cancer evolution metrics can be accessed and interpreted in the clinic which will have major impacts, ranging from better biomarkers to predict cancer evolution to the identification of drug targets that drive disease progression and therapy resistance.

Project End Date: **29-FEB-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833106	**SILK-EYE**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. SUSANA MARCOS CELESTINO**
Host Institution: Agencia Estatal Consejo Superior De Investigaciones Cientificas, ES

Silk-based ocular implants: treating eye conditions at the interface of photonics and biology

Prevalent eye diseases, such as myopia, presbyopia, and corneal disease affect millions worldwide, but for now cannot be prevented. Surgical interventions of these conditions are turning to additive surgery, exemplified by corneal implants or the replacement of the natural crystalline lens by (or addition of) an intraocular lens, as it reduces complications of tissue removal surgeries.

Current eye treatments involving adding tissue or lenses exist in the form of amnion bandages, corneal inlays, and intraocular lenses. However, those approaches suffer from a number of shortcomings: corneal haze or rejection; risk of disease transmission, short lifespan, need of cryopreservation and donor tissue; lack of compliance of lens designs and biomaterials. In particular, no material has been found that fully meets the requirements for mechanical properties, transparency, biocompatibility and versatility for applications in the cornea and in accommodating intraocular lenses.

In recent years, silk fibroin derived from silkworm cocoons has emerged as a protein polymer for biomaterial applications. SILK-EYE will develop a new generation of corneal and intraocular implants, using silk-based materials tuned to each specific application and light enabling procedure. The silk-based implants will feature both the accessibility advantages of synthetic materials and the structural and biocompatibility properties of allografts, capitalizing on silk's unique potential for transparency, controllable stiffness and degradability, refractive index and permeability, and their potential for light-induced cross-linking and bonding in the eye. SILK-EYE will design radically novel corneal dressings and implants, and accommodating intraocular lenses that are more biocompatible and functional than current synthetic implants, and are safer, more tunable, accessible and affordable than donor allografts, potentially revolutionizing how the major corrective procedures in ophthalmology are performed.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833816	**NEUMACS**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. GUY BOECKXSTAENS**
Host Institution: Katholieke Universiteit Leuven, BE

Neuron-associated macrophages in the gut as novel target for the treatment of enteric neuropathies

The gastrointestinal tract has the vital task to digest and absorb ingested food, a complex process requiring coordinated integration of motility, secretion, vascularization and absorption. Thereto the gastrointestinal tract is equipped with its own nervous system, the enteric nervous system (ENS), capable of controlling gut function independently of input from brain or spinal cord. Reduction in number or dysfunction of the neurons within the gut wall, also referred to as enteric neuropathy, significantly impacts on gut function, resulting in stasis of luminal contents and malabsorption, chronic pain, vomiting, bloating and severe constipation. Enteric neuropathies are common in prevalent disorders such as obesity, diabetes, and ageing, all major contributors to the health burden. Despite the continuous global increase in incidence of these disorders, the insight in the mechanisms leading to the reduction or dysfunction of enteric neurons is limited and most importantly, adequate treatment is lacking. Recently, we collected evidence that survival of enteric neurons is guaranteed by a unique subpopulation of resident macrophages closely associated to the ENS and expressing a typical neuroprotective / -supportive transcriptome. In line, depletion of these neuron-associated macrophages (NA-MF) results in apoptosis and a reduction in number of enteric neurons leading to severely impaired gastrointestinal motility. We pose the provocative hypothesis that enteric neuropathy results from impaired support to the ENS by NA-MF, leading to neural distress and apoptosis. Using state-of-the-art methods, we will first characterize in depth the NA-MF population to subsequently unravel the mechanisms leading to failure of NA-MF to support and protect the ENS in animal models and in patients. These ground-breaking insights will allow us to identify therapeutic targets for the treatment of enteric neuropathies, representing an exponentially growing health problem of the 21st century.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834300	**RODRESET**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. ROBIN ALI**
Host Institution: University College London, UK

Development of novel optogenetic approaches for improving vision in macular degeneration

In industrialized countries, age-related macular degeneration (AMD) is the leading cause of untreatable blindness. In addition to age-related disease, there are also inherited forms of macular degeneration, such as juvenile-onset Stargardt disease. These conditions, for which there are currently no effective treatments, involve the loss of photoreceptors in the central retina, where a high cone photoreceptor density is responsible for effecting high resolution vision. We recently discovered that cones can modulate the sensitivity of surrounding rod photoreceptors to enable them to be more effective in daylight conditions. In retinal disorders involving degeneration of the macular cones, this lateral interaction is impaired, leading to saturation of the rods' dynamic range and impaired daylight vision. We have also discovered that direct modulation the neurons underlying this lateral interaction, the horizontal cells, improves quality of vision in mice lacking functional cones. Together, our results identify a specific circuitry underlying rod-mediated vision as a potential therapeutic target following macular degeneration. Here, we aim to exploit these new findings to re-establish the rods' ability to function in daylight using two distinct approaches. Firstly, we will use direct modification of the rods to permanently shift their light sensitivity into the daylight range. A small area of modified rods that are effective in daylight, likely with a higher temporal resolution, would improve extra-foveal fixation and vision. Secondly, we intend to establish a system that confers light sensitivity onto horizontal cells, to replace light-mediated input from cones. This will restore the natural horizontal cell-derived modulation of light sensitivity to rods, allowing them to function in daylight. Thus, by utilizing our knowledge of specific aspects of retinal circuitry, we aim to develop novel therapies for improving vision in patients with advanced macular degeneration.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834618	**ARTimmune**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator:	**Dr. CARL FIGDOR**
Host Institution:	Stichting Katholieke Universiteit, NL

Programmable ARTificial immune systems to fight cancer

Immunotherapy has entered centre stage as a novel treatment modality for cancer. Notwithstanding this major step forward, toxicity and immunosuppression remain major obstacles, and illustrate the pressing need for more powerful and specific immunotherapies against cancer. To overcome these roadblocks, in ARTimmune, I propose to follow a radically different approach by developing local rather than systemic immunotherapies. Taking advantage of the architecture of a lymph node (LN), I aim to design fully synthetic immune niches to locally instruct immune cell function. I hypothesize that programmable synthetic immune niches, when injected next to a tumour, will act as local powerhouses to generate bursts of cytotoxic T cells for tumour destruction, without toxic side effects. Single cell transcriptomics on LN, obtained from patients that are vaccinated against cancer, will provide unique insight in communication within immune cell clusters and provide a blueprint for the intelligent design of synthetic immune niches. Chemical tools will be used to build branched polymeric structures decorated with immunomodulating molecules to mimic LN architecture. These will be injected, mixed with sponge-like scaffolds to provide porosity needed for immune cell infiltration. Programming of immune cell function will be accomplished by in vivo targeting- and proteolytic activation- of immunomodulators for fine-tuning, and to extend the life span of these local powerhouses. The innovative character of ARTimmune comes from: 1) novel fundamental immunological insight in complex communication within LN cell clusters, 2) a revolutionary new approach in immunotherapy, by the development of 3) injectable- and 4) programmable- synthetic immune niches by state-of-the-art chemical technology. When successful, it will revolutionize cancer immunotherapy, moving from maximal tolerable dose systemic treatment with significant toxicity to local low dose treatment in the direct vicinity of a tumour

Project End Date: **31-OCT-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834940	**SpreadMRI**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. KLAUS SCHEFFLER**
Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Ultra-Fast, Spread-Spectrum Magnetic Resonance Imaging

Imaging speed is a key factor to capture rapid changes at high spatial and temporal resolution. A major limitation of magnetic resonance (MR) imaging is its rather low speed compared to other modalities like ultra sound or computerized tomography. We aim to explore two novel concepts to boost MR imaging speed by another order of magnitude compared to existing techniques. SpreadMRI fundamentally steps beyond current concepts of image encoding by exploiting a spectral spin modulation that so far has not been utilized. SpreadMRI is based on the rapid and local modulation of magnetic fields produced by current loops and/or radiofrequency (RF) loops. Applied spectral modulations are in the MHz range bridging the low-frequency band of switched gradients (kHz) and the 100 MHz range of the Larmor frequency. SpreadMRI spreads the bandwidth of gradient-encoded spin frequencies using distinct carrier frequencies originating from a certain region of the object. This spatially unique information will then be used to disentangle parts of the object, and thus to drastically boost imaging speed. Approaching this intermediate frequency band requires to address several basic research questions related to image reconstruction, electromagnetic coupling, spin Physics and possible biological effects. Based on theoretical analysis and exhaustive electromagnetic simulations of dedicated current loop and RF coil arrangements, including variants of different modulation patterns, several types of SpreadMRI coils for human head imaging at 9.4T will be developed and applied for high temporal and spatial functional brain imaging. The specific approach of SpreadMRI will lead to major changes in the hard- and software environment of current MR-scanners. It will not only provide new insight within the areas covered by the proposal, but will definitely benefit conventional MR diagnostic by enabling new applications with a simultaneous reduction of motion artifacts and increased patient throughput.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850896	**E4I**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. PASCAL GELDSETZER**
Host Institution: Universitaetsklinikum Heidelberg, DE

Improving health services to prevent heart attacks and strokes: Evidence for interventions (E4I) in large middle-income countries

Largely due to the ageing of their populations and changing lifestyles, middle-income countries (MICs) are facing a rapidly increasing burden of heart attacks and strokes. Most of these cardio- and cerebrovascular disease (CCVD) events are preventable through successful treatment of three major risk factors: diabetes, dyslipidaemia, and hypertension. Yet despite the existence of inexpensive and effective medications, only a small minority of adults with these risk factors in MICs successfully transition through the care continuum from screening to effective treatment. There is currently little to no evidence from these settings on what health services interventions are most effective in reducing the loss of patients along the CCVD risk factor care continuum. Focussing on the four most populous MICs – which jointly account for 43% of the world's population – E4I thus aims to i) determine at which of the main steps in the care continuum – screening, linkage to care, and retention in care – the greatest loss of patients occurs; ii) establish which health services interventions have been most effective in reducing the loss of patients at each of these three care steps; and iii) ascertain the causal effect of reducing the loss of patients along the care continuum on individuals' health and economic outcomes. To do so, E4I will use novel causal inference techniques from different academic disciplines on large population-based cross-sectional and cohort datasets with jointly over seven million participants, challenging the frequently-held beliefs in public health that only randomised trials can provide causal effect estimates and that cohort data's principal value is the study of disease aetiology. By generating urgently needed knowledge on how to more effectively deliver proven treatments for a major public health problem in MICs, E4I will decisively advance public health research and has the potential to have an important impact on population health globally.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850936	**PANDORA**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. LORIS RIZZELLO**
Host Institution: Fundacio Institut De Bioenginyeria De Catalunya, ES

Pandemics Outbreaks Rationalized: towards a universal therapy to eliminate intracellular pathogens and drug resistance

I propose here a research vision that aims to revolutionise the way we cure infections caused by intracellular pathogens, with the aim to find a universal therapy to infectious diseases that will also counteract the development of drug resistance. In PANDORA, I will specifically focus on eradicating human tuberculosis, one of the worst pandemics so far. To do this, I will first probe what are the molecular 'bar-codes' of infected cells, namely those specific membrane proteins that cells express upon infection. I will use this to reversely engineer a repertoire of super-selective polymeric nanoparticles - known as Polymersomes - that will carry ligands to recognise, bind, and selectively attack infected cells only, while leaving non-infected cells completely untouched. Such nanocarriers will access the infected cells and locally deliver their payload, which is the core technology of the therapy. Such technology will be inspired by what nature invented: I will reproduce the binding sequence of autolisins, proteins expressed by bacteriophages that specifically bind the wall of Mycobacteria species (the agent causing tuberculosis). I will thus create fusion antibodies (Ab) characterized by (i) the binding sequence of mycobacteriophages autolisins (for selective recognising intracellular Mycobacterial wall) and (ii) an effector region promoting bacterial clearance through either the macrophage-triggered phagocytosis or an ubiquitin-proteasome system. This therapy will represent a complete revolution in the field of new antimicrobial development, as it will combine complete bacterial eradication, development of memory immunity and fight against drug resistance, the three core pillars of this project.

The super-selective polymersomes carrying the Abs-based universal therapy will be combined with the development of chimeric antigen receptor T-cells (CAR-T) against infection. These T-cells will be designed to chase and eradicate circulating infected cells in model organism.

Project End Date: **31-JUL-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850974	**MABSTER**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. ANDREAS LAUSTSEN**
Host Institution: Danmarks Tekniske Universitet, DK

Monoclonal Antibodies with Binding Sensitive To Environmental Regulation

Snakebite envenoming is a Neglected Tropical Disease (NTD) that each year affects 2.5 million victims and kills >100,000, unless they are treated with antivenom. Conventional antivenoms, derived from immunized animals, inflict serum sickness and anaphylaxis in patients, and are costly to manufacture. Monoclonal human antibodies with special toxin-binding properties that are sensitive towards regulation by their microenvironment (e.g. pH), which may be discovered using phage display selection, may solve this issue, providing significant societal impact by enabling the development of cost-effective antivenoms to victims in low and middle-income countries. In this project, phage display selection, high-density peptide microarray technology, and antibody engineering techniques will in three scientific objectives be harnessed in the pursuit of developing novel methodologies for discovery of therapeutic human monoclonal antibodies that are recyclable (can neutralize more than one snake toxin per antibody), broadly cross-reactive (can neutralize different types of snake toxins), and that are both broadly cross-reactive and recyclable at the same time. This will open up for entirely new ways of designing biotherapeutics against complex indications, such snakebite envenoming, but also cancer, infectious, and parasitic diseases, where the targets can be elusive due to hyper-mutability. The ERC Starting Grant offers a unique opportunity to consolidate me as an international key scientific researcher in this field of antibody discovery and NTDs. I have already independently led a research group in this area for 2 years, I have in-depth experience with toxin-targeted antibody discovery (my dr.tech dissertation similar to the German “habilitation” will be submitted during fall 2018), and I am already involved in high level policy in the field of snakebite envenoming via my role as a scientific advisor for the World Health Organization.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850997	**NanoGut**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. ANA BELOQUI GARCIA**
Host Institution: Universite Catholique De Louvain, BE

Exploiting the pathophysiology of the gut towards innovative oral peptide delivery strategies

The development of new oral drug delivery systems that will enable the absorption of therapeutic peptides to the systemic circulation is one of the greatest current challenges for the pharmaceutical industry and is the 'holy grail' of peptide delivery. Improved novel drug delivery systems are of utmost importance in order to fulfill the potential of this route of administration in the treatment of chronic diseases (e.g. type 2 diabetes mellitus), where daily injections are often required.
There are various advantages of using nanocarriers for this purpose: they offer protection against chemical and enzymatic degradation, controlled release, targeting, tolerability and/or improved uptake and translocation resulting in enhanced bioavailability and greater therapeutic efficacy. I was the first to demonstrate that lipid-based nanocarriers trigger endogenous glucagon-like peptide (GLP)-1 and GLP-2 secretion in vivo after orally administered to mice. This effect can be exploited to develop a novel and unconventional drug delivery nanosystem as a promising strategy for the treatment of gastrointestinal disorders (e.g. type 2 diabetes mellitus, Crohn's disease, ulcerative colitis).
There are significant gaps in current knowledge that need to be addressed to make this possible. I propose a series of studies to answer the following key questions: -First, can we develop a dual-action drug delivery nanosystem that synergizes its own biological effect and that of the encapsulated bioactive molecule? -Second, can we ameliorate type 2 diabetes mellitus (T2DM) and inflammatory bowel diseases (IBD) using an oral peptide-loaded dual-action lipid-based nanosystem? –Third, is this innovative strategy a viable alternative to current treatments in T2DM and IBD? By exploiting the gut pathophysiology, I propose an innovative therapeutic approach using cutting-edge advanced technologies to deal with an unmet therapeutical need in the treatment of gastrointestinal disorders.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851231	**THERAUTISM**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. LUCIE PELLISSIER**
Host Institution: Centre National De La Recherche Scientifique, FR

New molecular targets and proof-of-concept therapies for Autism Spectrum Disorders

Autism is the major neurodevelopmental health public issue, affecting 1/100 child births worldwide. These disorders are diagnosed before the age of 3, based on behavioural cues: deficits in social interaction and communication as well as stereotyped and restrained behaviours. There is no medication to improve this condition. Most recent molecular targets identified within narrow frameworks (unspecific molecule, single tissue targeted, single disease model used) have failed in clinical trials. My first objective aims at thwarting this autism research gap, unravelling the common molecular and cellular dysfunctions underlying autism-related behaviours across several preclinical models and neuronal circuits. In particular, setting up translatomic analyses in these paradigms will identify and validate new molecular therapeutic targets. I recently deciphered one such molecular substrate, involving the loss of oxytocin transcripts in oxytocinergic axon terminals thus demonstrating the feasibility of this global approach. The second major objective of my project is to hijack the properties of a newly identified protein function to restore this new target and rescue social deficits in different preclinical models of autism. This would yield a novel and safe gene therapy vector which has never been explored before. Altogether, my research project will deliver strategic resources to the scientific and medical communities that will spur the development of new treatment options for autistic patients.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851241	**TroyCAN**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. MARIA GENANDER**
Host Institution: Karolinska Institutet, SE

Redefining the esophageal stem cell niche – towards targeting of squamous cell carcinoma

Cancer develops from mutations in stem and progenitor cells. Patients suffering from esophageal squamous cell carcinoma are commonly treated by a combination of chemotherapy and esophagectomy, a debilitating surgical procedure. My group have identified heterogeneity within the esophageal progenitor population in homeostasis which is likely to have implications for the development of squamous cell carcinomas of the esophagus, lead to targeted therapeutic strategies and hopefully reduce the need for surgical intervention. Stem and progenitor cells reside in a complex microenvironment, or niche, that is instructive in determining cell fate during homeostasis and tumor initiation. In the morphologically uniform esophageal epithelium, the presence of progenitor subpopulations cells as well as local microenvironmental niches is not evident. My group aim to not only delineate the functional heterogeneity within the esophageal progenitor population during homeostasis and cancer development, but also map out and eventually target the stromal niche cells driving this phenotypic epithelial heterogeneity. Furthermore, we will use a clinically relevant platform to screen for druggable targets with the ability to eliminate esophageal tumor initiating cells. The incidence of human esophageal squamous cell carcinomas is dramatically increasing, and delineation of the esophageal stem cell niche is a vital first step towards identifying new combined therapeutic strategies directed at eliminating this cancer.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851936	**OBSERVE**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. PIETER VADER**
Host Institution: Universitair Medisch Centrum Utrecht, NL

Overcoming cellular barriers to therapeutic RNA delivery using extracellular vesicles

RNA-based therapeutics, including siRNA, miRNA, mRNA and CRISPR/Cas9 components, have unprecedented therapeutic potential and hold the promise of treating any disease with a genetic component. However, inefficient delivery into diseased cells hinders their clinical progress. Consequently, there is an urgent need for novel, original approaches to overcome the delivery challenges.

Recently, an endogenous RNA transport system has emerged, based on the release and uptake of extracellular vesicles (EVs). EVs are naturally equipped to transfer RNA molecules to other cells in a functional and selective manner. Furthermore, I have recently demonstrated that EVs deliver RNA more efficiently than state-of-the-art synthetic RNA nanocarriers. Thus, EVs hold promise as a new paradigm for RNA delivery. However, the mechanisms underlying EV-mediated RNA transfer are unknown, and reproducible methods for efficient loading of EVs with therapeutic RNA are lacking.

The aim of my proposal is to (1) elucidate the mechanisms underlying EV internalization and processing that lead to the functional delivery of their RNA content and (2) radically improve the loading efficiency of EVs for therapeutic RNA delivery. To realize this, I will:

1) Identify genes and pathways involved in EV-mediated RNA transfer using a novel CRISPR/Cas9-based RNA delivery reporter system.

2) Systematically compare uptake and intracellular trafficking of EVs and synthetic nanocarriers.

3) Design a novel and improved method to load EVs with therapeutic RNA.

4) Demonstrate the effect of EV-mediated delivery of therapeutic RNA in a murine model of myocardial infarction.

The outcome of this research will fundamentally advance our understanding of the cellular processes enabling EV-mediated RNA transfer, which is of crucial importance for the development of EV-based and EV-inspired delivery systems. This research will accelerate clinical translation of an entire new class of therapeutics based on EVs and RNA.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852220	**TrackCycle.2P**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. CHRISTINA SCHWARZ**
Host Institution: Eberhard Karls Universitaet Tuebingen, DE

Exploring Visual Processes with Two-Photon Ophthalmoscopy

In vivo methods to objectively assess retinal physiology are rare among existing imaging techniques. To accelerate the diagnosis of progressive outer retinal disease and the development of treatment before vision is seriously impaired, there is a need for such methods that can quantify visual cycle kinetics in the living eye.

Two-photon ophthalmoscopy shows potential to provide new information in this regard paired with microscopic resolution of retinal morphology. The technique can noninvasively track the visual cycle via the transient fluorophore all-trans-retinol in rods and cones separately. In this proposal, we aim to establish two-photon ophthalmoscopy as a method to assess outer retina function and to explore its prospect towards clinical application.

An adaptive optics scanning laser ophthalmoscope optimized for safe two-photon imaging in the human eye will be developed. With this instrument, we will quantify the visual cycle in rods versus cones in response to stimulation in healthy human subjects. Particularly the cone visual cycle is not yet fully understood and requires further study. Further, the visual experience of subjects exposed to two-photon ophthalmoscopy will be investigated. The technique uses a pulsed laser as imaging source aimed to evoke nonlinear processes in the retina that can potentially be perceived by the subjects. A detailed understanding of these pathways will provide greater insight into the first steps of vision and help to design suitable stimulus paradigms to test visual cycle function.

Successful implementation of two-photon ophthalmoscopy in the human eye promises to deepen our knowledge of normal and abnormal visual cycle function and further our understanding of retinal biochemistry in health and disease.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852373	**MultiSeroSurv**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator:	**Dr. MICHAEL WHITE**
Host Institution:	Institut Pasteur, FR

Algorithms and multiplex assays for integrated serological surveillance of malaria and neglected tropical diseases

Malaria and neglected tropical diseases (NTDs) such as lymphatic filariasis, onchocerciasis, trachoma and schistosomiasis affect almost 2 billion people every year. Coordinated targeting of these diseases will aid future control and elimination campaigns, but this will require integrated surveillance strategies. Malaria surveillance is routinely implemented through cross-sectional surveys where blood samples are tested for parasites. A major barrier to routine NTD surveillance is the range of samples required for parasite diagnosis: stool, urine, blood, eye swabs and skin snips. Instead of direct detection of parasites, there is an opportunity to implement serological surveillance by measuring antibodies to multiple pathogens in blood samples collected for malaria surveillance.

This proposal has four aims: (i) Characterise the sero-epidemiology of malaria and NTDs in longitudinal cohort studies in Senegal, Ethiopia, Cambodia and Papua New Guinea; (ii) Measure antibodies to 34 antigens from 12 pathogens from single blood samples; (iii) Model antibody kinetics and validate the use of serology for detecting infections; and (iv) Demonstrate how a population's concurrent and past exposure to multiple parasites can be estimated by analysing multiplex data from cross-sectional surveys.

These aims will be achieved through innovative epidemiological studies, new technologies, and especially developed analytic methods, including: (1) utilisation of multiplex bead-based Luminex assays; (2) mixed-effects models in a Bayesian framework with data augmentation to identify serologically suspected infections, with validation against confirmed infections; and (3) statistical algorithms for reconstructing long-term and recent transmission trends. This interdisciplinary project will undertake fundamental research in analytic methods for processing complex multiplex data and converting it to the actionable information needed for integrated serological surveillance of malaria and NTDs.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852814	**TAVI4Life**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. MAXIMILIAN Y. EMMERT**
Host Institution: Universitaet Zuerich, CH

A lifelong transcatheter aortic valve prosthesis

Transcatheter aortic valve implantation (TAVI) techniques have revolutionized the therapy options for valvular heart disease. Initially developed for elderly high-risk patients, TAVI is being extended to younger patients and may become a first-line treatment in the near future.
However, the available bioprostheses for TAVI are prone to degeneration, and patients may thus require multiple re-interventions, significantly affecting their life quality. To date, a native-analogous TAVI prosthesis with in-situ remodeling capacity does not exist. Tissue engineered (TE) heart valves represent a potential solution, but are not yet suitable for high-pressure applications and lack clinical translation because of uncontrolled in-vivo remodeling, impairing their long-term functionality.
In the TAVI4Life project, I aim to develop and validate a novel TAVI prosthesis for young patients with the unique ability to transform into a fully autologous valve within the body and last for life. This project will go far beyond previous TE concepts by engineering a novel decellularized human ECM and a bioresorbable stent and applying an unconventional bioengineering approach combining in-vitro, in-silico, and in-vivo TE methods. First, I will engineer and characterize a clinical-grade ECM for high-pressure conditions and test patient-specific immuno- and hemocompatibility profile (in-vitro). Next, using computational modeling, I will design and develop a bioresorbable stent and implement an analytical valve design to develop the transcatheter prosthesis (in-silico). Finally, I will evaluate valve performance and remodeling in a preclinical large animal model (in-vivo). This highly multidisciplinary approach will lead to a valve prosthesis that lasts for life, as guided in-situ tissue remodeling will enable their long-term performance. The clinical impact will be enormous as, particularly for young patients, the TAVI4Life will significantly enhance their life expectancy and quality of life.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852832	**RARITY**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. NOEL DE MIRANDA**
Host Institution: Academisch Ziekenhuis Leiden - Leids Universitair Medisch Centrum, NL

RAtional design of canceR ImmunoTherapY: one size does not fit all

Checkpoint blockade immunotherapies have revolutionized cancer treatment. However, this immunotherapy only benefits a minority of patients (< 15%), mainly those diagnosed with cancers having many mutations. Furthermore, checkpoint blockade therapy does not selectively activate cancer-reactive T cells.

RARITY responds to these shortcomings, aiming to provide innovative solutions for the development of effective immunotherapies for patients who do not benefit from current treatments. The ground-breaking preliminary data included in this application demonstrates that cancer-reactive T cells can be naturally present in so-called non-immunogenic cancers and that they acquire distinctive phenotypes. RARITY will apply state-of-the-art technologies to fingerprint these phenotypes. This will allow the isolation of cancer-reactive T cells from tumour tissues and their employment as highly-effective therapies. Therapeutic vaccination with cancer antigens can also be used to induce T cell responses in patients where natural activation of cancer-specific T cells is not detectable. However, the applicability of vaccination is compromised by the lack of specific targets, particularly in malignancies with few mutations. RARITY will address this problem by deploying a novel class of cancer antigens. An unprecedented screening of non-exomic genomic regions will be done to detect unannotated proteins that arise from de novo transcription and translation events. These proteins can then be targeted by personalized immunotherapies. Finally, thought-provoking findings included in RARITY suggest that immune cell subsets other than T cells play a major role in anti-tumour immune responses. These subsets need to be fully inventoried and categorised so that complementary strategies to T cell immunotherapies can be developed. RARITY will do so by conducting multidimensional analysis of cancer microenvironments using imaging mass cytometry and ex vivo modulation of immune responses.

Project End Date: **30-NOV-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
853568	**EPOCHAL**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. MARLOES EEFTENS**
Host Institution: Schweizerisches Tropen- Und Public Health-Institut, CH

Beyond seasonal suffering: Effects of Pollen on Cardiorespiratory Health and Allergies

As climate change increases the duration and intensity of the pollen season, allergies to airborne pollen are increasingly common in Europe. Yet, it is not well recognized that high pollen concentrations may increase respiratory and cardiovascular events, leading to mortality and excess hospitalizations. I aim to investigate how short-term exposure to pollen is related to mortality, hospitalization and allergic symptoms, both on its own and synergistically with air pollution and weather.

I will develop spatiotemporal exposure models of pollen for the years 2003-2022 based on a network of 14 pollen measurements stations in Switzerland. Taking advantage of large, real-world datasets without selection bias (Swiss National Cohort) and the efficient case-crossover study design, I will investigate the population effects of pollen on daily respiratory and cardiovascular mortality and hospitalization, also accounting for variation in air pollution and weather conditions. To explore individual sensitivity, I will conduct repeated measurements of lung function and airway inflammation in a dedicated panel of 400 allergic patients complemented with opportunistic repeated accounts of self-reported symptoms from the “e-symptoms” app by Swiss Allergy Centre. To provide personalized prevention recommendations and enhance quality of life for the allergic population, I will derive exposure-response relationships based on prevalent pollen, air pollution and weather triggers and individual symptom reports, allowing me to ultimately forecast symptom severity using machine learning techniques.

This highly innovative project utilizes available nationwide health datasets and systematic novel data collection methods (in the in-depth panel study), to better understand the role of pollen in respiratory and cardiovascular diseases at both personalized and population levels. The project will prevent and reduce health effects due to pollen, which constitute a large burden on health and economy.

Project End Date: **31-JUL-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864055	**PREDICT-HF**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. STEVEN NIEDERER**
Host Institution: King'S College London, UK

Predicting Outcome of Rate or Rhythm Control in Patients with Atrial Fibrillation and Heart Failure

Heart failure (HF) and atrial fibrillation (AF) are common co-morbidities (AF-HF). AF-HF is prevalent in Europe with high rates of hospitalisation and death. AF-HF patients have two treatment options: rate control, where AF is not treated but drugs are used to slow the heart rate, or rhythm control, where AF is treated to restore sinus rhythm. Rate control is the first-line treatment, yet specific patient groups do much better under rhythm control. Identifying patients that will do best under rhythm control remains a significant clinical challenge.

Potential responders to rhythm control can be identified by their disease history, however, this is often unknown, or their response to treatment, which can only be observed once the therapy has been delivered. We propose to address these challenges by developing patient specific biophysical cardiac models to infer patient history and predict patient response to treatment to inform optimal therapy selection for individual patients.

A model for simulating AF-HF in human hearts, representing all four cardiac chambers, will be created. Bayesian uncertainty quantification techniques will be used to combine physical laws, physiology, population data and measurements from individual patients into cardiac models that account for data uncertainty in model parameters and simulation predictions.

Patient specific cardiac models will be used to answer three critical clinical questions in prospective studies. Models will be used to predict: if AF led to HF, or HF led to AF in AF-HF patients where the index disease is unknown, response to rhythm control therapy in AF-HF patients and in which AF-HF patient's rate or rhythm control is best.

This proposal outlines an ambitious high risk/return program to address key technical challenges in bringing predictive patient specific models into clinical studies and will apply these innovative techniques to address important clinical questions on the treatment of patients suffering AF-HF.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864832	**ANTIBIOCLICKS**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. RUBEN HARTKOORN**
Host Institution: Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

BioInspired Clicked Siderophore-Antibiotics

The frightening increase in antibiotic drug resistance is threatening global healthcare as we know it. To this extent the World Health Organisation that has classes M. tuberculosis and Gram-negative nosocomial infections as the highest priority for novel R&D strategies. A major obstacle to drug discovery programs is to design inhibitors that can efficiently enter into bacteria. One such stealth strategy is exemplified by natural siderophore-antibiotics conjugates (sideromycins) that piggyback the bacterial iron acquisition machinery to enter bacteria. This Trojan-horse strategy has inspired the chemical synthesis of numerous sideromycin conjugates, with cefiderocol a current preclinical candidate. Despite the advances in this field, natural examples of sideromycins are still scarce, and finding new examples may provide further insight into siderophore antibiotic formation and delivery. ANTIBIOCLICKS will investigate a unique bioinspired conjugation chemistry that has been uncovered from a newly discovered natural sideromycin. This natural “click” chemistry is ideal for the coupling of catecholate containing siderophores (such as those of the WHO prioritised M. tuberculosis, A. baumannii, E. coli, P. aeruginosa and K. pneumonia) to antibiotics or other molecules. This project will aim to define the exact chemical mechanism behind this novel and surprisingly simple conjugation reaction, and use this unique and facile chemistry to generate a combinatorial library of siderophores with antibiotics and fluorophores. These products will subsequently be used to probe the exact mechanism of bacterial sideromycin uptake, potential intracellular decoupling and target engagement. Finally, the antibiotic and diagnostic potential of the generated siderophore conjugates will be evaluated. To this extent, ANTIBIOCLICKS will provide illuminating insight into new bioinspired conjugation chemistry, and evaluate its potential for novel bacterial therapeutics and diagnostics.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865792	**MIMICH**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. JENNY MYERS**
Host Institution: The University Of Manchester, UK

Metformin Impact on Maternal and Infant Cardiometabolic Health

Increasing numbers of older, obese women with poor cardiometabolic health (dyslipidaemia, hyperglycaemia, hypertension) are embarking on pregnancy. One in six of these high-risk pregnancies are complicated by an indicated preterm birth due to fetal growth restriction (FGR) or fetal overgrowth and/or maternal complications including gestational diabetes and pre-eclampsia. The cumulative cost of neonatal care, childhood and adult disease in individuals born preterm has been estimated at £1-3 billion pa in the UK. Older age, obesity, dyslipidaemia and hypertension are major risk factors for placental disease leading to FGR and pre-eclampsia. Conversely, hyperglycaemia is associated with fetal overgrowth and is therefore treated with hypoglycaemic agents such as metformin during pregnancy. In women with hyperglycaemia and concurrent risk factors for placental disease, the impact of metformin on placental function, fetal growth, and postnatal outcomes is not known. To address this evidence gap, I will perform an RCT which will incorporate a novel method of tracking fetal growth and investigate the impact of metformin on maternal and infant metabolic health at 12 months. The impact of metformin on gene expression and placental function will be assessed in placentas from women exposed (or not) to metformin. In the wider group of women with poor cardiometabolic health, I will map maternal disease biomarkers and fetal growth to molecular placental disease subtypes who have developed a range of pregnancy complications. The goals of this work are to improve pregnancy outcomes in women with poor cardiometabolic health by, (1) producing evidence to personalise the prescription of metformin (2) refining current diagnostic criteria to better reflect placental disease molecular subtypes, (3) understanding the associations between cardiometabolic health and placental disease such that drugs to treat hyperglycaemia, hypertension, dyslipidaemia can be tested in the right women.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865797	**DITSB**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. ANNARITA MICCIO**
Host Institution: Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

Development of Innovative Therapeutic Strategies for beta-hemoglobinopathies

Beta-thalassemia and sickle cell disease (SCD) are caused by mutations affecting the synthesis or the structure of the adult hemoglobin (Hb) beta-chain. The only definitive cure is transplantation of allogeneic hematopoietic stem cells (HSCs) from an HLA-matched donor, an option available to <30% of the patients. The clinical severity of beta-hemoglobinopathies is alleviated by the co-inheritance of mutations causing expression of fetal gamma-globin in adult life - a condition termed hereditary persistence of fetal hemoglobin (HPFH). Transplantation of autologous, genetically modified HSCs is an attractive therapeutic option for patients lacking a suitable donor. To this aim, genome editing approaches based on the use of site-specific nucleases have been explored by many groups, including ours. These approaches may either revert the single point mutation causing SCD or reactivate fetal globin expression, by mimicking HPFH mutations or by decreasing the level of BCL11A, a master repressor of fetal Hb synthesis. Site-specific nucleases, however, generate double-strand breaks (DSBs) in the genome and raise safety concerns for clinical applications, particularly when used in DSB-sensitive HSCs. In this proposal, we aim at exploiting targeted base-editing to develop novel, efficacious and safe strategies for beta-hemoglobinopathies without generating DSBs. This will be attempted by (i) correcting the SCD-causing mutation, (ii) mimicking HPFH mutations in the gamma-globin promoters, or (iii) modulating the activity of a BCL11A erythroid-specific enhancer. These approaches will be tested in human adult erythroid cell lines and patient HSCs, differentiated in vitro and in vivo into mature red cells to evaluate editing efficiency, fetal Hb expression, phenotypic cell correction and biosafety. The ultimate goal of the project is to provide sufficient proof of efficacy and safety to enable the clinical development of base-edited HSCs for the therapy of beta-hemoglobinopathies.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866411	**CompHematoPathology**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. CARSTEN MARR**
Host Institution: Helmholtz Zentrum Muenchen Deutsches Forschungszentrum Fuer Gesundheit Und Umwelt Gmbh, DE

Computational Hematopathology for Improved Diagnostics

Identifying hematologic malignancies still relies on the time-consuming and subjective visual assessment of images. Every day, cytologists and pathologists are confronted with rare diagnostic cells, ever-increasing image data, and heterogeneous disease manifestations. Although we understand blood better than any other human tissue, we are unable to quantitatively predict a patient's blood dynamics from a measurement. Diagnosis thus depends on rough staging schemes and the expertise and intuition of the clinician.

In my proposal, I address these challenges by establishing computational hematopathology, a combination of artificial intelligence algorithms and mathematical models that will boost the currently prevailing manual assessment. Based on my experience in using these methods for scrutinizing stem cell differentiation I will combine the power of deep learning and mathematical modeling with digitized and expertly annotated image data. My unique approach enables me to design and parametrize a data-driven model to predict hematopoietic dynamics in health and disease. Since the interpretation of digitized slides is becoming the clinical standard, novel algorithms for standardized disease classification and improved diagnosis are critically needed now.

This interdisciplinary project merges methods from digital pathology, machine learning, image processing, and mathematical modeling. ComHematoPathology will provide novel approaches and software tools for automated classification of hematopathology image data, allowing for reproducible and precise diagnosis at an unprecedented level. This will increase throughput and standardize the diagnosis of blood diseases and will thus improve the treatment of patients suffering from hematologic malignancies.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866448	**TrojanDC**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. CARLOS FILIPE RIBEIRO LEMOS PEREIRA**
Host Institution: Lunds Universitet, SE

Harnessing dendritic cell reprogramming for cancer immunotherapy

An important hallmark of cancer is the ability to evade the immune system. Genetic mutations in tumor cells result in the accumulation of tumor antigens (TAs), however, increased cell heterogeneity, downregulation of antigen presentation or inhibition of immune cell infiltration allows immune surveillance evasion. For the first time, direct cell reprogramming offers exciting opportunities to overcome these challenges. My group has recently identified a combination of transcription factors (TFs) sufficient to reprogram mouse fibroblasts into antigen-presenting dendritic cells (DCs), providing a new strategy to set in motion antigen-specific immune responses. I hypothesize that a similar combination reprograms tumor cells into antigen presenting cells (APCs). This proposal aims to test a cancer immunotherapy concept based on DC reprogramming and endowed APC function in tumor cells.

The work will proceed in three steps. First, I will define optimal TF combinations and external cues to efficiently reprogram human fibroblasts into DCs employing an innovative single-cell screen. Then, I will reprogram mouse and human tumor cells into tumor-APCs followed by characterization of transcriptome, chromatin accessibility, surface peptidome and ability to present antigens to T cells. Finally, I will test whether reprogrammed cells mount an attack against tumors in mouse models. I will further test the hypothesis that intratumoral delivery of reprogramming factors elicits in vivo antigen presentation, immune cell recruitment and tumor regression.

The approach proposed here will combine DCs' antigen processing and presenting abilities with the endogenous generation of TAs. The induction of DC identity in cancer cells with ability to present a constellation of TAs will open new research and therapeutic avenues. This project represents a pioneering contribution by merging cell reprogramming and cancer immunotherapy, paving the way for an entirely new approach to cancer gene therapy.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866478	**UCARE**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator:	**Dr. HESTER DEN RUIJTER**
Host Institution:	Universitair Medisch Centrum Utrecht, NL

Uncovering the epigenetic signature of female-specifiC biological networks and key driver genes of coronary ArteRy diseasE

Cardiovascular disease causes 51% of deaths in women and 42% of deaths in men in Europe. Women are contributing mostly to the worrying trend of increases in hospitalizations for coronary artery disease (CAD) at younger ages. Missed and delayed diagnoses in women are more common than in men, as the pathophysiology of CAD in women is different than in men. Men often have atherosclerotic plaque rupture as underlying mechanism for CAD whereas women more often suffer from plaque erosion. Plaque erosion refers to thrombus formation on top of an intact non-ruptured plaque in the coronary artery.

Early recognition of plaque erosion will, therefore, specifically aid in the diagnosis of CAD in women. However, knowledge on CAD and plaque erosion in women is lagging behind. This is due to the underrepresentation of women in clinical trials for CAD and biobank studies. This gap is now only gradually being recognized in research, but not yet fully addressed as pooling of data from both sexes is still common practice. My research efforts have convincingly contributed to the awareness that sex differences in human diseased vascular tissue are relevant. With my group I have shown that sex differences are specifically evident in regulatory gene networks and key player genes for CAD. This also corresponds with sex-specific epigenetic signatures of atherosclerotic plaques, and human endothelial gene expression patterns.

In UCARE, I propose to utilize vascular tissues and plaque samples from well-powered studies to analyze these by sex to a single-cell level. This approach will identify female-specific key player genes in individual cells of plaques and unravel clinically relevant female-specific biology of CAD and plaque erosion. These findings will be translated to systemically expressed DNA methylation profiles in cell free DNA in plasma to move towards early diagnostics. This is a necessary and challenging step towards closing the diagnostic gap between men and women.

Project End Date: **27-AUG-25**

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Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866510	**TRANSLATIONAL**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. ANDERS ROSENGREN**
Host Institution: Goeteborgs Universitet, SE

A new translational strategy for tailored treatment of type 2 diabetes

Type 2 diabetes (T2D) is an escalating health problem of enormous proportions. Current treatment strategies are unable to stop disease progression and prevent the devastating complications. Clinical guidelines emphasise the need for personalized treatment. However, this is currently implemented on trial-and-error fashion.

We have recently found that T2D patients can be divided into four clusters, each with different characteristics. This represents a major step forward by pointing out the high variability of the pathophysiology and leads us to propose that anti-diabetic treatment should ideally target the underlying pathophysiology of each patient.

The overall goal is to test this proposition by targeting existing and new treatment to patients who are archetypes of the two most severe T2D clusters, characterised by poor insulin secretion and pronounced insulin resistance, respectively.

As a starting point, we will study how treatment response to existing drugs is influenced by pathophysiological features and also the gut microbiota. Next, we will expand on our recent demonstration that b-cells dedifferentiate in T2D and define the functional and gene expression changes that cause secretory failure. These mechanistic insights will be used to identify new targets for b-cell preservation, which is essential to stop disease progression, in particular in patients with poor secretion. Finally, we will study new compounds for tailored treatment, including sulforaphane as an early intervention for those with severe insulin resistance.

My combined training in cell-physiology, bioinformatics and clinical medicine is unusual but necessary to conduct this multi-disciplinary programme. Whilst the programme builds firmly on my past research, it extends far beyond what I have attempted previously by exploiting novel state-of-the-art methodology to address central metabolic questions of high relevance to understand the causes, management and – ultimately – prevention of diabetes.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
884952	**UniMab**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator:	**Dr. GIULIO COSSU**
Host Institution:	Ospedale San Raffaele, IT

Immune-privileged, immortal, myogenic stem cells for gene therapy of Muscular Dystrophy.

Duchenne muscular dystrophy (DMD) is a devastating incurable disease, affecting thousands with heavy burden on health systems. This project combines the development of a safe, "immune-privileged cell" with genetic engineering to correct many dystrophin gene mutations for an efficacious and cost affordable therapy. The applicant pioneered systemic intra-arterial transplantation of mesoangioblasts (blood vessel-derived progenitors) that proved safe in DMD patients and is being implemented for efficacy. However, this personalised approach would prove prohibitively expensive for healthcare systems, as pricing of successful gene therapies is showing. We made the striking observation that human mesoangioblasts can be indefinitely expanded with a novel culture medium, even after genetic manipulation and cloning. Cells will be first genome edited to delete endogenous HLA (β2-microglubin and class II CTA) while inserting tolerogenic HLA-E, fused to β2-microglubin and, as safety device, the Herpes Simplex Thymidine Kinase suicide gene with truncated NGF receptor for selection. Edited clones will be checked for genome integrity. Selected clones will be engineered to express a small nuclear RNA (snRNA) that causes skipping of a given exon of the dystrophin gene. Due to the syncytial nature of muscle fibres, the snRNA also enters and corrects the genetic defect in neighbouring, dystrophic nuclei, thus amplifying of one log the therapeutic effect. Five different cell lines would correct the mutation in 60% of DMD patients. The cell lines will be transplanted in humanized DMD mice and assessed for the ability to escape immune surveillance and to differentiate in dystrophin expressing myofibers, establishing pre-clinical safety and efficacy for an off the shelf, affordable product. The applicant has unique expertise to successfully complete this project, whose strategy may be expanded to other recessive monogenic diseases, for a ground breaking impact in regenerative medicine.

Project End Date: **31-DEC-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
640384	**RuMicroPlas**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. Itzhak Mizrahi**
Host Institution: Ben-Gurion University of the Negev, IL

The Plasmidome: a Driving Force of Rumen Microbial Evolution from Birth to Adulthood

Plasmids are known to be major contributors to lateral gene transfer in bacterial genomes; however, their comprehensive evolutionary role within bacterial communities is poorly understood. Recently we have developed cutting edge abilities to access a plasmid population (plasmidome) of a given microbial community, and applied them to rumen microbial communities. These abilities are an element long-needed for the study of microbial lateral gene transfer and evolution. Ruminants house a highly complex microbial community in the rumen compartment of their digestive tract, with which they have evolved into an obligatory co-dependence. Its confined nature provides a perfect system for the study of evolutionary dynamics within microbial communities.

Here we propose to study the evolutionary and ecological dynamics of the rumen plasmidome and its interaction with the rumen microbiome using our established approaches, together with a dense host-sampling resolution. We aim to understand the origins and assembly of these two entities, as well as their interactions with each other. We will explore the effect of early assemblages on the adult plasmidome and microbiome phenotypes. To complement the overview of global trends, we will study local interactions among individual rumen plasmids with their microbial host's genome and physiology at the single-plasmid level. These two distinct perspectives will allow us to understand the role played by plasmids within this complex microbial community, the co-evolutionary relationships between these two entities and their importance to the overall rumen ecosystem.

Based on a plasmid-centric approach, this study bears the unique ability to examine lateral gene transfer in “real time” by following genes on their transfer “vehicles”, and providing new insights into the fine details of microbial evolution. Its goals, many challenges and new approach place this proposal at the cutting edge of current research in microbial ecology and evolution.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714916	**LEAF-FALL**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. MATTEO CAMPIOLI**
Host Institution: Universiteit Antwerpen, BE

What makes leaves fall in autumn? A new process description for the timing of leaf senescence in temperate and boreal trees

Leaf phenology is a key component in the functioning of temperate and boreal deciduous forests. The environmental cues for bud-burst in spring are well known, but little is known about the cues controlling the timing of leaf fall in autumn. Leaf fall is the last stage of leaf senescence, a process which allows trees to recover leaf nutrients. We urgently need to understand the controls timing leaf senescence to improve our projections of forest growth and climate change. I propose a new general paradigm of the onset of leaf senescence, hypothesizing that leaf senescence is triggered by the cessation of tree growth in autumn. I expect that: (i) in the absence of growth-limiting environmental conditions, tree growth cessation directly controls leaf-senescence onset; and (ii) in the presence of growth-limiting conditions, photoperiod controls leaf-senescence onset – this prevents trees from starting to senesce too early. I will test these hypotheses with a combination of: (i) manipulative experiments on young trees - these will disentangle the impact of photoperiod from that of other factors affecting tree growth cessation, namely: temperature, drought and soil nutrient availability; (ii) monitoring leaf senescence and growth in mature forest stands; (iii) comparing the leaf senescence dynamics of four major tree species (Fagus sylvatica, Quercus robur, Betula pendula and Populus tremula) in four European locations spanning from 40º to 70º N; and (iv) integrating the new paradigm into a model of forest ecosystem dynamics and testing it for the major forested areas of Europe. The aim is to solve the conundrum of the timing of leaf senescence in temperate and boreal deciduous trees, provide a new interpretation of the relationship between leaf senescence, tree growth and environment, and deliver a modelling tool able to predict leaf senescence and tree growth, for projections of forest biomass production and climate change.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715874	**FLIGHT**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. EMILY SHEPARD**
Host Institution: Swansea University, UK

The true costs of bird flight: From the laboratory to the field

Flight is thought to be one of the most energetically costly of bird activities. These costs matter by virtue of their magnitude, as factors affecting flight costs can have a disproportionate impact on the overall energy balance. Flight costs are fundamentally linked to airflows, as well as behavioural responses to them, because birds react to horizontal and vertical currents by changing flight mode (i.e. flapping/ gliding), speed and route. Even minor route adjustments can radically affect the flow conditions that birds experience due to the uniquely dynamic and heterogeneous nature of the aerial environment. Yet our understanding of how airflows impact birds is in its infancy, being constrained by a lack of information on the metabolic costs of flight. Currently, the main methods for measuring flight costs in the laboratory either restrain the bird (thereby increasing energy expenditure) or suffer from low resolution, and field methods do not allow costs to be resolved in relation to fine scale movement paths. FLIGHT will use interdisciplinary approaches, integrating laboratory and field techniques, to address these grand challenges. Breakthrough methodologies will be used to (1) measure the costs of unrestrained bird flight in the laboratory and (2) derive a new proxy for power use in flight that is linked to flight performance, using accelerometry measurements from cutting-edge data loggers. Loggers will then be (3) deployed on wild birds to quantify their responses to airflows and the energetic consequences over fine scales. This will provide completely novel, mechanistic insight into the way the physical environment impacts flight costs, and (4) enable variation in flight–related energy expenditure to be modelled geographically and seasonally in model species. Overall, FLIGHT will provide new macro-ecological insight into relationships between bird distributions and flow conditions and inform assessments of how birds may be affected by changing wind regimes.

Project End Date: **31-MAR-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724173	**RETVOLUTION**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. TONI GABALDÓN**
Host Institution: Fundacio Centre De Regulacio Genomica, ES

Reticulate evolution: patterns and impacts of non-vertical inheritance in eukaryotic genomes.

The traditional view is that species and their genomes evolve only by vertical descent, leading to evolutionary histories that can be represented by bifurcating lineages. However, modern evolutionary thinking recognizes processes of reticulate evolution, such as horizontal gene transfer or hybridization, which involve total or partial merging of genetic material from two diverged species. Today it is widely recognized that such events are rampant in prokaryotes, but a relevant role in eukaryotes has only recently been acknowledged. Unprecedented genomic and phylogenetic information, and recent work from others and us have shown that reticulate evolution in eukaryotes is more common and have more complex outcomes than previously thought. However, we still have a very limited understanding of what are the impacts at the genomic and evolutionary levels. To address this, I propose to combine innovative computational and experimental approaches. The first goal is to infer patterns of reticulate evolution across the eukaryotic tree, and relate this to current biological knowledge. The second goal is to trace the genomic aftermath of inter-species hybridization at the i) long-term, by analysing available genomes in selected eukaryotic taxa, ii) mid-term, by sequencing lineages of natural fungal hybrids, and iii) short-term, by using re-sequencing and experimental evolution in yeast. A particular focus is placed on elucidating the role of hybridization in the origin of whole genome duplications, and in facilitating the spread of horizontally transferred genes. Finally results from this and other projects will be integrated into emerging theoretical frameworks. Outcomes of this project will profoundly improve our understanding of reticular processes as drivers of eukaryotic genome evolution, and will impact other key aspects of evolutionary theory, ranging from the concept of orthology to the eukaryotic tree of life.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724324	**macroevolution.abc**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. LEE HSIANG LIOW**
Host Institution: Universitetet I Oslo, NO

Abiota, Biota, Constraints in Macroevolutionary Processes

To what degree do microevolutionary processes that happen on a generational time scale matter for macroevolutionary patterns recorded on time scales of millions of years in the fossil record? To answer this fundamental question in evolutionary biology, we need a model system in which we can overcome the conceptual and empirical boundaries imposed by disparate timescales. macroevolution.abc will develop bryozoans as the Drosophila of macroevolution, integrating molecular, fossil, phenotypic, ecological and environmental data to shed light on the currently inaccessible “Dark Time Scale” (thousands, to tens of thousands of years), spanning the chasm between microevolution studied by population geneticists and evolutionary ecologists and macroevolution studied by paleontologists and comparative phylogeneticists. Using bryozoans, a little-known but uniquely ideal study group for evolutionary questions, I will generate, then cross-integrate, (i) empirical time series of intra- and interspecific biotic interactions; (ii) phenotypic data describing variation within genetic individuals, variation among contemporaneous individuals in both extinct and living populations; (iii) robust estimates of abundance shifts in fossil populations; and (iv) speciation and extinction rate estimates from molecular phylogenies and the fossil record. The new bryozoan model evolutionary system will provide answers to previously intractable questions such as “do ecological interactions crucial for individual survival matter for group diversification patterns observed on geological time scales” and “why do we have to wait a million years for bursts of phenotypic change”?

Project End Date: **31-DEC-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725419	**COMPCON**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator:	**Dr. SARA MAGALHÃES**
Host Institution:	Fciencias.Id - Associacao Para A Investigacao E Desenvolvimento De Ciencias, PT

Competition under (niche) construction

Interspecific competition is arguably the best interaction to address how individual trait variation and eco-evolutionary feedbacks shape species distributions and trait evolution, due to its indirect effects via the shared resource. However, a clear understanding of such feedbacks is only possible if each contributing factor can be manipulated independently. With COMPCON, we will address how individual variation, niche width, niche construction and the presence of competitors shape species distributions and trait evolution, using a system amenable to manipulation of all these variables. The system is composed of two spider mite species, Tetranychus urticae and T. ludeni, that up- and down-regulate plant defences (i.e., negative and positive niche construction, respectively). Tomato mutant plants with low defences will be used as an environment in which niche construction is not expressed. Furthermore, tomato plants will be grown under different cadmium concentrations, allowing quantitative variation of available niches. Using isogenic lines, we will measure individual variation in niche width, niche construction and competitive ability. Different combinations of lines will then be used to test key predictions of recent theory on how such variation affects coexistence with competitors. Subsequently, mite populations will evolve in environments with either one or more potential niches, in plants where niche construction is possible or not, and in presence or absence of competitors (coevolving or not). We will test how these selection pressures affect niche width, niche construction and competitive ability, as well as plant damage. Finally, we will re-derive isogenic lines from these treatments, to test how evolution under different scenarios affects individual variation in niche width.

COMPCON will shed new light on the role of competition in shaping eco-evolutionary communities, with bearings on disciplines ranging from macro-ecology to evolutionary genetics

Project End Date: **30-APR-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
741298	**MagneticMoth**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. ERIC WARRANT**
Host Institution: Lunds Universitet, SE

Hunting for the elusive "sixth" sense: navigation and magnetic sensation in a nocturnal migratory moth

Many animals – including birds, sea turtles and insects – perform spectacular long-distance migrations across the surface of the Earth. Remarkably some, like birds, can accurately migrate between highly specific locations thousands of kilometres apart, a navigational feat that requires an external compass cue and a robust sensory system to detect it. The Earth's magnetic field is one such compass cue. But exactly how the magnetic field is sensed, and which receptor cells are involved, remains a mystery and its discovery is one of the greatest "holy grails" in modern sensory physiology, and also the main aim of this proposal. Fortuitously, I have made a pioneering discovery that a migratory insect – the Australian Bogong moth – relies on the Earth's magnetic field to navigate at night. Due to its tractable nervous system, this insect may thus hold the key to uncovering the identity of the enigmatic magnetosensor. By tethering flying migrating moths in a flight simulator, I will dissect for the first time how insects use magnetic cues to navigate, isolating which of the two current (contentious) hypotheses for magnetic sensation apply. The most likely of these involves the action of photoreceptor-based cryptochrome (Cry) molecules in the eyes. Having cloned genes for 4 visual opsins and 2 Cry in Bogong moths, I will use in situ hybridisation to localise putative magnetoreceptors in the eyes, targeting them with intracellular electrophysiology and magnetic stimulation in an attempt to describe the physiology of these elusive sensors for the first time. The project is ground breaking since it will elucidate how a migratory insect, despite its small eyes and brain, detects and uses the Earth's magnetic field for navigation. The discovery of the enigmatic magnetoreceptor would be a sensation, opening the floodgates for international research on this little understood sense.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
742288	**EVOSOM**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. PAULINE SCHAAP**
Host Institution: University Of Dundee, UK

Evolution of multicellularity and somatic cell specialization

The evolution of multicellularity allowed specialization of cells into functions that support rather than cause propagation. While yielding immense gain of function, the organisation of these somatic cells into tissues and organs required novel cell-cell signalling systems. We seek to identify the genetic changes that caused transitions to multicellularity and enabled cell specialization. We use genetically tractable Dictyostelia with multicellular structures that contain from 1 to 5 cell-types to address these fundamental questions. Dictyostelia evolved from unicellular Amoebozoa and are subdivided into 4 major groups, with most novel cell-types appearing in group 4. We found that gene expression patterns changed most frequently at the transition between groups 3 and 4, and that across groups ~10% of genes were alternatively spliced in the 5'UTR, indicative of promoter elaboration. Among known genes essential for multicellular development, those involved in intracellular signal processing were mostly conserved between Dictyostelia and unicellular Amoebozoa, while those encoding exposed and secreted proteins (ESPs) were unique to Dictyostelia or groups within Dictyostelia. Starting from a hypothesis that diversification of ESPs and gene regulatory mechanisms are major drivers of multicellular evolution, we will place unicellular relatives of Dictyostelia under selection to induce multicellularity, establish which genes are most changed in evolved populations and whether this involves ESP families that are also most changed in Dictyostelia. We will overexpress altered genes in unicellular forms to assess whether this induces multicellularity. We will retrace evolution of cell specialization by lineage analysis and phenotyping and seek correlations between cell-type innovation and alternative splice events and with emergence of novel signalling genes. Causality will be assessed by replacement of genes or promoters with ancestral forms in evolved species and vice versa

Project End Date: **30-APR-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
742312	**MATURATION**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. CRAIG PRIMMER**
Host Institution: Helsingin Yliopisto, FI

Age at maturity in Atlantic salmon: molecular and ecological dissection of an adaptive trait

Life history is the nexus of biology, because various biological questions ultimately revolve around the causes and consequences of variation in reproduction and survival, i.e. fitness. Traditionally, a major tool in life-history research has been quantitative genetics because it provides an important statistical link between phenotype and genotype. However, the mechanisms by which evolution occurs may remain unclear unless such traditional approaches are combined with molecular investigations. Another complicating factor is that the fitness of male vs female life histories do not always align, and hence life history traits may be shaped by sexual conflict. This is why life-history approaches focusing on both quantifying the conflict and understanding its resolution at the genetic level are needed.

As in many species, age at maturity in Atlantic salmon is tightly linked with size at maturity and thus represents a classic evolutionary trade-off: later maturing individuals spend more time at sea before returning to freshwater to spawn and have higher reproductive success due to their larger size but also have a higher risk of dying prior to first reproduction. Our recent cover paper in Nature reported a large-effect gene explaining 40% of the variation in this key life history trait. Remarkably, the locus exhibits sex-dependent dominance and this resolves a potential intra-locus sexual conflict in the species. The relatively simple genetic architecture of this trait combined with the features of Atlantic salmon as a model system offer an ideal opportunity to better understand the molecular mechanisms and ecological drivers underlying a locally adapted life history trait.

In MATURATION I will i) characterize age at maturity candidate gene functions and allelic effects on phenotypes ii) elucidate fitness effects of these phenotypes and GxE interactions iii) develop a mechanistic model for the sex-dependent dominance and validate intra-locus sexual conflict resolution

Project End Date: **31-AUG-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
754290	**MECH-EVO-INSECT**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. ALEXANDER BLANKE**
Host Institution: Universitaet Zu Koeln, DE

The mechanical evolution from biting-chewing to piercing-sucking in insects

Insects are extremely efficient feeders that impact on the world's ecosystems and our agriculture with their feeding capabilities. Insects evolved diverse mouthpart types during ~400 million years of evolution which allowed them to conquer many food recourses. How this feeding system evolved, in particular the transition from one mouthpart type to the other, is unclear. My idea represents the first extensive assessment of insect head mechanics applying latest semi-automatic workflows and engineering approaches to unravel the factors driving insect mouthpart evolution and performance.
Specifically, I will study the mechanical evolution from early biting-chewing to piercing-sucking mouthparts and head types, considering recent as well as fossil species.
In contrast to earlier studies, I aim to quantify mechanical evolution for the whole head which has never been attempted before for insects. This will be done using engineering software to simulate insect feeding, followed by 3D shape analysis and finally evolutionary modelling using algorithms based on likelihood models of evolutionary processes. The project is therefore positioned at the interconnection between experimental biology, engineering and biological simulation.
The results will impact our understanding of insect evolution, with the project identifying which mechanical factors made insects such extraordinarily successful feeders, and why their mouthparts evolved into so many different types. To achieve an integrative understanding, my idea will furthermore take into account ecological, evolutionary and life history factors. Understanding the mechanical head evolution has never been tried before in a systematic way at this scale. However, my project idea also delivers results for industry: Since modern engineering methods are used, the results can be readily exported to the industry for the design of lighter robot arms with better lifting capabilities, thus advancing robotic techniques.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757648	**ModelGenomLand**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. KONRAD LOHSE**
Host Institution: The University Of Edinburgh, UK

Modelling the genomic landscapes of selection and speciation

Understanding how natural selection, random genetic drift and demographic events interact to generate and maintain genetic and species diversity has been the central focus of population genetics for many decades. We now have the necessary genome sequence data to make detailed and powerful inferences about the evolutionary past of populations and species, yet our ability to meaningfully interpret such data has remained fundamentally limited.

This project will use a combination of theory, development of new inference tools and a large-scale comparative analyses of genome data and has two principal aims:

First to develop a general, statistical framework for making inferences about the joint action of past selection and demography from genome sequence data. This will be achieved using analytic calculations and approximations for the joint distribution of linked polymorphic sites. We will use these results to develop new methods to quantify the genome-wide rates of positive and background selection and to scan for genomic outliers of divergence between and positive selection within species. The new methods will be tested using simulations and data from model insects (Drosophila and Heliconius).

Second, we will apply the new inference approach to genome data for 20 species pairs of European butterflies and conduct a systematic comparison of the demographic and selective forces involved in speciation. This will reveal how repeatable speciation processes are both in terms of the demographic and selective events, and the genes and genomic architectures involved. Specifically, we will test whether selection during speciation is concentrated at chromosomal rearrangements and/or candidate gene families involved in mate recognition and host plant adaptation. This project will fundamentally improve both our understanding of speciation and selection and our ability to use sequence data to study population processes (be they selection, demography or both) in any system.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758382	**GUPPYCon**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. BONNIE FRASER**
Host Institution: The University Of Exeter, UK

Genomic basis of convergent evolution in the Trinidadian Guppy

Many species have independently evolved similar phenotypes in response to similar environmental challenges. This phenomenon, termed convergent evolution, reflects both the power and the limits of adaptation. However, we often do not know at what scale evolution has repeated itself: did selection act on the same genes in different populations or species, or did convergence result from selection on different genes? This is because, until recently, it has not been possible to investigate the genomic basis of evolution in most systems, limiting our understanding of the factors that facilitate or inhibit convergence and adaptation. To fully understand convergent evolution we need to query the genomic response to selection and determine genotype-phenotype links in systems where convergent adaptation is well established. The Trinidadian guppy (Poecilia reticulata) is a system that offers the opportunity to test the roles of multiple factors in convergent evolution: this species includes multiple natural and experimentally established populations that have repeatedly evolved similar phenotypes under similar predation environments. I propose to fully characterize the genomic-basis of repeated adaptive evolution in guppies. Aim 1 will identify regions that repeatedly show signatures of selection, and will contrast the nature of selection in natural and experimental populations that differ in age and levels of founding genetic diversity. Aim 2 will identify genomic regions associated with phenotypes that are known to play a significant role in local adaptation in the guppy using quantitative genetics approaches. I will then directly test the effects of candidate genes using novel functional genomic approaches, as detailed in Aim 3. Overall, this project will test whether repeated selection led to convergence at the genomic level, determine the genetic basis of convergent adaptations, and ultimately understand how convergent evolution has occurred in an important wild system.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758508	**MuBoEx**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. STEPHEN MONTGOMERY**
Host Institution: University Of Bristol, UK

Mushroom Body Expansion in Heliconius butterflies

The brain plays a central role in the production of adaptive behaviour. It must extract and integrate the most relevant sensory cues from the environment, and combine this information with memories of past experience to trigger appropriate behavioural responses. To fully understand the origins of behavioural novelty we need a detailed understanding of how behavioural differences are generated, both across evolutionary time and during development. This requires the integration of behavioural and neuroanatomical variation, and their genomic and developmental bases.

Mushroom bodies (MBs) are the most enigmatic structures in the insect brain. They have 'higher order' functions, integrating sensory information and storing memories of past experience. MBs share a conserved ground plan, but their size and structure varies extensively across species. MB morphology is determined by the number of MB neurons, and the nature and extent of connections they make with other brain regions. As such, they provide a model for asking fundamental questions about how selection, development and functional constraints shape brain evolution.

This project will establish a new study system in evolutionary neuroscience, Heliconius butterflies. MB volume in Heliconius is among the highest across insects, 3-4 times larger than typical for Lepidoptera, including closely related genera. The proposal represents a synthesis of four key objectives that will provide a cohesive understanding of MB expansion in Heliconius, encompassing both proximate and ultimate causes. Specifically, I will ask: i) How does MB expansion enhance behavioural function? ii) How do volumetric changes relate to differences in neuron number, density and connectivity? iii) What developmental mechanisms control region specific changes in neural proliferation? And iv) what is the genetic basis of MB expansion? Addressing these questions will provide profound advances in our understanding of brain evolution.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758873	**TreeMort**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. THOMAS PUGH**
Host Institution: The University Of Birmingham, UK

Redefining the carbon sink capacity of global forests: The driving role of tree mortality

Everything that lives must die. Yet when it comes to the world's forests, we know much more about the processes governing their life than those governing their death. Global forests hold enormous amounts of carbon in their biomass, which has absorbed about 20% of anthropogenic carbon dioxide emissions over recent decades. Whether the size of this sink will persist, intensify, decrease or even become a source is highly uncertain, yet knowing this is crucial to the calculation of carbon emission budgets consistent with limiting global temperature rise. One of the most compelling explanations for this uncertainty is a lack of knowledge of how tree mortality affects forest carbon storage on a global scale. Mortality rates and mechanisms are closely tied to forest structure and composition, and thus the storage of carbon in biomass, but mechanistic complexity and the difficulty of measurement have hindered understanding, resulting in a striking lack of consensus in existing assessments. TreeMort will remedy this, combining newly available sources of data with appropriate conceptualisation and innovative modelling, to provide quantifications of the rates and causes of tree death, and their relation to environmental drivers, that set new standards for robustness, comprehensiveness and consistency at the global scale. This breaking-out of the narrower foci of previous work will be a game-changer, finally enabling globally-comprehensive investigation of the extent to which whole forest structure and function are governed by and interact with mortality, and their likely evolution under environmental change. TreeMort will assess this using state-of-the-art ecosystem modelling, which will then be employed to make a fundamental reassessment of the current and future carbon storage capacity of global forests. TreeMort will thus bring us significantly closer to understanding fully how forests interact with the global carbon cycle, assisting efforts to mitigate climate change.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
770964	**ANTSolve**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. OFER FEINERMAN**
Host Institution: Weizmann Institute Of Science, IL

A multi-scale perspective into collective problem solving in ants

Cognition improves an animal's ability to tune its responses to environmental conditions. In group living animals, communication works to form a collective cognition that expands the group's abilities beyond those of individuals. Despite much research, to date, there is little understanding of how collective cognition emerges within biological ensembles. A major obstacle towards such an understanding is the rarity of comprehensive multi-scale empirical data of these complex systems.

We have demonstrated cooperative load transport by ants to be an ideal system to study the emergence of cognition. Similar to other complex cognitive systems, the ants employ high levels of emergence to achieve efficient problem solving over a large range of scenarios. Unique to this system, is its extreme amenability to experimental measurement and manipulation where internal conflicts map to forces, abstract decision making is reflected in direction changes, and future planning manifested in pheromone trails. This allows for an unprecedentedly detailed, multi-scale empirical description of the moment-to-moment unfolding of sophisticated cognitive processes.

This proposal is aimed at materializing this potential to the full. We will examine the ants' problem solving capabilities under a variety of environmental challenges. We will expose the underpinning rules on the different organizational scales, the flow of information between them, and their relative contributions to collective performance. This will allow for empirical comparisons between the 'group' and the 'sum of its parts' from which we will quantify the level of emergence in this system. Using the language of information, we will map the boundaries of this group's collective cognition and relate them to the range of habitable environmental niches. Moreover, we will generalize these insights to formulate a new paradigm of emergence in biological groups opening new horizons in the study of cognitive processes in general.

Project End Date: **31-MAY-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771419	**DOUBLE EXPRESS**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator:	**Dr. AOIFE MCLYSAGHT**
Host Institution:	The Provost, Fellows, Foundation Scholars & The Other Members Of Board Of The College Of The Holy & Undivided Trinity Of Queen Elizabeth Near Dublin, IE

Gene expression level as a keystone to understanding gene duplication: evolutionary constraints, opportunities, and disease

Duplicate genes are important in disease, are a hugely important source of evolutionary novelty, and for many years we thought we understood them. We thought that duplication relieved selective constraints. We thought that gene knockout neutrality was due to redundancy. We thought that a duplicate is a duplicate is a duplicate. Evidence is accumulating challenging each of these views. Rather than being the result of an unbiased process, the genes that tend to duplicate in our genome and others are quickly evolving, non-essential genes, irrespective of current duplication status. Conversely, genes retained after whole genome duplication (WGD) are slowly evolving, important genes.

I propose that different resolution of the evolutionary constraints imposed by the demands of gene expression can explain these contrasting relationships. I propose that the opposing constraints on gene-by-gene duplications as compared to WGD channel these different sets of genes into remarkably different evolutionary trajectories. In particular, in much the same way that individual gene duplication creates an opportunity for the evolution of a new gene, the co-evolution of expression of sets of interacting genes after WGD creates an opportunity for the evolution of new biochemical pathways and protein complexes. Furthermore, I suggest a common mechanism of pathogenicity for many duplication events independent of the biochemical function of the encoded genes.

With the availability of abundant high-quality genomics data, now is an opportune time to address these questions. Primarily through computational and statistical analysis I will reveal the relationship between gene duplication and expression and test a model that the indirect costs of gene expression are a major determinant of the outcome of gene duplication. I will explore the effects this has on gene and genome evolution. Finally, I will link the patterns of gene expression and duplicability to pathogenic effects.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771592	**Amitochondriates**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. VLADIMIR HAMPL**
Host Institution: Univerzita Karlova V Praze, CZ

Life without mitochondrion

Mitochondria are often referred to as the “power houses” of eukaryotic cells. All eukaryotes were thought to have mitochondria of some form until 2016, when the first eukaryote thriving without mitochondria was discovered by our laboratory – a flagellate Monocercomonoides. Understanding cellular functions of these cells, which represent a new functional type of eukaryotes, and understanding the circumstances of the unique event of mitochondrial loss are motivations for this proposal. The first objective focuses on the cell physiology. We will perform a metabolomic study revealing major metabolic pathways and concentrate further on elucidating its unique system of iron-sulphur cluster assembly. In the second objective, we will investigate in details the unique case of mitochondrial loss. We will examine two additional potentially amitochondriate lineages by means of genomics and transcriptomics, conduct experiments simulating the moments of mitochondrial loss and try to induce the mitochondrial loss in vitro by knocking out or down genes for mitochondrial biogenesis. We have chosen Giardia intestinalis and Entamoeba histolytica as models for the latter experiments, because their mitochondria are already reduced to minimalistic “mitosomes” and because some genetic tools are already available for them. Successful mitochondrial knock-outs would enable us to study mitochondrial loss in ‘real time’ and in vivo. In the third objective, we will focus on transforming Monocercomonoides into a tractable laboratory model by developing methods of axenic cultivation and genetic manipulation. This will open new possibilities in the studies of this organism and create a cell culture representing an amitochondriate model for cell biological studies enabling the dissection of mitochondrial effects from those of other compartments. The team is composed of the laboratory of PI and eight invited experts and we hope it has the ability to address these challenging questions.

Project End Date: **30-APR-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772284	**IceCommunities**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. GENTILE FRANCESCO FICETOLA**
Host Institution: Universita Degli Studi Di Milano, IT

Reconstructing community dynamics and ecosystem functioning after glacial retreat

Glaciers show a pattern of retreat at the global scale. Increasing areas are exposed and colonized by multiple organisms, but lack of global studies hampers a complete understanding of the future of recently deglaciated terrains. What will be the fate of these areas? How do animals, plants and microorganisms colonize them? How do they interact to perform successful colonization? Which are the climatic, geological and biogeographical processes determining colonization patterns? How does ecosystem functioning evolves through time? Until now, the complete reconstruction of soil communities was hampered by the complexity of identification of organisms, thus analyses at broad geographical and taxonomic scale have been so far impossible. IceCommunities will combine innovative methods and a global approach to boost our understanding of the evolution of ecosystems in recently deglaciated areas. I will investigate chronosequences ranging from recently deglaciated terrains to late successional stages of soil pedogenesis. Through environmental DNA metabarcoding I will identify species from multiple taxonomic groups (bacteria, fungi, protists, soil invertebrates, plants), to obtain a complete reconstruction of biotic communities along glacier forelands over multiple mountain areas across the globe. This will allow measuring the rate of colonization at an unprecedented detail. Information on assemblages will be combined with analyses of soil, landscape and climate to identify the drivers of community changes. I will also identify the impact of eco-geographical factors (climate, regional pool of potential colonizers) on colonization. Analysis of functional traits will allow reconstructing how functional diversity emerges during community formation, and how it scales to the functioning of food webs. IceCommunities will help to predict the future development of these increasingly important ecosystems, providing a supported rationale for the appropriate management of these areas

Project End Date: **31-MAR-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787514	**CRISPR-EVOL**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. URI GOPHNA**
Host Institution: Tel Aviv University, IL

The eco-evolutionary costs and benefits of CRISPR-Cas systems, and their effect on genome diversity within populations

CRISPR-Cas systems are microbial defense systems that provide prokaryotes with acquired and heritable DNA-based immunity against selfish genetic elements, primarily viruses. However, the full scope of benefits that these systems can provide, as well as their costs remain unknown. Specifically, it is unclear whether the benefits against viral infection outweigh the continual costs incurred even in the absence of parasitic elements, and whether CRISPR-Cas systems affect microbial genome diversity in nature.

Since CRISPR-Cas systems can impede lateral gene transfer, it is often assumed that they reduce genetic diversity. Conversely, our recent results suggest the exact opposite: that these systems generate a high level of genomic diversity within populations. We have recently combined genomics of environmental strains and experimental genetics to show that archaea frequently acquire CRISPR immune memory, known as spacers, from chromosomes of related species in the environment. The presence of these spacers reduces gene exchange between lineages, indicating that CRISPR-Cas contributes to diversification. We have also shown that such inter-species mating events induce the acquisition of spacers against a strain's own replicons, supporting a role for CRISPR-Cas systems in generating deletions in natural plasmids and unessential genomic loci, again increasing genome diversity within populations.

Here we aim to test our hypothesis that CRISPR-Cas systems increase within-population diversity, and quantify their benefits to both cells and populations, using large-scale genomics and experimental evolution. We will explore how these systems alter the patterns of recombination within and between species, and explore the potential involvement of CRISPR-associated proteins in cellular DNA repair.

This work will reveal the eco-evolutionary role of CRISPR-Cas systems in shaping microbial populations, and open new research avenues regarding additional roles beyond anti-viral defense

Project End Date: **30-APR-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788203	**INNOVATION**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. MICHAEL BENTON**
Host Institution: University Of Bristol, UK

Innovation and opportunity in the evolution of life

The aim is to produce a complete evolutionary tree of tetrapods and use this to explore two core questions in macroevolution: the balance between innovation and external processes in driving the evolution of life; and, identifying the best model for morphological evolution. Biodiversity today is unbalanced, with a small number of highly successful groups, like birds and beetles, and many others of equal antiquity but with far fewer species. Why are those groups so successful – was it chance or do they have some remarkable adaptation(s)? The core of the project is to construct a complete evolutionary tree of all 30,000 living species of tetrapods (amphibians, reptiles, birds, mammals) and add the 10,000 fossil species; this will generate a database of key characters, the homologies, shared by major groups. The probability of different drivers of diversification will be tested, focusing on those key, highly successful groups (e.g. lizards, birds, neornithines, passerines, rodents) that show explosive evolution to very high species diversity. The proposal goes to the roots of macroevolutionary understanding, and encompasses key questions about origins and modern biodiversity. The project is ambitious, but is possible because of advances in knowledge of relationships of all key tetrapod groups based on phylogenomic and morphological data, increasing precision of geological dating, and the availability of a range of computational methods to construct large phylogenetic trees, to assess likelihood of trees, to explore innovation and evolutionary rates and models, and Bayesian modelling techniques that can map trait data onto large trees and evaluate multiple models of drivers and bias. A unique outcome will be the chance to explore waiting time between major morphological changes, assessing distribution and magnitude, and use this information to inform the construction of a meaningful model of morphological evolution for computational phylogenetics.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788380	**LEAP-EXTREME**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. UTE KRAEMER**
Host Institution: Ruhr-Universitaet Bochum, DE

Local Edaphic Adaptation in Plants through Leveraging an Extremophile Model

The discontinuous mosaic of soil compositions on the Earth's changeable surface intermittently requires the adaptation of plants as crucial mediators for ecosystems with the inorganic lithosphere harbouring all nutrient, but also toxic minerals. Only few gene variants have been implicated in local soil adaptation. There is a general lack of information about their relation with soil composition in the field, the manner in which such adaptations function and evolve, and why they arise in some taxa but never in others. To answer these questions, we will take advantage of the repeated evolution and the unusually large phenotypic ranges for multiple edaphic traits in Arabidopsis halleri. This species has undergone uniquely divergent natural selection for increased hyperaccumulation in leaves of the toxic metals zinc and cadmium as well as metal hypertolerance on ordinary soils, and for enhanced hypertolerance involving attenuated metal hyperaccumulation on heavy metal-contaminated soils.

Capitalizing on the most comprehensive collection ever established of a wild extremophile, and with a pioneering approach recording critical field data for each genotype, we will conduct large-scale genome resequencing and identify multi-trait multi-gene associations, complemented by genetic linkage mapping based on crosses. Local edaphic adaptation causal variants will be placed into the context of metal homeostasis network architecture and plasticity using transcriptomics, and we will comparatively evaluate mutation rates in A. halleri under ecologically relevant edaphic conditions.

Implementing state-of-the-art genome-enabled and novel phenotyping methodologies in this wild and biologically complex species will require continuous pioneering developments. Our work will deliver novel fundamental insights into local adaptation in plants and identify large-effect gene variants with potential for applications in environmental restoration, biotechnology and crop breeding.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
801669	**EVOCELFATE**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. JOSE M MARTIN DURAN**
Host Institution: Queen Mary And Westfield College University Of London, UK

Evolution of cell fate specification modes in spiral cleavage

Spiral cleavage is a highly stereotypical early embryonic program, and the ancestral, defining feature to Spiralia, a major phylogenetic clade including almost half of the animal phyla. Remarkably, spiral-cleaving embryos specify homologous cell fates (e.g. the progenitor cell of posterodorsal structures) conditionally –via cell interactions– or autonomously –via segregation of maternal inputs. This variation occurs naturally, even between closely related species, and has been related to the precocious formation of adult characters (adultation) in larvae of autonomous spiral-cleaving species. How spiralian lineages repeatedly shifted between these two cell fate specification modes is largely unexplored, because the mechanisms controlling spiral cleavage are still poorly characterized.

This project tests the hypothesis that maternal chromatin and transcriptional regulators differentially incorporated in oocytes with autonomous spiral cleavage explain the evolution of this mode of cell fate specification. Through a comparative and phylogenetic-guided approach, we will combine bioinformatics, live imaging, and molecular and experimental techniques to: (i) Comprehensively identify differentially supplied maternal factors among spiral cleaving oocytes with distinct cell fate specification modes using comparative RNA-seq and proteomics; (ii) Uncover the developmental mechanisms driving conditional spiral cleavage, which is the ancestral embryonic mode; and (iii) Investigate how maternal chromatin and transcriptional regulators define early cell fates, and whether these factors account for the repeated evolution of autonomous specification modes.

Our results will fill a large gap of knowledge in our understanding of spiral cleavage and its evolution. In a broader context, this project will deliver fundamental insights into two core questions in evolutionary developmental biology: how early embryonic programs evolve, and how they contribute to phenotypic change.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804569	**FIT2GO**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. CLAUDIA BANK**
Host Institution: Fundacao Calouste Gulbenkian, PT

A toolbox for fitness landscapes in evolution

A major challenge in evolutionary biology is to quantify the processes and mechanisms by which populations adapt to new environments. In particular, the role of epistasis, which is the genetic-background dependent effect of mutations, and the constraints it imposes on adaptation, has been contentious for decades. This question can be approached using the concept of a fitness landscape: a map of genotypes or phenotypes to fitness, which dictates the dynamics and the possible paths towards increased reproductive success. This analogy has inspired a large body of theoretical work, in which various models of fitness landscapes have been proposed and analysed. Only recently, novel experimental approaches and advances in sequencing technologies have provided us with large empirical fitness landscapes at impressive resolution, which call for the evaluation of the related theory.

The aim of this proposal is to build on the theory of fitness landscapes to quantify epistasis across levels of biological organization and across environments, and to study its impact on the population genetics of adaptation and hybridization. Each work package involves classical theoretical modelling, statistical inference and method development, and data analysis and interpretation; a combination of approaches for which my research group has strong expertise. In addition, we will perform experimental evolution in Escherichia coli and influenza to test hypotheses related to the change of fitness effects across environments, and to adaptation by means of highly epistatic mutations. We will specifically apply our methods to evaluate the potential for predicting routes to drug resistance in pathogens. The long-term goal lies in the development of a modeling and inference framework that utilizes fitness landscape theory to infer the ecological history of a genome, which may ultimately allow for a prediction of its future adaptive potential.

Project End Date: **29-FEB-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804673	**sEEIngDOM**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. ANDREW TANENTZAP**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

Ecological and Evolutionary Importance of Molecular Diversity in Dissolved Organic Matter

Dissolved organic matter (DOM) is central to the functioning of freshwater ecosystems that support life on Earth. For example, DOM has a major role in global carbon (C) cycling by helping to bury four times more C in the bottom of lakes and rivers than across all of the world's oceans. DOM also majorly influences the growth of aquatic organisms and impedes drinking water treatment for millions of people, such as by increasing microbial growth. Yet, despite its importance, DOM remains poorly understood because it has been measured with little resolution for nearly 200 years. Recent technological advances have now shown that a handful of lake water can contain at least 2,000 different molecules of varying origin and composition. But the role of all these different molecules in aquatic ecosystems largely remains a mystery.

This project will discover the importance of the tremendous diversity of molecules – termed chemodiversity – found in DOM for lake functioning and human wellbeing. It will do so by combining cutting-edge techniques in analytical chemistry, genomics, and statistical modelling with careful lab-based studies, proven field experiments, and large-scale observational surveys. By thinking about species of molecules as we would species of organisms, this project will draw upon rich theory and methods developed for the study of biodiversity. The work will allow us to learn how variation in chemodiversity across lakes is driven by associations with different microbes and how these microbes reciprocally adapt and evolve to different DOM. In the process, we will improve predictions of how important functions and services provided by lakes, such as C cycling and drinking water, vary with chemodiversity. An exciting application of this work is to improve emerging technologies for water purification by identifying microbial consortia that can consume chemodiversity and make water clearer.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
805046	**EvoConBiO**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. IAIN JOHNSTON**
Host Institution: Universitetet I Bergen, NO

Uncovering and engineering the principles governing evolution and cellular control of bioenergetic organelles

Complex life on Earth is powered by bioenergetic organelles -- mitochondria and chloroplasts. Originally independent organisms, these organelles have retained their own genomes (mtDNA and cpDNA), which have been dramatically reduced through evolutionary history. Organelle genomes form dynamic populations within present-day eukaryotic cells, akin to individuals co-evolving in a "cellular ecosystem". The structure of these populations is central to eukaryotic life. However, the processes shaping the content of these genomes through history, and maintaining their integrity in modern organisms, are poorly understood. This challenges our understanding of eukaryotic evolution and our ability to design rational strategies to engineer bioenergetic performance.

EvoConBiO will address these questions using a unique and unprecedented interdisciplinary approach, combining experimental characterisation and manipulation of organelle genomes with mathematical modelling and cutting-edge statistics. This highly novel combination of experiment and theory will drive the field in a new direction, for the first time uncovering the universal principles underlying the evolution and cellular control of mitochondria and chloroplasts. Our groundbreaking recent work on mtDNA suggests a common tension underlying organelle evolution, between genetic robustness (transferring genes to the nucleus) and the control and maintenance of organelles (retaining genes in organelles). EvoConBiO will reveal the pathways underlying organelle evolution, why organisms adapt to different points on these pathways, and how they resolve this underlying tension. In addition to these "blue sky" scientific insights into a process of central evolutionary importance, we will harness our findings to "learn from evolution" in high-risk high-reward development of new experimental strategies to engineer chloroplast performance in plants and algae of importance in EU agriculture, biofuel production, and bioengineering.

Project End Date: **30-JUN-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
817535	**UltimateCOMPASS**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. MARIE DACKE**
Host Institution: Lunds Universitet, SE

Navigating the most challenging habitats on earth: unravelling the architecture of a universal compass system

When lost in the desert at night, or in dense forests, people tend to walk in circles. This is because the seemingly simple act of walking in a straight line involves a complex interplay of various sensory modalities, the motor system and cognition. A ball-rolling dung beetle released in the same type of uncharted territory, does not walk in circles, but rather keeps steadfastly to a chosen bearing. The main goal of this project is unravel the sensory and neuronal architecture of the newly discovered 'snapshot compass', that supports orientation over all continents and terrestrial habitats on earth (except Antarctica). This goal will be realized through a fusion of biology, bio-informatics and mathematics.

A quickly growing pool of studies indicates that neuronal networks are modulated in a context-dependent manner. Therefore, to truly understand how this compass works, and to formulate the core computational algorithms underlying this remarkable system, I aim to obtain the first ever brain recordings from the compass of a freely orienting insect. Is this possible? Certainly! But only in an animal with a robust orientation behaviour, and that is strong enough to carry a little backpack of electronics. The large dung-beetles, with their easily manipulated orientation behavior, offers a unique opportunity to attain this holy grail of neuroethology.

The beetle's compass makes use of a large range of celestial cues, which can vary drastically in availability and strength. While the challenge of cue integration has been solved effectively in the compass system of the beetles, it remains a key problem within the field of cognition and perception, as well as for the design of artificial intelligence systems. Taken together, almost two decades of studies of the dung beetle compass system have paved the way for this timely and unique opportunity, that will impact the advancement of science well outside the field of biology.

Project End Date: **31-MAY-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819374	**DrivenByPollinators**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. YANN CLOUGH**
Host Institution: Lunds Universitet, SE

Driven by mutualists: how declines in pollinators impact plant communities and ecosystem functioning

Pollinator declines in response to land-use intensification have raised concern about the persistence of plant species dependent on insect pollination, in particular by bees, for their reproduction. Recent empirical studies show that reduced pollinator abundance decreases densities of seedlings of insect-pollinated plants and thereby changes the composition of grassland plant communities. Cascading effects on ecosystem functioning and associated organisms are expected, but to which extent and under which conditions this is the case is yet unexplored. Here, I propose a bold, multi-year, landscape-scale experimental assessment of the extent of pollinator-driven plant community changes, their consequences for associated organisms and important ecosystem functions, and their likely contingency on other factors (soil fertility, herbivory).

Specifically I will:

(1) Set up a network of long-term research plots in landscapes differing in pollinator abundance to measure the changes in plant reproduction over successive years, and assessing experimentally how herbivory and soil fertility mediate these effects.

(2) Explore the individual processes linking pollinators, plant communities and ecosystem functioning using long-term experiments controlling pollinator, herbivore and nutrient availability, focusing on a sample of plant species covering both the dominant species and a diversity of functional traits.

(3) Assess the context-dependence of pollinator-mediated plant community determination by building and applying process-based models based on observational and experimental data, and combine with existing spatially-explicit pollinator models to demonstrate the applicability to assess agri-environmental measures.

This powerful blend of complementary approaches will for the first time shed light on the cornerstone role of this major mutualism in maintaining diverse communities and the functions they support, and pinpoint the risks threatening them and the need for mitigation.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819507	**CELL-in-CELL**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. THOMAS RICHARDS**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Understanding host cellular systems that drive an endosymbiotic interaction

Endosymbiosis is a key phenomenon that has played a critical role in shaping biological diversity, driving gene transfer and generating cellular complexity. During the process of endosymbiosis, one cell is integrated within another to become a critical component of the recipient, changing its characteristics and allowing it to chart a distinct evolutionary trajectory. Endosymbiosis was fundamentally important to the origin and evolution of eukaryotic cellular complexity, because an endosymbiotic event roots the diversification of all known eukaryotes and endosymbiosis has continually driven the diversification of huge sections of the eukaryotic tree of life. Little is known about how nascent endosymbioses are established or how they go on to form novel cellular compartments known as endosymbiotic organelles. Paramecium bursaria is a single celled protist that harbours multiple green algae within to form a phototrophic endosymbiosis. This relationship is nascent as the partners can be separated, grown separately, and the endosymbiosis reinitiated. This project will identify, for the first time, the gene functions that enable one cell to incubate another within to form a stable endosymbiotic interaction. To identify and explore which host genes control endosymbiosis in P. bursaria we have developed RNAi silencing technology. In the proposed project we will conduct genome sequencing, followed by a large-scale RNAi knockdown screening experiment, to identify host genes that when silenced perturb the endosymbiont population. Having identified candidate genes, we will investigate the localisation and function of the host encoded proteins. This project will significantly change our current understanding of the evolutionary phenomenon of endosymbiosis by identifying the cellular adaptations that drive these interactions, advancing our understanding of how these important moments in evolution occur and how core cellular systems can diversify in function.

Project End Date: **31-MAY-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819952	**Mari.Time**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. KRISTIN TESSMAR**
Host Institution: Universitaet Wien, CH

Dissecting the mechanistic basis of moon-controlled monthly timing mechanisms in marine environments

The correct timing of biological processes is crucial for organisms. The moon is an important timing cue for numerous marine species, ranging from brown and green algae to corals, worms and fishes. It acts either directly or via the synchronization of monthly (circalunar) inner clocks. Such lunar timing mechanisms typically control the gonadal maturation and behavioral changes associated with reproductive rhythms, including spectacular mass-spawning events. Despite their biological importance, the mechanisms underlying circalunar clocks, as well as their responses to naturalistic stimuli are unknown.

My lab has spearheaded research into the mechanisms underlying circalunar timing systems, establishing tools and resources for two well-suited, complementary animal models: Platynereis dumerilii and Clunio marinus. We unraveled first principles of the circalunar clock, e.g. its continuous function in the absence of oscillation of the daily (circadian) clock. Recent unpublished work revealed the first gene that functionally impacts on circalunar rhythms.

By capitalizing on these powerful tools and key findings, my lab is in a leading position to dissect the mechanisms of circalunar clocks and their interaction with other rhythms and the environment via three objectives:

(1) A reverse genetic approach to unravel how nocturnal light sets the phase of the monthly clock.

(2) A forward genetic screen to identify molecules involved in the circalunar clock, an experimental strategy that was the key to unravel the principles of animal circadian clocks.

(3) By growing animals in outside tanks and subjecting them to established analyses, we will test our lab-based results in more naturalistic conditions.

This project will substantially deepen our mechanistic insight into marine rhythms – ecologically important phenomena – and provide a first basis to predict how environmental changes might impact on timing systems of crucial importance to many marine species and likely beyond.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
832352	**EvolSexChrom**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. TATIANA GIRAUD**
Host Institution: Centre National De La Recherche Scientifique, FR

Testing new hypotheses on the evolution of sex-related chromosomes

The sex chromosomes of plants and animals often contain large non-recombining regions due to a stepwise cessation of recombination generating “evolutionary strata” of genetic differentiation. The reasons for the extension of recombination suppression beyond sex-determining genes remain unclear. Sexual antagonism, involving the linkage to sex-determining genes of alleles beneficial in only one sex, is the prevailing hypothesis, as this explanation is both theoretically plausible and attractive. However, decades of research have unearthed little evidence to support this hypothesis. Furthermore, I have shown that chromosomes involved in sexual compatibility in systems lacking male and female functions can nevertheless display a stepwise suppression of recombination beyond mating-compatibility genes. Thus, evolutionary strata can evolve without sexual antagonism. Alternative hypotheses, such as neutral rearrangements, epigenetic changes associated with transposable elements and the sheltering of deleterious alleles accumulating near non-recombining regions, must thus be seriously considered. I propose to use a synergic combination of different approaches and biological systems to refine and test these hypotheses, to broaden the theory of sex-related chromosome evolution, and, more generally, of the evolution of supergenes (linked allelic combinations). I will use mathematical modeling to test hypothesis plausibility and generate predictions. I will use comparative and population genomic approaches to test predictions, and an innovative experimental evolution approach with functional manipulations to assess the ability of the proposed mechanisms to generate strata. The EvolSexChrom project will challenge the current theory, opening up new avenues of research and potentially creating a paradigm shift in the dynamic research field focusing on the evolution of sex-related chromosomes and other supergenes, relevant to diverse traits and organisms.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850529	**E-DIRECT**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. CHRISTIAN HILBE**
Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Evolution of Direct Reciprocity in Complex Environments

Direct reciprocity is a fundamental mechanism for cooperation among non-kin. It is based on the idea that individuals are more cooperative when they interact in stable groups in which retaliation is possible. To model the evolution of reciprocity, researchers have used the framework of repeated games. Traditionally, these models rest on two assumptions. First, players are symmetric: they coincide in their strategic options, in their incentives to cooperate, and how they discount future payoffs. Second, the players' environment is fixed: players face the same game, with the same payoffs, in every round. Both assumptions are crucial, as they promote conditionally cooperative strategies like Tit-for-Tat. Yet in most natural applications, individuals are heterogeneous, and the games they play change over time. To address these two critical model limitations, we need to expand the theory of reciprocity. We focus on the following objectives: 1) Develop a theory of reciprocity in heterogeneous groups. Based on mathematical models and simulations, we study how different dimensions of heterogeneity affect the evolution of reciprocity. 2) Develop a theory of reciprocity in changing environments. Here, we explore the evolution of cooperation when the players' environment (and hence their feasible payoffs and strategies) can change from one round to the next. We ask which environmental feedback is most favorable to cooperation. 3) Explore the dynamics of asymmetric games with changing environments. Here, we analyze the intricacies that arise when both previous sources of complexity are present. 4) Verify the theory using behavioral experiments with human subjects. The success of the project will establish a novel framework and new tools to study the evolution of strategic behavior in non-constant environments. It will significantly enhance our ability to predict when reciprocity emerges under natural conditions.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850859	**ECOLBEH**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. DAMIEN FARINE**
Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

The Ecology of Collective Behaviour

The evolutionary transition from solitary to group living has fundamentally changed how organisms interact with their environment. However, to reap the rewards of group living, from collective intelligence to predator avoidance, group members must maintain cohesion by making collective decisions. Theory suggests that individuals' ability to influence collective decisions could be determined by a range of factors, including their state, social role, relationships with other group members, the composition of their social group, and the physical environment. Although these factors could all interact, most empirical studies have investigated them in isolation. The aim of this project is to take a 'whole-system' approach by quantifying (1) how individual-level factors determine leadership, (2) how movement decisions are modulated by long-term social and genetic relationships among group members, and (3) whether the mechanisms by which groups reach consensus are resilient to rapid environmental change. This research program will add unprecedented ecological validity and replication to the field of collective decision making. I will leverage state-of-the-art technology and develop novel methods to simultaneously collect and analyse multi-scale data in a wild population of highly social birds. These data include the movement of individuals within and between groups (high-resolution GPS), social interactions (direct observations), kinship (whole-genome sequencing), physiology (heart rate), and environmental conditions (drone-based mapping). The analytical methods I will develop (e.g. multi-layered dynamic social network analysis) will provide new tools for the research community, while integrating these unique data across replicated groups and over multiple generations, the project will bring new depth to the field. This depth is essential to address the questions that are central to our understanding of social behaviour in mobile animal groups, including humans.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851040	**SpeciationBehaviour**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. RICHARD MERRILL**
Host Institution: Ludwig-Maximilians-Universitaet Muenchen, DE

The genetic and neural basis of reproductive isolation

Speciation is a fundamental evolutionary process, which relies on the accumulation of reproductive barriers. These barriers often act before mating, and many taxa remain separate not because they fail to produce viable offspring, but because they 'choose' not to mate in the first place. Although the significance of behavioural barriers has long been recognized, an integrated understanding remains elusive: How is behavioural isolation mediated through changes in the sensory systems? Are these changes driven by selection? And what is the genetic and developmental basis of behavioural divergence in natural populations?

My research will address these questions to understand how behavioural barriers are generated, both during development and across evolutionary time. This project will be novel in uniting genomic and neurosensory data, with ecological and behavioural studies across a single radiation. Heliconius butterflies offer an excellent opportunity to achieve this as they are a group of closely related species with well-characterised ecologies, high-quality genomic resources, and are emerging as a model of evolutionary neurobiology.

These attributes will allow me to address the enduring problem of how natural selection and genetics interact to drive divergence in behavioural preferences. I will determine how components of behavioural isolation vary with ecology, both within and between species; and then explicitly test whether changes in sensory perception and processing in the brain are driven by selection imposed by the external environment. Genetic mapping will allow me to test for a link between changes in the sensory systems and mate choice. By combining these data with expression and functional analyses I will identify genes strongly implicated in the divergence of behavioural preferences. This will lead to novel insights into the developmental and neurological bases of behavioural isolation, a process fundamental to biodiversity.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851523	**EPIDEMIC**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. YUKO ULRICH**
Host Institution: Universite De Lausanne, CH

Experimental Epidemiology in Ant Societies

The risks and impact of disease are exacerbated in social organisms, which live in dense groups wherein pathogens can rapidly propagate. Theoretical epidemiology predicts that disease dynamics will depend in large part on a group's social interaction network, but empirical data are scarce. Experimental epidemiology is currently hampered by a lack of study systems that would enable a rigorous investigation of the causal link between network structure and disease transmission.

I will tackle this question using a novel system, the clonal raider ant, a social insect whose unique biology affords unparalleled control over the main aspects of colony composition that are thought to modulate social network structure, and therefore, disease transmission. My approach will combine cutting-edge automated techniques for behavioral tracking with molecular tools, and develop new methods to monitor transmission in real time. In a first step, I will create empirical networks that are theoretically predicted to vary in transmission risk and map individual immune function onto these networks, to measure the prophylactic network properties that might reduce disease transmission. Second, I will test if experimental increases in immune activity induce changes in behavior that are relevant for disease transmission, to measure inducible network properties. Finally, I will inoculate colonies with nematodes and quantify infection propagation in real time. This will allow me to compare various types of social networks (healthy, immune-activated, infected), to probe the link between behavior and immunity, and to experimentally test predictions from theoretical epidemiology.

This project takes an integrative approach—from individual immunity to collective behavior—to uncover the properties of social groups that protect them against disease. By linking theoretical epidemiology to real-world disease dynamics, it will push the limits of our ability to predict disease dynamics in social groups.

Project End Date: **31-JUL-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851678	**SHIFTFEEDBACK**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. FRANCISKA DE VRIES**
Host Institution: Universiteit Van Amsterdam, NL

Ecosystem response to drought: unravelling the unexplored role of plant-soil feedback

Drought is severely threatening our ecosystems and their functioning: it causes strong shifts in plant community composition that are difficult to revert. Positive feedbacks often underlie these dramatic shifts, but in many ecosystems drought causes fast-growing species to increase. These species are not only vulnerable to drought, but they also suffer negative plant-soil feedback, i.e. they change the soil microbial community in a way that keeps their own abundance in check. Thus, drought-induced shifts in plant communities do not result from positive feedbacks, unless drought changes plant-soil feedback. We know that plant-soil feedback drives plant community succession, but its role in community response to drought has never been explored. Here, I will unravel whether and how changes in plant-soil feedback underlie strong shifts in plant community composition following drought. This knowledge is crucial for mitigating the effects of drought on terrestrial ecosystems.
My objectives are:
1. Examining how drought affects plant community and soil microbial community composition and the implications for plant-soil feedback
2. Quantifying the effects of plant-plant and plant-microbial interactions on plant growth and subsequent shifts in plant community composition in response to drought
3. Disentangling the mechanisms underlying drought-induced changes in plant-soil feedback
I will address these objectives in a novel set of approaches. I will identify general patterns in plant-soil feedback across European drought experiments, and assess the role of plant-plant and plant-microbial interactions across a Dutch secondary successional gradient. In a set of targeted mesocosm experiments, I will elucidate the mechanisms underlying changes in plant-soil feedback and the consequences for plant community composition. These approaches will result in a step-change in understanding the dynamics of plant-soil interactions under drought and the consequences for ecosystem change.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864287	**THRESHOLD**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. PAUL KARDOL**
Host Institution: Sveriges Lantbruksuniversitet, SE

Thresholds and tipping points in ecosystem responses to global warming

Terrestrial ecosystems are important in providing key services to humankind, but under global warming the provisioning of such ecosystem services is at risk. However, there is little consensus on how the functioning of terrestrial ecosystems will change under projected scenarios of global warming, or when we will reach or surpass thresholds and tipping points. This is largely because most studies have failed to unravel ecosystem responses to increasing temperatures in terms of the underlying non-linear responses of plants, soil organisms, and their communities. Since plants and their associated soil organisms (i.e., pathogens, mutualists, and decomposers) can vary in their responses to temperature change, global warming may disrupt or decouple interactions among coexisting and co-evolved species. This may have unforeseen consequences for key ecosystem functions, such as carbon and nutrient cycling.

THRESHOLD will use a novel cross-disciplinary approach to advance our fundamental knowledge of how non-linear temperature responses transcend different levels of ecological organization. Specifically, this project aims to:

1) Establish a global network of forest-tundra and forest-alpine ecotone sites, to assess how responses of ecosystem carbon and nutrient cycling to global warming will be pushed across thresholds and tipping points.

2) Perform mesocosm experiments under different temperatures, to estimate how ecosystem process responses to global warming can be predicted from the reordering of plant and soil communities, as well as from the functional traits that they possess and express.

3) Reveal how community responses to warming and extreme temperatures can be predicted from the physiological responses of their component species.

To achieve these aims, this work will utilize a powerful approach that harnesses an array of cutting-edge tools, and it will advance our conceptual understanding in an area of urgent importance for ecology and society.

Project End Date: **31-DEC-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864642	**BeePath**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. LENA WILFERT**
Host Institution: Universitaet Ulm, DE

Impact of vector-mediated transmission on the evolution and ecology of a bee virus

The emergence of novel transmission routes is likely to have profound impacts on the ecology and evolution of infectious diseases, with potentially dramatic effects on host populations. This might be particularly drastic when transmission changes from direct to vector-borne transmission, where prevalence and virulence are expected to increase. Despite its importance for disease control, we lack empirical and theoretical understanding of this process. The emergence of Varroa destructor in honeybees provides a unique opportunity to study how a novel vector affects pathogen ecology and evolution: this ectoparasitic mite is a novel vector for Deformed Wing Virus (DWV), a disease linked to severe increases in hive mortality. To study the fundamental evolutionary ecology of emerging vector-borne diseases, I will exploit a unique natural experiment, the presence of Varroa-free island refugia, to test how this novel vector affects epidemiology and evolution in the field. I will adapt cutting-edge single molecule sequencing to guide controlled lab experiments by viral evolution in the wild, establishing novel reverse genetics approaches in DWV to test causal links between phenotypic and molecular evolution. Like all emerging diseases, DWV is a multi-host pathogen that also infects wild bee species not infested by Varroa, such as bumblebees. This raises an additional question, highly relevant for zoonotic diseases: does this specialist honeybee vector impact disease in wild bee populations? I will model the impact of vector acquisition and evolving pathogens on host populations and test potential prevention and mitigation strategies to safeguard these crucial pollinators. This system will not only provide fundamental insights into the evolutionary ecology of disease, but is also of immediate applied importance: bees are key pollinators of crops and wildflowers, and halting population declines facilitated by infectious disease is crucial for food security and biodiversity.

Project End Date: **28-FEB-26**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865101	**HYPERDIVERSE**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. NICOLAS PUILLANDRE**
Host Institution: Museum National D'Histoire Naturelle, FR

Keys to evolutionary success: untangling drivers of hyperdiversification

Explaining why some taxa are more diversified than their closest relatives remains one of the major challenges in evolutionary biology. However, much of Earth's biodiversity is concentrated in few diverse non-vertebrate animal lineages, whose analysis of diversification dynamics is hampered by the lack of empirical data. The NEOME project will focus on one hyperdiverse and poorly-known taxon of molluscs, the marine predators Neogastropoda. Their high species diversity (>15,000 species), largely undescribed, and the key innovations they evolved, linked to their feeding habits and dispersal abilities, make them a perfect model system to test hypotheses related to the diversification of hyperdiverse taxa. The first objective of the project will be to reconstruct a robust, precise and complete phylogeny of the group by using cutting-edge omic technologies. The second goal will be to test correlations between two traits – the exogenome diversity as proxy of feeding habits, and the type of larval development as a proxy of dispersal capabilities, which are keys for understanding diversification dynamics, using genomic, transcriptomic and proteomic approaches. The same data will also be used to fulfil the last objective: identifying the genetic determinants of the two traits, the molecular mechanisms at the origin of their diversity, and the processes by which these traits interact with the environment to mediate the diversification of the neogastropods. The major breakthrough of the project will thus rely on the joint analysis of the correlation between traits and diversification and of the causal factors at the origin of this correlation. Furthermore, the project will also impact other fields of research, with the production of unique data on many culturally, economically and scientifically important species, including the first complete genomes for the group, and the characterization of numerous compounds potentially promising in human therapeutics and biotechnologies.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865225	**MYCOREV**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. KATIE FIELD**
Host Institution: The University Of Sheffield, UK

A Mycorrhizal Revolution: The role of diverse symbiotic fungi in modern terrestrial ecosystems

The colonisation of the landmasses by plants >500 Mya was a major turning point in Earth's history, drastically altering the development of the biosphere and providing the basis for all terrestrial life ever since. The hypothesis that early plants were facilitated in their invasion of the land environment by forming symbioses with arbuscular mycorrhizal fungi (AMF) is widely supported by fossil and molecular evidence. My previous findings in physiology identified the role of AMF as a driving force in evolution by supporting growing nutrient demands of increasingly large plants, against a background of declining atmospheric CO2.

Recently, it was revealed that the earliest groups of extant plants form symbioses with a different group of fungi - Mucoromycotina "fine root endophytes" (MFRE) and I have since shown that MFRE symbioses are nutritionally mutualistic. These findings support a new hypothesis: the earliest land plants had a wider range of symbiotic options than was previously thought with MFRE also playing an important role in their supply of nutrients. I have now discovered that MFRE symbioses are not limited to early divergent plants, but instead span the entire land plant phylogeny. Coupled with my most recent findings that MFRE symbionts are distinct from AMF in terms of function and responses to changing atmospheric CO2 concentrations, these discoveries call into question much of what we thought we knew about plant-fungal symbioses. Much of the fundamental biology of MFRE remains unknown, preventing us from understanding the true complexity of plant-fungal symbioses, how they might respond to environmental change and their potential exploitation. This project will address the fundamental knowledge gaps surrounding the diversity, structure and functional significance of plant-MFRE symbioses, paving the way for a revolution in mycorrhizal research in the 21st century.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865694	**DiversiPHI**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. BAS E DUTILH**
Host Institution: Universiteit Utrecht, NL

Predicting the evolution of complex phage-host interactions

What determines if a phage can infect a host? This question arises as we work to understand the ecological roles of the hundreds of thousands of unknown viruses that I and others have discovered around the world. Phages are the most abundant life forms on Earth with important applications in medicine and biotechnology and far-ranging effects on microbial community functioning in all environments. Phage-host interactions (PHI) are an emergent trait that depends on the complex integration of factors like their taxonomic identity, the environment, and phage- and host-encoded proteins. With DiversiPHI, I propose a research program to unravel PHI by 1) measuring, 2) modelling, and 3) experimentally testing these diverse factors to develop a predictive understanding of host-range evolution.

I will first measure a range of evolutionary, ecological, and molecular factors contributing to PHI at high resolution using newly developed computational tools that exploit high-throughput datasets from thousands of natural environments around the world. Next, I will apply deep learning to integrate these measurements to simultaneously (i) quantify the relative importance and complex inter-dependencies of the different factors, and (ii) create a unique predictive model of host-range evolution. To complement these in silico predictions, I will develop an experimental evolution setup that tests the effect of the different PHI factors on host-range evolution in vitro.

Little is known about the abundant phages and their role in shaping our microbial world. DiversiPHI will vastly elevate this understanding and contribute new fundamental knowledge on how species-species interactions evolve in complex environments. Moreover, I will provide valuable new analysis tools to the community and consolidate my strong international reputation as a pioneering researcher in the cross-disciplinary field encompassing microbial ecology, virology, metagenomics, bioinformatics, and computer learning.

Project End Date: **30-APR-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866489	**COOPERATIVE PARTNER**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator:	**Dr. RITA COVAS**
Host Institution:	Iceta Instituto De Ciencias, Tecnologias E Agroambiente Da Universidade Do Porto, PT

Partner choice and the evolution of cooperation

Cooperation represents an evolutionary puzzle because natural sCooperation poses an evolutionary problem because natural selection is thought to favour cheaters over co-operators. However, theory and studies in humans show us that co-operators are preferred over cheaters as social and sexual partners. Partner choice may therefore provide a powerful explanation for the evolution and stability of cooperation, alongside kin selection and self-serving benefits, but we lack an understanding of its importance in natural systems. Recent studies showing that animals have a preference for associating with more cooperative individuals are promising but were mostly conducted in artificial captive conditions, making the evolutionary implications of partner choice hard to assess. Manipulating cooperation in the wild to test the fitness consequences of partner choice is the leap that is required to understand whether or not partner choice provides an evolutionary explanation for cooperation. I will pursue this goal using a long-term study that I established on a highly cooperative wild bird, the sociable weaver Philetairus socius. New methodological developments now allow us to conduct large-scale experiments in the wild, and detailed tracking of individual for several years will allow us to quantify the fitness consequences of choice. Specifically, here I will: i) use a new conceptual framework to test whether cooperation is repeatable (a pre-requirement for partner choice); ii) use state-of-the-art technology to manipulate cooperative behaviour and measure the resulting patterns of social and sexual partner choice; iii) use physiological measures and lifetime reproductive success to examine the fitness benefits arising from partner choice and the underlying mechanisms for both co-operators and the individuals that associate with them. Ultimately, the project will provide a novel and robust evaluation of the roles of social and sexual selection for the evolution of cooperation.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
883621	**SoilResist**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. RICHARD BARDGETT**
Host Institution: The University Of Manchester, UK

Diversity, stability and functioning of the soil microbiome

A major challenge for advancing our understanding of the functional role of highly complex soil microbial communities is to systematically link changes in their structure and functioning to biogeochemical cycles under realistic scenarios of global change. This is a formidable challenge: not only does it require a step change in our understanding of the factors that shape soil microbial communities and their functioning, but also it requires new knowledge of the ecological and genetic mechanisms that underpin its stability, or ability to resist and recover from abiotic perturbations associated with global change. By embracing technological and theoretical developments in microbial ecology, SoilResist will make a major step forward in our understanding of the mechanisms that underpin the resistance and resilience of soil microbial communities and their functioning to natural and anthropogenic perturbations. Specifically, I seek to develop a novel mechanistic understanding of the factors that underpin the resistance and resilience of complex soil microbial communities and their functioning to different types of anthropogenic perturbations, and, for the first time, identity critical thresholds for abrupt transitions of microbial communities to alternative states and consequences for soil functioning. My overarching hypothesis is that the stability of microbial functions, in terms of their capacity to resist and recover from a pulse perturbation caused by climate extremes, is determined by microbial functional diversity, based on range and relative abundance of microbial traits. I also hypothesize that shifts in microbial functional diversity resulting from press perturbations erode the capacity of soil microbial communities to buffer climate-related pulse perturbations, rendering them more vulnerable to an abrupt transition to alternative taxonomic and functional state with negative consequences for soil functioning.

Project End Date: **31-DEC-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695669	**PicoCB**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. FLORIAN HOLLFELDER**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

Exploring the Chemical Biology of Sequence Space via Picoliter Droplets

Directed evolution of functional proteins has arguably emerged as an approach to protein engineering that can complement or better design-led approaches to protein function. However, as a random process, enormous numbers of variants have to be screened and selected to have a chance to identify successful catalysts. This process is costly and cumbersome: Industrial screening facilities require investment of tens to hundred millions of dollars. My group has implemented key steps towards conducting quantitative biological experiments in a much cheaper format. Screening of individual library members in monodisperse oil-in-water compartments ('microdroplets') that are generated at kHz frequencies in microfluidic devices has been shown to be possible. The droplet compartment constitutes a link between a given phenotype and its encoding genotype, by capturing reaction product, and thus providing a unique system to screen for catalysis.In this way quantitative fitness landscapes for interconversion of members of enzyme superfamilies along the lines of catalytic promiscuity, understanding the factors governing specificity and the mechanistic interpretation of the observed evolutionary pathways can be made. We now apply this screening system of unprecedented capacity for directed evolution and metagenomic screening of enzymes in in vivo and in vitro formats. We plan to apply this system to do experiments that would not be possible with conventional, lower throughput approaches: (i) screening of metagenomic libraries for rare and promiscuous activities that characterise environmental gene collections for their reactivity and potential for applied biocatalysis; (ii) developing a fundamental understanding of and strategic guidelines for enzyme evolution based on fitness landscapes that record data on multiple, promiscuous activities in response to Indel mutations; and (iii) evolution of gene networks to build up signalling networks in vitro.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714239	**PERVOL**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. MATTHIAS ERB**
Host Institution: Universitaet Bern, CH

Perception of Plant Volatiles

The capacity to produce and perceive organic chemicals is essential for most cellular organisms. Plant leaves that are attacked by insect herbivores for instance start releasing distinct blends of herbivore-induced plant volatiles, which in turn can be perceived by non-attacked tissues. These tissues then respond more rapidly and more strongly to herbivore attack. One major question that constrains the current understanding of plant volatile communication is how plants perceive herbivore induced volatiles. Can plants smell danger by detecting certain volatiles with specific receptors? Or are other mechanisms at play? Answering these questions would push the boundaries of plant signaling research, as it would allow for the creation of perception impaired mutants to perform detailed analyses of the biological functions and potential agricultural benefits of plant volatile perception.
My recent work identified indole as a key herbivore induced volatile priming signal in maize. As indole is produced by many different plant species and has been well studied as a bacterial volatile, it is an ideal candidate to study the mechanisms and biological functions of plant volatile perception. The key objectives of PERVOL are 1) to develop a new high-throughput plant volatile sampling system for genetic screens of indole perception, 2) to use the system to identify molecular mechanisms of indole perception and 3) to create indole perception mutants to uncover novel biological functions of volatile priming. If successful, PERVOL will set technological standards by providing the community with an innovative and powerful volatile sampling system. Furthermore, it will push the field of plant volatile research by elucidating mechanisms of herbivore induced volatile perception, generating new genetic resources for functional investigations of plant volatile signaling and testing new potential biological functions of the perception of herbivore induced volatiles.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714289	**Stress Imaging**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. ROMANA SCHIRHAGL**
Host Institution: Academisch Ziekenhuis Groningen, NL

Nanoscale Stress Imaging with Imperfect Diamonds

My goal is to optically detect the magnetic resonance of free radicals/ROS inside cells. Radicals are suspected to play a crucial role in numerous pathogenic conditions including diseases responsible for most deaths worldwide (as arteriosclerosis, cancer, immune responses to pathogens). They are also involved in many processes in healthy cells as mitochondrial metabolism or aging of cells and part of the working mechanism of many drugs. Despite their relevance relatively little is known about where and when radicals are built, how they work or which ones play a role. Their short lifetime and reactivity poses a problem for many state of the art methods. Thus they are often a bottleneck in understanding stress responses. My goal is to develop a method, which can detect their magnetic resonance in the nanoscale. The method is based on a fluorescent defect in diamond, which changes its optical properties based on its magnetic surrounding. While this technique has been able to detect even the faint signal of a single electron spin, this technique is entirely new to biological fields. We can localize where, when and how much of a certain radical is generated with nm resolution. This is impossible with the current state of the art. Furthermore, since we obtain spectra we can also differentiate radicals to some extent. I am proposing to investigate two systems: 1) the involvement of radicals in the aging of yeast cells 2) the response of macrophages to stress. In the first project I will test the so-called free radical theory, which states that organisms age because cells accumulate free radical damage over time. In the second project I will answer the question how a macrophage reacts to the impact of a pathogen or a drug. Outcomes of this project would enable us to increase our understanding on how stress responses work on a molecular level. This will open up new possibilities to assess if and how drugs are working or how and why certain pathogens are worse than others.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715062	**HiChemSynPro**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. VLADIMIR TORBEEV**
Host Institution: Centre International De Recherche Aux Frontieres De La Chimie, FR

High-throughput combinatorial chemical protein synthesis as a novel research technology platform for chemical and synthetic biology

Chemical protein synthesis is an indispensable method in chemical and synthetic biology. However, at the present moment, it is laborious and involves multiple optimization and purification steps. High-throughput approaches for total synthesis of combinatorial libraries of custom-modified protein variants are needed. To change the situation, the work will be carried out in two directions: (1) implementation of microfluidic techniques for automation, miniaturization and multiplexing of experimental steps involved in the total synthesis of proteins, and (2) design and synthesis of novel catalytic proteins for efficient enzyme-assisted peptide ligations under denatured conditions. This innovative research technology will allow robust chemical synthesis of protein libraries with (100–10,000)-compounds with natural and unnatural modifications, bearing variety of post-translational modifications and also protein-like biopolymers. In this project, the new methodology will be validated by chemical synthesis of library of phosphorylated analogues of high mobility group protein A (HMGA), which is involved in gene-transcription and cancer development. Other potential future applications include protein design, biological problems where post-translational modifications play a crucial role (ranging from the 'histone code' hypothesis to understanding long-term memory) and functional annotation of newly discovered genes.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716058	**DeNovoImmunoDesign**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. BRUNO E. CORREIA**
Host Institution: Ecole Polytechnique Federale De Lausanne, CH

Computational Design of Novel Functional Proteins for Immunoengineering

Finely orchestrated protein activities are at the heart of the most fundamental cellular processes. The rational and structure-based design of novel functional proteins holds the promise to revolutionize many important aspects in biology, medicine and biotechnology. Computational protein design has led the way on rational protein engineering, however many of these designed proteins were solely focused on structural accuracy and completely impaired of function. DeNovoImmunoDesign proposes novel computational design strategies centered on the exploration of de novo protein topologies and the use of structural flexibility with the ultimate goal of designing functional proteins. The proposed methodologies aim to solve a prevalent problem in computational design that relates to the lack of optimal design templates for the optimization of function. By expanding beyond the known protein structural space, our approaches represent new paradigms on the design of de novo functional proteins. DeNovoImmunoDesign will leverage our new methodologies to design functional proteins with rational approaches for two crucial biomedical endeavors - vaccine design and cancer immunotherapy. Our strategy for vaccine design is to engineer structure-based epitope-focused immunogens to elicit potent neutralizing antibodies – a requirement for vaccine protection. The underlying basis of cancer immunotherapy is the inhibition of key protein-protein interactions - an arena where rational design is lagging. To meet this central need we will develop innovative approaches to design new protein binders for cancer immunotherapy applications. DeNovoImmunoDesign is a multidisciplinary proposal where computation is intertwined with experimentation (biochemistry, structural biology and immunology). Our unique competences and groundbreaking research have all the components to translate into transformative advances for both basic and applied biology through innovations in rational protein design.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724321	**Sense2SurviveSalt**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. CHRISTA TESTERINK**
Host Institution: Wageningen University, NL

Surviving salinity: How do plants sense Na+?

A major gap in our knowledge of how plants respond to soil salinity is their initial perception of sodium (Na+) ions. Salt is detrimental to plants and soil salinization is an increasing threat to global food security; 6% of the world's total land area and 20% of irrigated land is affected by salinity. I recently discovered Na+-specific root growth responses of plants and will now exploit these to identify the elusive sodium sensing mechanism of plants. I will use an innovative approach combining genome-wide genetic screens in the model plant Arabidopsis thaliana with dedicated biochemical assays.

I will identify candidate Na+-sensor genes through a natural genetic variation screen for the Na+-specific inhibition bending of the root in response to gravity (WP1). In parallel, I will follow a chemical genomics approach to find novel compounds that impair Na+ sensing, and their target proteins in plants (WP2). Subsequent complementary in silico and biochemical approaches will characterize Na+-affinity of the candidates (WP3). Selected putative Na+ sensors will be characterized in planta, by studying their localization, activity, their interactors, and by salt response phenotyping of mutants (WP4). Finally, mutant varieties of sensors will be introduced in the economically relevant crop plant tomato, to provide proof-of-concept for improving salt tolerance by modulating sensor function and implementation in crop improvement programs (WP5).

The impact of elucidation of plant Na+ sensing will be monumental; it will reveal how plant responses to salinity stress are driven, and ultimately what is required to cope with salinity. In addition, it will open up new applied directions for agriculture, where improved sodium sensing modules will be used to allow crop growth on marginal, saline soils.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725061	**TEMUBLYM**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. CAROLINA TAFALLA**
Host Institution: Instituto Nacional De Investigacion Y Tecnologia Agraria Y Alimentaria, ES

Teleost mucosal B1-like lymphocytes at the crossroad of tolerance and immunity

B cells are one of the main players of immunity, responsible for the production of immunoglobulins (Igs). In 2011, I was granted an ERC Starting grant to undertake the phenotypical and functional characterization of teleost B lymphocytes based on the hypothesis that they do not behave as mammalian B2 cells (conventional B cells) but closely resemble mammalian innate B1 lymphocytes involved in extrafollicular T-independent (TI) responses. Since then, my laboratory has gathered considerable evidences that strengthen this hypothesis. These studies were mostly carried out in central lymphoid compartments, but did not address how teleost B1-like cells regulate the delicate balance between immunity and tolerance at mucosal interfaces, in species lacking follicular structures. In this new project, I want to pursue my studies on B lymphocyte functionality, focusing on how teleost mucosal B cells are regulated, still under the assumption that fish B lymphocytes resemble better a B1 model. We will study how fish B cells differentiate to antibody secreting cells (ASCs) and establish extrafollicular long-term memory, taking into account novel results in mammals that have challenged traditional paradigms and revealed that long-term immunological memory can be established through TI IgM B1-like responses. Furthermore, we will also study the role of IgD in the gills, as previous studies from my group suggest that this Ig plays a key role in the regulation of immunity in this specific mucosa, as it seems to do in humans in areas such as the upper respiratory tract.

Addressing how fish B cells mount a protective mucosal immune response in the absence of T cell help from organized follicles could provide new mechanistic insights into IgM and IgD responses emerging in humans. From a practical view, our work will contribute to understand why satisfactory mucosal vaccination is still an unreached goal for most diseases in both mammals and fish, despite their strong demand.

Project End Date: **31-MAR-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
726151	**DeE-Nano**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. GIOVANNI MAGLIA**
Host Institution: Rijksuniversiteit Groningen, NL

Design and Engineering Next-Generation Nanopore Devices for Bioplymer Analysis

Nanopores have emerged in the past few years as a promising analytical technique. The basic concept of nanopore sensing is to apply a potential across individual nanoscale pores and observe the disruption of the ionic flow caused by single molecules entering the pore. Ionic currents through protein pores have been successful at recognizing tiny differences in molecules in solution. Most notably, arrays of thousands of nanopores integrated in low-cost and portable devices are now capable of sequencing DNA at the single-molecule level. The main challenge of nanopore sensing is the inability of controlling the protein pore diameter and geometry, which determines the signal and enables selectivity based on physical size.

The aim of this proposal is to design a new generation of protein nanopores that will take on the next grand challenge in nanopore sensing, that is the sequence identification of single proteins.

In order to sequence proteins, the designed nanopores must: unfold a target protein, control the speed of its transit across the nanopore and recognize individual amino acids. Our approach is to design a transmembrane molecular machine that will unfold target proteins and feed the linearize polypeptide through the nanopore where single amino acids will be recognized by modulations of the nanopore current.

The specific objectives are:

i) Develop chemical and biotechnological methods to design synthetic protein-based pores

ii) To precisely attach the unfolding machine to a nanopore

iii) To genetically engineer the nanopore for optimal amino acid recognition

Our nanopore devices will be used to develop the first technology to sequence single proteins. Compared to the state of the art 'shotgun proteomics', the nanopore approach will allow long polypeptide reads, recognition of low-abundance proteins, including biomarkers linked to diseases, and real-time monitoring with minimal cost, time and sample preparation.

Project End Date: **30-JUN-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
742654	**EpiTrack**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. SAULIUS KLIMASAUSKAS**
Host Institution: Vilniaus Universitetas, LT

Single-cell temporal tracking of epigenetic DNA marks

Over the past decade, epigenetic phenomena have taken centre stage in our understanding of gene regulation, cellular differentiation and human disease. DNA methylation is a prevalent epigenetic modification in mammals, which is brought about by enzymatic transfer of methyl groups from the S-adenosylmethionine (SAM) cofactor by three known DNA methyltransferases (DNMTs). The most dramatic epigenomic reprogramming in mammalian development occurs after fertilization, whereby a global loss of DNA methylation is followed by massive reinstatement of new methylation patterns, different for each cell type. Although DNA methylation has been extensively investigated, key mechanistic aspects of these fascinating events remain obscure. The goal of this proposal is to bridge the gap in our understanding of how the genomic methylation patterns are established and how they govern cell plasticity and variability during differentiation and development. These questions could only be answered by precise determination of where and when methylation marks are deposited by the individual DNMTs, and how these methylation marks affect gene expression. To achieve this ambitious goal, we will metabolically engineer mouse cells to permit SAM analog-based chemical pulse-tagging of their methylation sites in vivo. We will then advance profiling of DNA modifications to the single cell level via innovative integration of microdroplet-based barcoding, precise genomic mapping and super-resolution imaging. Using this unique experimental system we will determine, with unprecedented detail and throughput, the dynamics and variability of DNA methylation and gene expression patterns during differentiation of mouse embryonic cells to neural and other lineages. This project will give a comprehensive, time-resolved view of the roles that the DNMTs play in mammalian development, which will open new horizons in epigenomic research and will advance our understanding of human development and disease.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
743165	**BLASTOFF**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. SOPHIEN KAMOUN**
Host Institution: The Sainsbury Laboratory, UK

Retooling plant immunity for resistance to blast fungi

Plant NLR-type immune receptors tend to have a narrow spectrum of pathogen recognition, which is currently limiting their value in agriculture. NLRs can recognize pathogen effectors through unconventional domains that have evolved by duplication of an effector target followed by fusion into the NLR. One NLR with an integrated domain is the rice resistance protein Pik-1, which binds an effector of the blast fungus Magnaporthe oryzae via its Heavy-Metal Associated (HMA) domain. We solved the crystal structure of the HMA domain of Pik-1 in complex with a blast fungus effector and gained an unprecedented level of detail of the molecular interactions that define pathogen recognition. This led to the overall aim of this proposal to generate a complete picture of the biophysical interactions between blast fungus effectors and HMA-containing cereal proteins to guide the retooling of the plant immune system towards resistance to blast diseases. M. oryzae is a general cereal killer that infects wheat, barley and rice, which are staple food for a majority of the world population. The central hypothesis of the proposed research is that mutations in cereal HMA-containing proteins will result in broad-spectrum resistance to blast fungi.

To achieve our goal, we will pursue the following objectives:

1. BIOPHYSICS. Define the biophysical properties that underpin binding of M. oryzae effectors to HMA-containing proteins of cereal crops.

2. RECEPTOR ENGINEERING. Develop Pik-1 receptors that respond to a wide-spectrum of M. oryzae effectors.

3. GENOME EDITING. Mutate HMA domain-containing genes in cereal genomes to confer broad-spectrum blast resistance.

At the completion of this project, we will generate a thorough understanding of the biophysical properties of pathogen effector binding to cereal HMA proteins, and deliver traits and non-transgenic cultivars for breeding blast disease resistance in cereal crops.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
755617	**SENTIFLEX**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. JOCHEM VERRELST**
Host Institution: Universitat De Valencia, ES

Fluorescence-based photosynthesis estimates for vegetation productivity monitoring from space

Global food security will remain a worldwide concern for the next 50 years and beyond. Agricultural production undergoes an increasing pressure by global anthropogenic changes, including rising population, increased protein demands and climatic extremes. Because of the immediate and dynamic nature of these changes, productivity monitoring measures are urgently needed to ensure both the stability and continued increase of the global food supply. Europe has expressed ambitions to keep its fingers on the pulse of its agricultural lands. In response to that, this proposal - named SENTIFLEX - is dedicated to developing a European vegetation productivity monitoring facility based on the synergy of Sentinel-3 (S3) with FLEX satellite fluorescence data. ESA's 8th Earth Explorer FLEX is the first mission specifically designed to globally measure Sun-Induced chlorophyll Fluorescence (SIF) emission from terrestrial vegetation. These two European Earth observation missions offer immense possibilities to increase our knowledge of the basic functioning of the Earth's vegetation, i.e., the photosynthetic activity of plants resulting in carbon fixation. Two complementary approaches are envisioned to realize quantification of photosynthesis through satellite SIF and S3. First, the work seeks to advance the science in establishing and consolidating relationships between canopy-leaving SIF and unbiased estimates of photosynthesis of the plants, thereby disentangling the role of dynamic vegetative and atmospheric variables. Second, consolidated relationships between SIF and photosynthesis will be used to build a FLEX-S3 data processing assimilation scheme through process-based vegetation models that will deliver spatiotemporally highly resolved information on Europe's vegetation productivity. To streamline all these datasets into a prototype vegetation productivity monitoring facility, new data processing concepts will be introduced such as the emulation of radiative transfer models.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757384	**YEAST-TRANS**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. IRINA BORODINA**
Host Institution: Danmarks Tekniske Universitet, DK

Deciphering the transport mechanisms of small xenobiotic molecules in synthetic yeast cell factories

Industrial biotechnology employs synthetic cell factories to create bulk and fine chemicals and fuels from renewable resources, laying the basis for the future bio-based economy. The major part of the wanted bio-based chemicals are not native to the host cell, such as yeast, i.e. they are xenobiotic. Some xenobiotic compounds are readily secreted by synthetic cells, some are poorly secreted and some are not secreted at all, but how does this transport occur? Or why does it not occur? These fundamental questions remain to be answered and this will have great implications on industrial biotechnology, because improved secretion would bring down the production costs and enable the emergence of novel bio-based products.

YEAST-TRANS will fill in this knowledge gap by carrying out the first systematic genome-scale transporter study to uncover the transport mechanisms of small xenobiotic molecules by synthetic yeast cells and to apply this knowledge for engineering more efficient cell factories for bio-based production of fuels and chemicals.

To achieve these ambitious goals, we will create the first genome-scale yeast transportome library expressed in Xenopus oocytes and establish the methodology, based on mass spectrometry and electrophysiology, for semi high-throughput screening of the library for transporter activities. Using this library, the transport of a number of industrially relevant xenobiotic compounds by yeast transporters will be studied. The results of this large screening will present an unprecedented data set, which will enable uncovering the relationship between transporter proteins and their specificities. Moreover, a methodology for identification of native transporters from plants and bacteria, based on the gene clustering principle will be developed. We will use the acquired knowledge to modulate transporter activities and enhance the performance of chemical-producing synthetic yeast cell factories.

Project End Date: **30-NOV-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757833	**FORMICA**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. PIETER DE FRENNE**
Host Institution: Universiteit Gent, BE

Microclimatic buffering of plant responses to macroclimate warming in temperate forests

Recent global warming is acting across ecosystems and threatening biodiversity. Yet, due to slow responses, many biological communities are lagging behind warming of the macroclimate (the climate of a large geographic region). The buffering of microclimates near the ground measured in localized areas, arising from terrain features such as vegetation and topography, can explain why many species are lagging behind macroclimate warming. However, almost all studies ignore the effects of microclimatic buffering and key uncertainties still exist about this mechanism. Microclimates are particularly evident in forests, where understorey habitats are buffered by overstorey trees. In temperate forests, the understorey contains the vast majority of plant diversity and plays an essential role in driving ecosystem processes.

The overall goal of FORMICA (FORest MICroclimate Assessment) is to quantify and understand the role of microclimatic buffering in modulating forest understorey plant responses to macroclimate warming. We will perform the best assessment to date of the effects of microclimates on plants by applying microtemperature loggers, experimental heating, fluorescent tubes and a large-scale transplant experiment in temperate forests across Europe. For the first time, plant data from the individual to ecosystem level will be related to microclimate along wide temperature gradients and forest management regimes. The empirical results will then be integrated in cutting-edge demographic distribution models to forecast plant diversity in temperate forests as macroclimate warms.

FORMICA will provide the first integrative study on microclimatic buffering of macroclimate warming in forests. Interdisciplinary concepts and methods will be applied, including from climatology, forestry and ecology. FORMICA will reshape our current understanding of the impacts of climate change on forests and help land managers and policy makers to develop urgently needed adaptation strategies.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757886	**ELONGAN**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. PABLO BERMEJO-ÁLVAREZ**
Host Institution: Instituto Nacional De Investigacion Y Tecnologia Agraria Y Alimentaria, ES

Gene editing and in vitro approaches to understand conceptus elongation in ungulates

In contrast to human or rodent embryos, ungulate embryos do not implant into the uterus right after blastocyst hatching. Before implantation, the hatched ungulate blastocyst must undergo dramatic morphological changes characterized by cell differentiation, proliferation and migration processes leading to the development of extra-embryonic membranes, the appearance of a flat embryonic disc and gastrulation. This prolonged preimplantation development is termed conceptus elongation and deficiencies on this process constitute the most frequent cause of reproductive failures in ungulates, including the 4 most relevant mammalian livestock species in Europe. The purpose of this project is to elucidate the factors involved in conceptus elongation by gene editing and in vitro culture approaches. A first objective will be to identify key genes involved in differentiation processes by RNA-seq analysis of different embryo derivatives from bovine conceptuses at different developmental stages. Subsequently, the function of some of the genes identified as well as others known to play a crucial role in mouse development or putatively involved in embryo-maternal interactions will be assessed. For this aim, bovine embryos in which a candidate gene has been ablated (KO) will be generated by CRISPR and transferred to recipient females to assess in vivo the function of such particular gene on conceptus development. A second set of experiments pursue the development of an in vitro system for conceptus elongation that would bypass the requirement for in vivo experiments. For this aim we will perform metabolomics and proteomics analyses of bovine uterine fluid at different stages and will use these data to rationally develop a culture system able to sustain conceptus development. The knowledge generated by this project will serve to develop strategies to enhance farming profitability by reducing embryonic loss and to understand Developmental Biology questions unanswered by the mouse model.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757993	**LubSat**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. ANWESHA SARKAR**
Host Institution: University Of Leeds, UK

Unravelling Multi-scale Oral Lubrication Mechanisms (macro-to-nano): A Novel Strategy to Target Satiety

Obesity is a serious form of malnutrition that is known to have substantial morbidity and mortality consequences. Hence, to directly promote weight management, there is an immense need to design satiety-enhancing foods that terminate appetite for longer periods after consumption. Although the concept of “satiety cascade” was proposed nearly 20 years ago, the changing dynamics of food properties in the oral mucosa remains the greatest source of uncertainty in food design. In particular, our quantitative multi-scale understanding of lubrication of the human salivary film when exposed to stimuli from food biomolecules, which in turn can have significant appetite suppression consequences, remains poorly understood. The key limitation to accurately measure oral lubrication is the lack of tribo-contact surfaces that effectively emulate the oral surfaces (i.e. the soft, slippery mucous-coated human tongue and the upper palate).

I intend to address these deficiencies by proposing a whole hierarchy of scales (from human scale down to nanometres). To do so, I will use a unique combination of in vitro and in vivo experimental approaches to quantitatively establish molecular mechanisms of salivary lubrication and its psychological and physiological consequences. In order to determine the true oral lubrication mechanism of food-saliva mixtures, I propose to develop and deploy new instrument based on novel 3D printing coupled with both surface-patterning and unique biochemical functionalization to emulate the surface topologies and chemistries of oral environments at macro-to-nano scales. The ground-breaking nature of the project will be to discover how food-mediated alteration of salivary lubricity will result in enhanced satiety perception for longer periods. This will bring the paradigm shift in thinking that is needed to underpin the creation of the next generation of weight management foods and allow the development of coordinated public health strategies to tackle obesity.

Project End Date: **31-OCT-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
770835	**SynBioBrain**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. CHRIS BARNES**
Host Institution: University College London, UK

Building biological computers from bacterial populations

Biosensors detect compounds using a biological component combined with a physio-chemical detector. Using synthetic biology, we can now engineer bacteria into whole-cell biosensors where sensing, transduction and output occur within the living cell. Applications include the detection of harmful environmental agents, bioprocess monitoring, and detecting medically relevant biomarkers. As we move towards more sophisticated applications, single channel read-out will be replaced with sensors that have multiple inputs and more complex information processing capabilities. Whilst digital logic within a single strain of bacteria can be implemented, consortia offer a powerful alternative, where information is integrated and processed in a distributed fashion. This proposal sets out a research project that will construct biological computers formed from engineered bacterial populations that communicate using quorum sensing molecules. Information from multiple biosensor inputs will be integrated and processed by the biocomputer, the output of which will be spatial patterning. The architecture will be based on cellular automata, which can perform any computation, including logic and temporal logic operations, memory and counting, all of which can be used to distinguish states in complex biological and chemical environments. Our biocomputers will be housed in microfluidic devices using hydrogel structures to create two and three dimensional regular arrangements. As a proof-of-concept, we will develop a biocomputer for the analysis and monitoring of intestinal and microbiota health through stool samples. Sensors for inflammation, pH and short chain fatty acids will be combined into a device that can indicate whether an individual has inflammatory bowel disease or irritable bowel syndrome. A low-cost device for use at home, which distinguishes between these conditions, could potentially save the global health care industry billions of dollars in unnecessary diagnostic treatments.

Project End Date: **30-APR-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771049	**FREEDLES**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. MIINA RAUTIAINEN**
Host Institution: Aalto-Korkeakoulusaatio, FI

From needles to landscapes: a novel approach to scaling forest spectra

Accounting for vegetation structure – clumping of foliage into shoots or crowns – is the largest remaining challenge in modelling scattered and absorbed radiation in complex vegetation canopies such as forests. Clumping controls the radiation regime of forest canopies, yet it is poorly quantified. Currently, the communities working with vegetation structure and optical measurements do not have a common understanding of the concept. The FREEDLES project sets out to develop a universal method for quantifying clumping of foliage in forests based on detailed 3D structure and spectral reflectance data. Clumping will be linked to photon recollision probability, an exciting new development in the field of photon transport modelling. Photon recollision probability will, in turn, be used to develop a spectral scaling algorithm which will connect the spectra of vegetation at all hierarchical levels from needles and leaves to crowns, stands and landscapes. The spectral scaling algorithm will be validated with detailed reference measurements in both laboratory and natural conditions, and applied to interpret forest variables from satellite images at different spatial resolutions. The proposed approach is contrary to many other lines of current development where more complexity is favoured in canopy radiation models. If successful, the approach will significantly improve estimates of absorbed and scattered radiation fields in forests and retrieval results of forest biophysical variables from satellite data. Future applications can also be expected in global radiation and carbon balance estimation and in chlorophyll fluorescence models for forests. Most importantly, the spectral scaling model will open new horizons for our scientific understanding of photon-vegetation interactions.

Project End Date: **30-APR-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787115	**MaCChines**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. ROMAN JERALA**
Host Institution: Kemijski Institut, SI

Molecular machines based on coiled-coil protein origami

Proteins are the most versatile and complex smart nanomaterials, forming molecular machines and performing numerous functions from structure building, recognition, catalysis to locomotion. Nature however explored only a tiny fraction of possible protein sequences and structures. Design of proteins with new, in nature unseen shapes and features, offers high rewards for medicine, technology and science. In 2013 my group pioneered the design of a new type of modular coiled-coil protein origami (CCPO) folds. This type of de novo designed proteins are defined by the sequence of coiled-coil (CC) dimer-forming modules that are concatenated by flexible linkers into a single polypeptide chain that self-assembles into a polyhedral cage based on pairwise CC interactions. This is in contrast to naturally evolved proteins where their fold is defined by a compact hydrophobic core. We recently demonstrated the robustness of this strategy by the largest de novo designed single chain protein, construction of tetrahedral, pyramid, trigonal prism and bipyramid cages that self-assemble in vivo.

This proposal builds on unique advantages of CCPOs and represents a new frontier of this branch of protein design science. I propose to introduce functional domains into selected positions of CCPO cages, implement new types of building modules that will enable regulated CCPO assembly and disassembly, test new strategies of caging and release of cargo molecules for targeted delivery, design knotted and crosslinked protein cages and introduce toehold displacement for the regulated structural rearrangement of CCPOs required for designed molecular machines, which will be demonstrated on protein nanotweezers. Technology for the positional combinatorial library-based single pot assembly of CCPO genes will provide high throughput of CCPO variants. Project will result in new methodology, understanding of potentials of CCPOs for designed molecular machines and in demonstration of different applications.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787768	**H-Unique**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. SUE BLACK**
Host Institution: University Of Lancaster, UK

In search of uniqueness - harnessing anatomical hand variation

H-unique will be the first multimodal automated interrogation of visible hand anatomy, through analysis and interpretation of human variation. It will be an interdisciplinary project, supported by anatomists, anthropologists, geneticists, bioinformaticians, image analysts and computer scientists. We will investigate inherent and acquired variation in search of uniqueness, as the hand retains and displays a multiplicity of anatomical variants formed by different aetiologies (genetics, development, environment, accident etc).

Hard biometrics, such as fingerprints, are well understood and some soft biometrics are gaining traction within both biometric and forensic domains (e.g. superficial vein pattern, skin crease pattern, morphometry, scars, tattoos and pigmentation pattern). A combinatorial approach of soft and hard biometrics has not been previously attempted from images of the hand. We will pioneer the development of new methods that will release the full extent of variation locked within the visible anatomy of the human hand and reconstruct its discriminatory profile as a retro-engineered multimodal biometric. A significant step change is required in the science to both reliably and repeatably extract and compare anatomical information from large numbers of images especially when the hand is not in a standard position or when either the resolution or lighting in the image is not ideal.

Large datasets are vital for this work to be legally admissible. Through citizen engagement with science, this research will collect images from over 5,000 participants, creating an active, open source, ground-truth dataset. It will examine and address the effects of variable image conditions on data extraction and will design algorithms that permit auto-pattern searching across large numbers of stored images of variable quality. This will provide a major novel breakthrough in the study of anatomical variation, with wide-ranging, interdisciplinary and transdisciplinary impact.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802629	**INTERACT**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. KORBINIAN SCHNEEBERGER**
Host Institution: Ludwig-Maximilians-Universitaet Muenchen, DE

Phylogenetic association mapping and its application to secondary metabolite variation in Brassicaceae species

During the past years, great progress has been made in connecting phenotypes to genotypes based on within-species variation. However, the more dramatic variation that can be found between species has not been explored for phenotype/genotype associations so-far. Using classical genetics to mine between-species variation is mostly impossible, because crosses between distinct species hardly work and their genomes are usually highly rearranged.
The goal of this project is to develop unprecedented genomics-based methods for inter-species (phylogenetic) association mapping, which can find signals even in highly re-arranged genomes of different species. To ensure that these methods are also useful in practice, we will apply them to the variation in secondary metabolites within the Brassicaceae plant family. Secondary metabolites are highly variable, genetically controlled, easy to measure and have broad application in cancer prevention, pest control and food design. Given the great potential of phylogenetic association mapping in general and secondary metabolites in particular, our work promises to be ground-breaking and have profound impact on many different fields of genetic research.

Specifically, our work plan includes the following points:
I) We will develop strategies for phylogenetic association mapping and implement them in publicly-available software.
II) We will establish a panel of inbred lines from ~200 Brassicaceae species and generate whole-genome assemblies for each of them.
III) We will exemplify the usefulness of phylogenetic association mapping by correlating the diversity of secondary metabolites to the differences in the respective genomes and validate the results by transforming or mutating candidate genes in appropriate species.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804229	**LIMBo**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. CLÁUDIA NUNES DOS SANTOS**
Host Institution: Universidade Nova De Lisboa, PT

Zooming the link between diet and brain health: how phenolic metabolites modulate brain inflammation

Currently a big concern of our aging society is to efficiently delay the onset of neurodegenerative diseases which are progressively rising in incidence. The paradigm that a diet rich in the phenolics, prevalent e.g. in fruits, is beneficial to brain health has reached the public. However their mechanistic actions in brain functions remain to be seen, particularly since the nature of those acting in the brain remains overlooked. I wish to address this gap by identifying candidate compounds that can support development of effective strategies to delay neurodegeneration.

Specifically, I will be analysing the potential of dietary phenolics in both prevention and treatment (i.e delay) of neuroinflammation – key process shared in neurodegenerative diseases. To break down the current indeterminate status of "cause vs effect", my vision is to focus my research on metabolites derived from dietary phenolics that reach the brain. I will be investigating their effects in both established and unknown response pathways of microglia cells - the innate immune cells of the central nervous system, either alone or when communicating with other brain cells. Ultimately, to attain an integrated view of their effects I will establish nutrition trials in mice. LIMBo considers both pro- and anti- inflammatory processes to preliminary validate the action of any promising metabolite in prevention and/or therapeutics.

LIMBo provides valuable scientific insights for future implementation of healthy brain diets. My group is in a unique position to address LIMBo objectives due to multidisciplinary expertise in organic synthesis, metabolomics and molecular and cellular biology, together with our previous data on novel neuroactive metabolites.

LIMBo also creates far-reaching opportunities by generating knowledge that impacts our fundamental understanding on the diversity of phenolic metabolites and their specific influences in neuroinflammation and potential use as prodrugs.

Project End Date: **31-MAR-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
805094	**GRASP**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. CHARLES MELNYK**
Host Institution: Sveriges Lantbruksuniversitet, SE

Overcoming plant graft incompatibility by modifying signalling and perception

For millennia, people have cut and joined together different plants through a process known as grafting. Plants tissues from different genotypes fuse, vasculature connects and a chimeric organism forms that combines desirable characteristics from different plants such as high yields or disease resistance. However, plants can only be grafted to closely related species and in some instances, they cannot be grafted to themselves. This phenomenon is referred to as graft incompatibility and the mechanistic basis is completely unknown. Our previous work on graft formation in Arabidopsis thaliana has uncovered genes that rapidly activate in grafted tissues to signal the presence of adjoining tissue and initiate a vascular reconnection process. These genes activate around the cut only during graft formation and present a powerful tool to screen large numbers of chemicals and genes that could promote tissue perception and vascular formation. With these sensors and our previously established grafting tools in the model plant Arabidopsis, we can address fundamental questions about grafting biology that have direct relevance to improving graft formation through:

1. Identifying genes required for the recognition response using forward and reverse genetic screens.
2. Determining and characterising signals that activate vascular induction using a chemical genetics screen.
3. Characterising the transcriptional basis for compatibility and incompatibility by analysing tissues and species that graft and comparing these to tissues and species that do not graft.
4. Overcoming graft incompatibility and improving graft formation by applying the knowledge obtained from the three previous objectives.

We thus aim to broaden our fundamental understanding of the processes associated with grafting including wound healing, vascular formation and tissue regeneration, while at the same time, use this information to improve graft formation and expand the range of grafted species.

Project End Date: **31-JUL-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818890	**ArtHep**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. BRIGITTE STADLER**
Host Institution: Aarhus Universitet, DK

Hepatocytes-Like Microreactors for Liver Tissue Engineering

The global epidemics of obesity and diabetes type 2 lead to higher abundancy of medical conditions like non-alcoholic fatty liver disease causing an increase in liver failure and demand for liver transplants. The shortage of donor organs and the insufficient success in tissue engineering to ex vivo grow complex organs like the liver is a global medical challenge.

ArtHep targets the assembly of hepatic-like tissue, consisting of biological and synthetic entities, mimicking the core structure elements and key functions of the liver. ArtHep comprises an entirely new concept in liver regeneration with multi-angled core impact: i) cell mimics are expected to reduce the pressure to obtain donor cells, ii) the integrated biocatalytic subunits are destined to take over tasks of the damaged liver slowing down the progress of liver damage, and iii) the matching micro-environment in the bioprinted tissue is anticipated to facilitate the connection between the transplant and the liver.

Success criteria of ArtHep include engineering enzyme-mimics, which can perform core biocatalytic conversions similar to the liver, the assembly of biocatalytic active subunits and their encapsulation in cell-like carriers (microreactors), which have mechanical properties that match the liver tissue and that have a camouflaging coating to mimic the surface cues of liver tissue-relevant cells. Finally, matured bioprinted liver-lobules consisting of microreactors and live cells need to connect to liver tissue when transplanted into rats.

I am convinced that the ground-breaking research in ArtHep will contribute to the excellence of science in Europe while providing the game-changing foundation to counteract the ever increasing donor liver shortage. Further, consolidating my scientific efforts and moving them forward into unexplored dimensions in biomimicry for medical purposes, is a unique opportunity to advance my career.

Project End Date: **30-APR-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819934	**ProMiDis**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. GEORGIOS SKRETAS**
Host Institution: Ethniko Idryma Erevnon, GR

A unified drug discovery platform for protein misfolding diseases

It is now widely recognized that a variety of major diseases, such as Alzheimer's disease, Huntington's disease, systemic amyloidosis, cystic fibrosis, type 2 diabetes etc., are characterized by a common molecular origin: the misfolding of specific proteins. These disorders have been termed protein misfolding diseases (PMDs) and the vast majority of them remain incurable. Here, I propose the development of a unified approach for the discovery of potential therapeutics against PMDs. I will generate engineered bacterial cells that function as a broadly applicable discovery platform for compounds that rescue the misfolding of PMD-associated proteins (MisPs). These compounds will be selected from libraries of drug-like molecules biosynthesized in engineered bacteria using a technology that allows the facile production of billions of different test molecules. These libraries will then be screened in the same bacterial cells that produce them and the rare molecules that rescue MisP misfolding effectively will be selected using an ultrahigh-throughput genetic screen. The effect of the selected compounds on MisP folding will then be evaluated by biochemical and biophysical methods, while their ability to inhibit MisP-induced pathogenicity will be tested in appropriate mammalian cell assays and in established animal models of the associated PMD. The molecules that rescue the misfolding of the target MisPs and antagonize their associated pathogenicity both in vitro and in vivo, will become drug candidates against the corresponding diseases. This procedure will be applied for different MisPs to identify potential therapeutics for four major PMDs: Huntington's disease, cardiotoxic light chain amyloidosis, dialysis-related amyloidosis and retinitis pigmentosa. Successful realization of ProMiDis will provide invaluable therapeutic leads against major diseases and a unified framework for anti-PMD drug discovery.

Project End Date: **29-FEB-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834631	**DNA-DOCK**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. IMRE BERGER**
Host Institution: University Of Bristol, UK

Precision Docking of Very Large DNA Cargos in Mammalian Genomes

Gene editing has developed at breath-taking speed. In particular CRISPR/Cas9 provides a tool-set thousands of researchers worldwide now utilize with unprecedented ease to edit genes, catalysing a broad range of biomedical and industrial applications. Gene synthesis technologies producing thousands of base pairs of synthetic DNA have become affordable. Current gene editing technology is highly effective for local, small genomic DNA edits and insertions. To unlock the full potential of this revolution, however, our capacities to disrupt or rewrite small local elements of code must be complemented by equal capacities to efficiently insert very large synthetic DNA cargos with a wide range of functions into genomic sites. Large designer cargos would carry multicomponent DNA circuitry including programmable and fine-tuneable functionalities, representing the vital interface between gene editing which is the state-of-the-art at present, and genome engineering, which is the future. This challenge remained largely unaddressed to date.

We aspire to resolve this bottleneck by creating ground-breaking, generally applicable, easy-to-use technology to enable docking of large DNA cargos with base pair precision and unparalleled efficiency into mammalian genomes. To achieve our ambitious goals, we will apply a whole array of sophisticated tools. We will unlock a small non-human virus to rational design, creating safe, flexible and easy-to-produce, large capacity DNA delivery nanodevices with unmatched transduction capability. We will exploit a range of techniques including Darwinian in vitro selection/evolution to accomplish unprecedented precision DNA integration efficiency into genomic sites. We will use parallelized DNA assembly methods to generate multifunctional circuits, to accelerate T cell engineering, resolving unmet needs. Once we accomplish our tasks, our technology has the potential to be exceptionally rewarding to the scientific, industrial and medical communities.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
849029	**EpigeneticScars**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. DEBORAH TOIBER**
Host Institution: Ben-Gurion University Of The Negev, IL

Understanding DSB repair from pathway choice to long term effects and their consequences.

DNA safekeeping is one of the most important functions of the cell. Since DNA damage occurs in the context of chromatin, it affects both the DNA itself, but also the epigenetic landscape. While the repair mechanism of the DNA has been extensively studied, questions abound regarding the restoration of the epigenetic landscape, and the long-term effects that damage leaves in the region. In this proposal I aim to address these questions using modified DSBs repair sensors from different pathways such as “homologous recombination” and “non-homologous end joining” to map the repair process. Our method will allow us to investigate the influence of the natural epigenetic landscape on pathway choice, the dynamic process of repair and the restoration of the region. Moreover, we will investigate whether certain repair processes leave long- lasting effects at the site of damage or even “epigenetic scars”. The advantage of our method is that it allows us to map each sensor repair time-line in an unbiased and high throughput manner over extended periods of time, even once the damage is already repaired. These questions are especially important for our understanding of ageing, and age-related diseases that are driven by DNA damage. Last, we will test the long-lasting effects of past damage in two different contexts: animal models of neurodegeneration, where DNA damage accumulates, and in the efficiency of reprograming to produce healthy induced pluripotent stem cells (IPCs).

Project End Date: **28-FEB-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851765	**SweetBrain**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. BEN MEIR MAOZ**
Host Institution: Tel Aviv University, IL

A new perspective on the metabolic pathway to neuronal dysfunction: Using organs on a chip to elucidate the role of the brain microvasculature

Despite decades of research, the underpinnings of central nervous system (CNS) diseases and clear pathways to effective treatment remain elusive, mainly because of a scarcity of adequate models and methods with the capacity to elucidate human brain physiology. Recent studies suggest that high glucose levels are correlated with neuronal dysfunction and neurodegeneration, yet very little is known about the mechanisms of this relationship. Research in this vein has focused primarily on direct metabolic interactions between neurons and astrocytes, ignoring other cell populations in the neurovascular unit (NVU) that might have a meaningful role. My recent research revealed that the brain vasculature—the 'gatekeeper' through which all metabolites must pass to reach the neurons—has direct metabolic coupling with the neurons. Drawing from these observations, I adopt a previously unconsidered perspective and propose that the vasculature drives the neurodegenerative effects of hyperglycemia. Specifically, I hypothesize that high glucose levels change the metabolic function of the brain vasculature, thereby altering the direct endothelium-neuronal crosstalk and triggering neuronal dysfunction. To investigate this hypothesis, I will develop cutting-edge Organ-on-a-Chip (OoC) technology that overcomes the limitations of modeling NVU functionality and cell-cell interactions. Specifically, I will:

(1) establish a human-relevant NVU-OoC model for metabolic and functional interactions, in which different cell types grow separately while remaining metabolically and functionally coupled;

(2) identify the major metabolic and functional interactions in the human NVU at homeostasis and under diabetic conditions; and subsequently (3) target the vasculature communications to diminish neuronal dysfunction. This research has the potential to revolutionize the study of CNS disease, pointing to an unexplored pathway to a cure, and illuminating fundamental questions regarding brain metabolism.

Project End Date: **30-JUN-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851919	**MAGNIFISCENT**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. SHAI BERLIN**
Host Institution: Technion - Israel Institute Of Technology, IL

mesoscale multi-mode MRI of molecular targets

Imaging defined cells, over extended time, depends on signal strength, stability, accessibility and specificity. Whereas light-microscopy (LM) can provide these, it does not allow imaging of entire intact tissues; imaging-depths and area-size are restricted, and not easily obtained through skin and bone. Magnetic Resonance Imaging (MRI) outperforms LM in these instances; providing images of large-fields-of-view (i.e., mesoscale), at any depth, easily across bone. Nevertheless, MRI suffers from low signals, spatial resolution and cannot detect specific biological targets. To remedy these shortcomings, and significantly extend the capabilities of MRI, we propose a novel chemo-genetic approach—MAGNIFISCENT (MAGNetic Including Fluorescence Imaging of Select Cells with ENzymatic Tags)—to jointly image multiple defined cellular-targets by MRI and LM. In parallel thrusts, we will synthesize a novel family of multifunctional, membrane-permeable, liganded-Contrast-Agents (CA; patented) that irreversibly bind original genetically-encoded enzymatic tags (eTags). When several eTags are expressed in various cells, each will bind its corresponding liganded-CA bearing a unique MRI-signature ('color'); affording multicolor-MRI of the brain. To mitigate hurdles of expression, we introduce enrichment, an elegant scheme to increase binding-surface for MFS-agents. We estimate it to increase resolution of MRI to the single-cell level. Lastly, developing split-eTags will enable imaging cellular interactions of up to four different cellular populations jointly, a feat never shown before for MRI. We develop an innovative targeted-recombination scheme to ENTRAP neurons destined for apoptosis; a hallmark of neurodegeneration. Together, when combined, select targets will be irreversibly 'tagged' for long-term multimodal imaging at high resolutions. The multidisciplinary nature of my group ensures our success in developing this versatile technology for studying the brain in health and disease.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852012	**Synthetic T-rEX**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. VELIA SICILIANO**
Host Institution: Fondazione Istituto Italiano Di Tecnologia, IT

A synthetic biology approach for T cell exhaustion

Synthetic Biology has revolutionised approaches for several scientific, industrial and medical applications. These include the development of immunotherapies based on bioengineered cells, most notably engineering of patients T cells with tumor-targeting receptors, the CAR-T cells. Cell-based immunotherapies have shown remarkable clinical success; yet, long-term benefits are hampered by dysfunction of T cells occurring following antigen chronic exposure, a process known as T cell exhaustion. Current treatments of T cell exhaustion are limited and exhibit adverse effects.

Synthetic T-rEX aims to reprogram exhausted T-cells using synthetic biology circuits, to implement enhanced and more effective immune cell-based therapies. We will develop specific, self-contained genetic circuits with improved capabilities that minimise the impact on normal cell physiology; by pre-programmed integration of exhaustion-specific intracellular signals, these will rewire T cell activity and restore normal function. Circuits will be developed using a stepwise, bottom-up approach to identify exhaustion-specific inputs by RNA and microRNA-sequencing profile performed on ex vivo exhausted human CD8+ T cells. We will then design (a) synthetic promoters and (b) microRNA-regulated 5'UTR that will compute information processing to trigger output activation. Localised therapy will rely on concerted action of genetically encoded immune-checkpoint blockade and fine-tuning of epigenetic modulators that play a major role in T cell exhaustion. Finally, we will engineer T cells with sensor-actuator synthetic devices that revert exhaustion (T-rEX cells). In summary, our proposal provides a paradigm shift in the development of strategies against T cell exhaustion and a solid break-through towards enhanced natural and cell-based immunotherapy. More broadly, the proposed approach will unleash the potential of synthetic biology to the next level of therapeutic intervention.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852600	**Lacto-Be**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. SARAH LEBEER**
Host Institution: Universiteit Antwerpen, BE

Advancing Lactobacillus' beneficial potential

Lactobacillus bacteria have a strong, but underexplored potential as sustainable bio-based solutions for many food and health-related problems. Since Nobel-laureate Eli Metchnikoff hypothesized that lactic acid bacteria can promote human health in the gut, the research on lactobacilli and probiotics has mainly focused on the human gut and fermented dairy foods. However, a major knowledge gap exists on the beneficial potential of Lactobacillus species in other human body sites (vagina, skin, upper respiratory tract), animals (e.g. chickens, honey bees), plants, crops, and even on abiotic surfaces. In addition, lactobacilli play a key role in many plant- and vegetable-based fermentations, where they promote the shelf life and nutritional value of food and feed. Yet, why and how Lactobacillus species can be beneficial in such a wide variety of niches is currently underexplored. Therefore, the core aim of this project is a systematic and integrated analysis of the evolutionary history, ecology, and beneficial functions of Lactobacillus species. I propose an unconventional approach situated at the intersections of molecular microbiology (focusing on a single microbe), molecular ecology (focusing on microbial communities) and comparative genomics with an evolutionary perspective on niche adaptation of lactobacilli. By looking deeper into Lactobacillus biology, a paradigm shift can be made moving from a classical ad hoc base to a unique knowledge-based framework for strain selection and analysis of fitness and performance.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852621	**LeDNA**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. KRISTY DEINER**
Host Institution: Eidgenoessische Technische Hochschule Zurich, CH

Global measure of biodiversity by understanding biogeochemical cycling of environmental DNA in lakes

The global loss and redistribution of biodiversity is a hallmark of the Anthropocene. Our challenge is to generate information about how altered biodiversity influences ecosystems and use this information to change our impact on the biosphere. To meet this challenge, we must know where species are, how their distributions change in time and why. However, current methods for determining species distributions is expensive, time intensive and hard to do for multiple species and large geographic regions- rendering global trend analysis near infeasible. We therefore need a paradigm shift. I will utilize the biotechnology of the fourth industrial revolution (i.e., inexpensive sequencing and computational power) to empirically change how we sample animal and plant biodiversity to solve the infeasibility problem of tracking multiple species distributions on large spatial scales. I am among the first to show that DNA shed from animals into the environment ('eDNA') is transported in rivers (10-12 km) and that it is from aquatic and terrestrial species. Building on these observations, I hypothesize that transported eDNA allows for sampling multiple species on large spatial scales and will test my hypothesis by determining if lakes act as accumulators of eDNA in the landscape by receiving transported eDNA from rivers. Thus, my proposed research will investigate (1) how chemical, physical, and biotic processes cause eDNA decay to understand its transport potential in the environment, (2) how much eDNA from a catchment is transported into a lake, and (3) in a global set of lakes, test whether eDNA measures seasonal turnover of biodiversity for large spatial scales. If lakes accumulate eDNA from their catchments, sampling them will provide the paradigm shift needed to vastly change the cost, speed and geographic scale with which species can be surveyed through time to understand what effect their change has on the biosphere.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
853272	**PALAEOFARM**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. LAURENT FRANTZ**
Host Institution: Queen Mary And Westfield College University Of London, UK

Linking livestock genetic diversity with three thousand years of agricultural crises and resilience

Over the last 50 years, chiOver the last 50 years, chicken production has increased fivefold, chicken growth rate has tripled, and milk production per cow has doubled. Yet, many of the biotechnological tools responsible for this accelerated trend are now under threat of becoming obsolete. While the causes are numerous, one significant driver is a dramatic reduction of genetic diversity in livestock populations.

Cycles of agricultural productivity growth and decline have occurred throughout European history, spurred by major historical forces such as the spread of empires and continent-wide epidemics. For example, productivity crashed between the 4th-13th centuries, only to rebound during the Agricultural Revolution of the 13-18th centuries. Fluctuating levels of genetic diversity were likely both cause and remedy to these cycles. Genetic diversity acts as a fuel for selection: the lower it is, the more difficult it is to improve traits, and the more likely that epidemics will develop and spread. Given this importance, maintaining diversity amongst livestock is recognised as one of the UN's Sustainable Development Goals. Despite this, we lack any understanding of how much genetic variability was present, and subsequently lost, before, during, and after either the Green or Agricultural Revolutions, nor do we understand how efficiently it was utilised.

PALAEOFARM will assess the long-term sustainability of modern breeding practices by unravelling how genetic variability was leveraged across major agricultural transitions in European history. Using an innovative combination of ancient DNA, archaeozoology, and experimental immunology, I will explore how livestock populations withstood epidemics and selective breeding in a world without antibiotics or quantitative genetic techniques. This will provide a novel perspective on how a multi-billion euro industry, responsible for feeding billions of people, can be sustained in the face of major biotechnological obsolescence.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
853433	**ONCO-VAX**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. JENNIFER ALTOMONTE**
Host Institution: Klinikum Rechts Der Isar Der Technischen Universitat Munchen, DE

A multifaceted cancer immunotherapy based on an immune checkpoint-modulating chimeric oncolytic virus vector in combination with a dendritic cell vaccine

Despite many decades of intensive research, cancer remains a major worldwide health concern and imposes a heavy societal burden, both epidemiologically and financially. Cancer immunotherapy is rapidly transforming the face of medical oncology as an exciting paradigm shift in treating cancer by exploiting the immune system of the patient as the basis for the therapy. Although dramatic results have been achieved in a subset of patients, the responses in most solid tumors have been disappointing. Hepatocellular carcinoma (HCC) represents a particularly challenging malignancy to treat, due to the inherently immune-suppressive microenvironment in the liver. Oncolytic viruses (OVs) offer an elegant multimodal approach to combat HCC through their ability to cause direct tumor cell lysis, while stimulating immune responses directed against the tumor. Nevertheless, the potential of OVs as monotherapeutics is limited by the innate antiviral immune response, which rapidly restricts virus replication and spread within the tumor mass. Therefore, a successful therapeutic strategy should employ a combination scheme involving a mechanism to improve the intratumoral dissemination of the OV, while exploiting the immune-stimulatory capacity of the virus, in order to achieve far-reaching synergistic responses that can target metastatic disease. The ONCO-VAX approach aims to accomplish just that. A novel chimeric oncolytic virus backbone with an enhanced cell-cell spreading capacity, will be utilized as a platform to express an optimized gene for eradicating the local immune-suppressive microenvironment in the tumor. As an additional layer of therapy, the virus will be combined with a cutting edge dendritic cell vaccine approach to initiate a broad antitumor response for systemic and potentially life-long immunity against the cancer. This multifaceted approach represents an innovative and crucial step forward in the rapidly evolving field of cancer immuno-oncology.

Project End Date: **31-MAR-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864117	**nbPTMs**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. IVAN MATIC**
Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

A multifaceted platform for exploring nucleotide-based post-translational modifications

Nucleotide-based post-translational modifications (nbPTMs) play key roles in health and disease, from bacterial pathogenesis to cancer. However, technical challenges of these versatile, but chemically complex protein modifications have constrained our fundamental understanding of even the most intensely studied nbPTMs for decades. The overarching aim of this proposal is to establish, apply and disseminate a methodology to unveil novel types of nbPTMs and allow site-specific proteomic analyses. The conceptual innovation lies in a strategy for turning the complex chemical structures of nbPTMs from a challenge to an advantage. First, shared chemical moieties will be exploited to develop pan-specific enrichment of multiple nbPTMs. For this purpose, we will generate the first nbPTMs-specific antibodies by converting specific signalling proteins into biotechnology tools for chemoenzymatic synthesis of challenging peptide antigens (aim 1). Second, we will take advantage of the chemical lability of nbPTMs to analyse modified peptides using a nucleobase-targeted mass spectrometry approach (aim 2). The unbiased scope of our methodology will make possible the discovery of as yet unknown forms of nbPTMs (aim 3) and nbPTM site mapping throughout eukaryotic proteomes (aim 4). These new materials, methods, discoveries and datasets will be made publicly available to allow future investigations of nbPTMs by the scientific community. The new substrates, sites and nbPTMs will provide starting points for biological characterization (aim 5). Poised at the interface of biology and technology, this interdisciplinary research project has the potential to explore new territories within established biomedical fields and to contribute to the knowledge base for improved treatment of diseases.

Project End Date: **31-MAR-26**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864528	**PArtCell**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. ARNOLD BOERSMA**
Host Institution: Dwi Leibniz-Institut Fur Interaktive Materialien Ev, DE

Physiologically Crowded Artificial Cells for Relevant Drug Screens

In the crowded cell, nonspecific interactions between biomolecules alter biochemical equilibria. This matrix of weak nonspecific interactions is composed of hydrophobic, electrostatic, H-bonding, van der Waals, and steric interactions, and is “the dark matter of biology”.
Inaccurate prediction of the behaviour of biomolecules inside cells hampers drug discovery: A high throughput drug screen against a purified target protein in dilute buffer ignores the presence of these weak interactions and results are less relevant. High throughput screens directly in cells are however more difficult to control, interpret and measure.
PArtCell provides a key advance by combining the high level of control and ease of high-throughput screening on purified proteins, with the relevance of screening in the native environment.
The aim is to construct artificial cells that provide a physiologically relevant drug-screening platform.
We will achieve this aim by constructing artificial cells with a matrix of weak nonspecific interactions akin living cells as verified with newly engineered fluorescent probes. The probes measure hydrophobicity, electrostatics and steric effects, as well as the physicochemical state of pathogenic condensates, in healthy and stressed living cells. With this information, we will benchmark artificial cells. Drug screens are applied against pathogenic oligomers that we now can observe in these well-characterized artificial cells.
This research will update textbook knowledge and provide the molecular origin of the matrix of weak nonspecific interactions in living cells. It provides a platform that allows screening against targets under native-like conditions not achievable with other methods. This research thus provides a new opportunity to screen drugs against diseases for which we have no cure yet.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864669	**e-MICROBe**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator:	**Dr. MIRIAM ROSENBAUM**
Host Institution:	Leibniz-Institut Fur Naturstoff-Forschung Und Infektionsbiologie Ev Hans-Knoll-Istitut, DE

Energizing microbes with redox mediators for new bioproductions

In many bioprocesses a broad bioproduct portfolio can currently only be obtained when microorganisms can access oxygen as an electron acceptor. For numerous target substances, however, oxygen is detrimental to product stability and the bioprocess operation. The central aim of e-MICROBe is to innately couple microbial metabolism and electrochemistry via a self-secreted soluble electron mediator to achieve efficient oxygen independent energy metabolism and to directly steer and control metabolism and product formation. This will require creating entirely new physiological traits for production and utilization of redox mediators to generate cellular energy. Thereby, mediators can either act as electron discharge shuttle to enable electro-respiration at an anode or they are employed as inorganic energy donor to deliver electrons from a cathode into the metabolism. We will clarify the underlying reaction pathways in known environmental microorganisms and re-engineer the energy metabolism of common biotech hosts. Thereby, we will switch cellular energy generation from aerobic respiration to anaerobic anodic electro-respiration or from hydrogen consumption as autotrophic electron donor to cathodic electron consumption. The latter process will provide a mechanism to store electrical energy in microbial products. For a new level of in situ insight into microbial energy metabolism, a novel micro-scale bioelectrochemical reactor coupled to microscopic observation and high performance analysis will be developed. With this technique two fundamental concepts for future mediator-based bioprocesses will be evaluated: An all-in-one strategy where one cell is generating the mediators and the targeted product as well as a co-culture system, whereby one cell produces the mediators and a partner cell utilizes them for electro-respiration and product formation. This concept will lay the foundation for a plug-and-play exchange of biotech strains in a mediator-producing co-culture system.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865973	**CRISPRcombo**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. CHASE BEISEL**
Host Institution: Helmholtz-Zentrum Fur Infektionsforschung Gmbh, DE

Interrogating native CRISPR arrays to achieve scalable combinatorial screens and dissect genetic redundancy

A ubiquitous yet poorly understood theme pervading biology is redundancy, wherein seemingly equivalent components drive shared processes. In cases from development to pathogenesis, untangling the ensuing web of potential genetic interactions can be virtually impossible with conventional techniques. CRISPR technologies, with their propensity for multiplexing, are well poised to address this challenge. However, current CRISPR-based screens have not exceeded more than two targets at a time. Here, I will achieve a major leap forward for CRISPR-based screens and dissecting redundancy by harnessing a core yet underexplored part of CRISPR: CRISPR arrays. CRISPR arrays naturally form the immunological memory of CRISPR-Cas systems and produce multiple targeting gRNAs processed from a single transcript. The arrays are highly compact, genetically stable, and can encode hundreds of gRNAs. However, the repetitive “repeats” within each array have hampered their construction and widespread adoption. My group recently made a breakthrough with the modular one-pot assembly of long arrays and array libraries. This capability grants us the unique opportunity to develop the first high-throughput, CRISPR-based screens that readily scale to many gene targets at a time. In parallel, our first assembled arrays highlighted technical constraints to designing robust and highly active arrays. I posit that native CRISPR arrays have faced similar limitations and thus can inform the design of array libraries. I thus propose to

1) Develop design rules for CRISPR arrays yielding only intended and uniformly abundant guide RNAs.
2) Elucidate and exploit why CRISPR arrays are genetically stable.
3) Perform scalable combinatorial screens using redundancy by small RNAs in E. coli as a compelling case study.

If successful, this project will reveal unexplored properties of CRISPR arrays and, for the first time, achieve scalable combinatorial screens for interrogating redundancy throughout biology.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
668998	**OCLOC**	**PE1** Mathematics

Principal Investigator: **Dr. KARL KUNISCH**
Host Institution: Universitaet Graz, AT

From Open to Closed Loop Optimal Control of PDEs

The proposal addresses some of the most pressing topics in optimal control of partial differential equations (PDEs): Non-smooth, non-convex optimal control and computational techniques for feedback control. These two topics will be applied to the large scale optimal control problems for the bidomain equations, which are the established model to describe the electrical activity of the heart. Due to their rich dynamical systems behavior these systems are particularly challenging.

The use of non-smooth functionals is of great practical relevance in many diverse situations. They promote sparsity, and provide a perfect formulation for switching and multi-bang controls, and for the optimal actuator location problem. For inverse problems the case L^{p} with $p\in (0,1)$ is of special statistical importance, and L^0 can be the basis of a new formulation for topology optimization problems. But lack of Lipschitz continuity and of convexity are significant obstacles which can only be overcome by the development of new analytical and numerical concepts. The new algorithmic concepts will also be applicable to important non-smooth problems in continuum mechanics, as for instance the quasi-static evolution of fractures.

Closed loop control is of paramount importance due to its {\bf robustness} against system perturbations. Nevertheless, numerical realization of optimal feedback strategies for nonlinear PDEs has barely been touched since the curse of dimensionality makes direct numerical treatment of the Hamilton-Jacobi-Bellman equation unfeasible. We shall therefore develop and analyze suboptimal strategies based on model reduction and interpolation techniques, and on model-predictive control. The availability of boundary and near-to-the boundary measurements together with dynamic observer techniques will allow to test the proposed methods to obtain suboptimal feedback controls for the bidomain equations.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724903	**PEPCo**	**PE1** Mathematics

Principal Investigator: **Dr. MATHIAS SCHACHT**
Host Institution: Universitaet Hamburg, DE

Problems in Extremal and Probabilistic Combinatorics

Extremal and probabilistic combinatorics is a central and currently maybe the most active and fastest growing area in discrete mathematics. The field can be traced back to the work of Turán and it was established by Erdős through his fundamental contributions and his uncounted guiding questions. Since then it has grown into an important discipline with strong ties to other mathematical areas such as theoretical computer science, number theory, and ergodic theory.

The PI proposes a variety of extremal problems for hypergraphs and for sparse random and pseudorandom graphs. The work for hypergraphs is motivated by Turán's problem, maybe the most prominent open problem in the area. After solving an analogous question for graphs, Turán asked to determine the maximum cardinality of a set E of three-element subsets of a given n-element set V such that for any 4 elements of V at least one triple is missing in E. This innocent looking problem seems to be out of reach by our current methods and despite a great deal of effort over the last 70 years, our knowledge is still very limited.

We suggest a variant of the problem by imposing additional restrictions on the distribution of the three-element subsets in E. These additional assumptions yield a finer control over the corresponding extremal problem. In fact, this leads to many interesting and hopefully more manageable subproblems, some of which were already considered by Erdős and Sós. We suggest a unifying framework for these problems and one of the main goals would be the development of new techniques for this type of problems. These additional assumptions on the hyperedge distribution are closely related to the theory of quasirandom discrete structures, which was pioneered by Szemerédi and became a central theme in the field. In fact, the hypergraph extension by Gowers and by Rödl et al. of the regularity lemma provide essential tools for this line of research.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759967	**CatDT**	**PE1** Mathematics

Principal Investigator: **Dr. BEN DAVISON**
Host Institution: The University Of Edinburgh, UK

Categorified Donaldson-Thomas Theory

According to string theory, coherent sheaves on three-dimensional Calabi-Yau spaces encode fundamental properties of the universe. On the other hand, they have a purely mathematical definition. We will develop and use the new field of categorified Donaldson-Thomas (DT) theory, which counts these objects. Via the powerful perspective of noncommutative algebraic geometry, this theory has found application in recent years in a wide variety of contexts, far from classical algebraic geometry.

Categorification has proved tremendously powerful across mathematics, for example the entire subject of algebraic topology was started by the categorification of Betti numbers. The categorification of DT theory leads to the replacement of the numbers of DT theory by vector spaces, of which these numbers are the dimensions. In the area of categorified DT theory we have been able to prove fundamental conjectures upgrading the famous wall crossing formula and integrality conjecture in noncommutative algebraic geometry. The first three projects involve applications of the resulting new subject:

1. Complete the categorification of quantum cluster algebras, proving the strong positivity conjecture.

2. Use cohomological DT theory to prove the outstanding conjectures in the nonabelian Hodge theory of Riemann surfaces, and the subject of Higgs bundles.

3. Prove the comparison conjecture, realising the study of Yangian quantum groups and the geometric representation theory around them as a special case of DT theory.

The final objective involves coming full circle, and applying our recent advances in noncommutative DT theory to the original theory that united string theory with algebraic geometry:

4. Develop a generalised theory of categorified DT theory extending our results in noncommutative DT theory, proving the integrality conjecture for categories of coherent sheaves on Calabi-Yau 3-folds.

Project End Date: **31-OCT-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
770880	**COMANFLO**	**PE1** Mathematics

Principal Investigator: **Dr. SIDDHARTHA MISHRA**
Host Institution: Eidgenoessische Technische Hochschule Zurich, CH

Computation and analysis of statistical solutions of fluid flow

Entropy (admissible) weak solutions are widely considered to be the standard solution framework for hyperbolic systems of conservation laws and incompressible Euler equations. However, the lack of global existence results in several space dimensions, the recent demonstration of non-uniqueness of these solutions and computations showing the lack of convergence of state of the art numerical methods to them, have reinforced the need to seek alternative solution paradigms.

Although one can show that numerical approximations of these nonlinear PDEs converge to measure-valued solutions i.e Young measures, these solutions are not unique and we need to constrain them further. Statistical solutions i.e, time-parametrized probability measures on spaces of integrable functions, are a promising framework in this regard as they can be characterized as a measure-valued solution that also contains information about all possible multi-point spatial correlations. So far, well-posedness of statistical solutions has been shown only in the case of scalar conservation laws.

The main aim of the proposed project is to analyze statistical solutions of systems of conservation laws and incompressible Euler equations and to design efficient numerical approximations for them. We aim to prove global existence of statistical solutions in several space dimensions, by showing convergence of these numerical approximations, and to identify suitable additional admissibility criteria for statistical solutions that can ensure uniqueness. We will use these numerical methods to compute statistical quantities of interest and relate them to existing theories (and observations) for unstable and turbulent fluid flows. Successful completion of this project aims to establish statistical solutions as the appropriate solution paradigm for inviscid fluid flows, even for deterministic initial data, and will pave the way for applications to astrophysics, climate science and uncertainty quantification.

Project End Date: **31-JUL-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
770924	**IPTheoryUnified**	**PE1** Mathematics

Principal Investigator: **Dr. MIKKO SALO**
Host Institution: Jyvaskylan Yliopisto, FI

Inverse boundary problems: toward a unified theory

This proposal is concerned with the mathematical theory of inverse problems. This is a vibrant research field at the intersection of pure and applied mathematics, drawing techniques from PDE, geometry, and harmonic analysis as well as generating new research questions inspired by applications. Prominent questions include the Calderón problem related to electrical imaging, the Gel'fand problem related to seismic imaging, and geometric inverse problems such as inversion of the geodesic X-ray transform.

Recently, exciting new connections between these different topics have begun to emerge in the work of the PI and others, such as

- the explicit appearance of the geodesic X-ray transform in the Calderón problem
- an unexpected connection between the Calderón and Gel'fand problems involving control theory
- pseudo-linearization as a potential unifying principle for reducing nonlinear problems to linear ones
- the introduction of microlocal normal forms in inverse problems for PDE

These examples strongly suggest that there is a larger picture behind various different inverse problems, which remains to be fully revealed.

This project will explore the possibility of a unified theory for several inverse boundary problems. Particular objectives include:

1. The use of normal forms and pseudo-linearization as a unified point of view, including reductions to questions in integral geometry and control theory
2. The solution of integral geometry problems, including the analysis of convex foliations, invertibility of ray transforms, and a systematic Carleman estimate approach to uniqueness results
3. A theory of inverse problems for nonlocal models based on control theory arguments

Such a unified theory could have remarkable consequences even in other fields of mathematics, including controllability methods in transport theory, a solution of the boundary rigidity problem in geometry, or a general pseudo-linearization approach for solving nonlinear operator equations.

Project End Date: **30-APR-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771507	**StabCondEn**	**PE1** Mathematics

Principal Investigator: **Dr. PAOLO STELLARI**
Host Institution: Universita Degli Studi Di Milano, IT

Stability Conditions, Moduli Spaces and Enhancements

I will introduce new techniques to address two big open questions in the theory of derived/triangulated categories and their many applications in algebraic geometry.
The first one concerns the theory of Bridgeland stability conditions, which provides a notion of stability for complexes in the derived category. The problem of showing that the space parametrizing stability conditions is non-empty is one of the most difficult and challenging ones. Once we know that such stability conditions exist, it remains to prove that the corresponding moduli spaces of stable objects have an interesting geometry (e.g. they are projective varieties). This is a deep and intricate problem.
On the more foundational side, the most successful approach to avoid the many problematic aspects of the theory of triangulated categories consisted in considering higher categorical enhancements of triangulated categories. On the one side, a big open question concerns the uniqueness and canonicity of these enhancements. On the other side, this approach does not give a solution to the problem of describing all exact functors, leaving this as a completely open question. We need a completely new and comprehensive approach to these fundamental questions.
I intend to address these two sets of problems in the following innovative long-term projects:
1. Develop a theory of stability conditions for semiorthogonal decompositions and its applications to moduli problems. The main applications concern cubic fourfolds, Calabi-Yau threefolds and Calabi-Yau categories.
2. Apply these new results to the study of moduli spaces of rational normal curves on cubic fourfolds and their deep relations to hyperkaehler geometry.
3. Investigate the uniqueness of dg enhancements for the category of perfect complexes and, most prominently, of admissible subcategories of derived categories.
4. Develop a new theory for an effective description of exact functors in order to prove some related conjectures.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772466	**NOISE**	**PE1** Mathematics

Principal Investigator: **Dr. GABOR PETE**
Host Institution: Magyar Tudomanyos Akademia Renyi Alfred Matematikai Kutatointezet, HU

Noise-Sensitivity Everywhere

Noise-sensitivity of a Boolean function with iid random input bits means that resampling a tiny proportion of the input makes the output unpredictable. This notion arises naturally in computer science, but perhaps the most striking example comes from statistical physics, in large part due to the PI: the macroscopic geometry of planar percolation is very sensitive to noise. This can be recast in terms of Fourier analysis on the hypercube: a function is noise sensitive iff most of its Fourier weight is on "high energy" eigenfunctions of the random walk operator.

We propose to use noise sensitivity ideas in three main directions:

(A) Address some outstanding questions in the classical case of iid inputs: universality in critical planar percolation; the Friedgut-Kalai conjecture on Fourier Entropy vs Influence; noise in First Passage Percolation.

(B) In statistical physics, a key example is the critical planar FK-Ising model, with noise being Glauber dynamics. One task is to prove noise sensitivity of the macroscopic structure. A key obstacle is that hypercontractivity of the critical dynamics is not known.

(C) Babai's conjecture says that random walk on any finite simple group, with any generating set, mixes in time poly-logarithmic in the volume. Two key open cases are the alternating groups and the linear groups SL(n,F2). We will approach these questions by first proving fast mixing for certain macroscopic structures. For permutation groups, this is the cycle structure, and it is related to a conjecture of Tóth on the interchange process, motivated by a phase transition question in quantum mechanics.

We will apply ideas of statistical physics to group theory in other novel ways: using near-critical FK-percolation models to prove a conjecture of Gaboriau connecting the first ell2-Betti number of a group to its cost, and using random walk in random environment to prove the amenability of the interval exchange transformation group, refuting a conjecture of Katok.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772960	**Loops and groups**	**PE1** Mathematics

Principal Investigator: **Dr. NATHALIE WAHL**
Host Institution: Kobenhavns Universitet, DK

Loops and groups: Geodesics, moduli spaces, and infinite discrete groups via string topology and homological stability

This proposal lies at the intersection of algebra, topology, and geometry, with the scientific goal of answering central questions about homological stability, geodesics on manifolds, and the moduli space of Riemann surfaces. Homological stability is a subject that has seen spectacular progress in recent years, and recent work of the PI has opened up new perspectives on this field, through, among other things, associating a canonical family of spaces to any stability problem. The first two goals of the proposal are to give conditions under which this family of spaces is highly connected, and to use this to prove homological and representation stability theorems, with determination of the stable homology. Particular attention is given to Thompson-like groups, building on a recent breakthrough of the PI with Szymik. The last two goals concern geodesics and moduli spaces via string topology: The third goal seeks a geometric construction of compactified string topology, which we propose to use to address counting problems for geodesics on manifolds. Finally our fourth goal is to use compactified string topology to study the harmonic compactification itself, and give a new approach to finding families of unstable homology classes in the moduli space of Riemann surfaces. The feasibility of the last goals is demonstrated by the PIs earlier algebraic work in this direction; the proposal is to incorporate geometry in a much more fundamental way.

The project combines breakthrough methods from homotopy theory with methods from algebraic, differential and geometric topology. Some of the goals are high risk, but we note that in those cases even partial results will be of significant interest. The PI has a proven track record at the international forefront of research, and as a research leader, e.g., through a previous ERC Starting Grant. The research team will consist of the PI together with 3 PhD students and 3 postdocs in total during the 5 years.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
786854	**G-Statistics**	**PE1** Mathematics

Principal Investigator: **Dr. XAVIER PENNEC**
Host Institution: Institut National De Recherche En Informatique Et En Automatique, FR

Foundations of Geometric Statistics and Their Application in the Life Sciences

Invariance under gauge transformation groups provides the natural structure explaining the laws of physics. In life sciences, new mathematical tools are needed to estimate approximate invariance and establish general but approximate laws. Rephrasing Poincaré: a geometry cannot be more true than another, it may just be more convenient, and statisticians must find the most convenient one for their data. At the crossing of geometry and statistics, G-Statistics aims at establishing the mathematical foundations of geometric statistics and to exemplify their impact on selected applications in the life sciences.

So far, mainly Riemannian manifolds and negatively curved metric spaces have been studied. Other geometric structures like quotient spaces, stratified spaces or affine connection spaces naturally arise in applications. G-Statistics will explore ways to unify statistical estimation theories, explaining how the statistical estimations diverges from the Euclidean case in the presence of curvature, singularities, stratification. Beyond classical manifolds, particular emphasis will be put on flags of subspaces in manifolds as they appear to be natural mathematical object to encode hierarchically embedded approximation spaces.

In order to establish geometric statistics as an effective discipline, G-Statistics will propose new mathematical structures and theorems to characterize their properties. It will also implement novel generic algorithms and illustrate the impact of some of their efficient specializations on selected applications in life sciences. Surveying the manifolds of anatomical shapes and forecasting their evolution from databases of medical images is a key problem in computational anatomy requiring dimension reduction in non-linear spaces and Lie groups. By inventing radically new principled estimations methods, we aim at illustrating the power of the methodology and strengthening the "unreasonable effectiveness of mathematics" for life sciences.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788250	**NONFLU**	**PE1** Mathematics

Principal Investigator:	**Dr. DIEGO CORDOBA**
Host Institution:	Agencia Estatal Consejo Superior De Investigaciones Cientificas, ES

Non-local dynamics in incompressible fluids

The goal of this project is to pursue new methods in the mathematical analysis of non-local and non-linear partial differential equations. For this purpose we present several physical scenarios of interest in the context of incompressible fluids, from a mathematical point of view as well as for its applications: both from the standpoint of global well-posedness, existence and uniqueness of weak solutions and as candidates for blowup.

The equations we consider are the incompressible Euler equations, incompressible porous media equation and the generalized Quasi-geostrophic equation. This research will lead to a deeper understanding of the nature of the set of initial data that develops finite time singularities as well as those solutions that exist for all time for incompressible flows.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802787	**KAPIBARA**	**PE1** Mathematics

Principal Investigator: **Dr. PIOTR ACHINGER**
Host Institution: Instytut Matematyczny Polskiej Akademii Nauk, PL

Homotopy Theory of Algebraic Varieties and Wild Ramification

The aim of the proposed research is to study the homotopy theory of algebraic varieties and other algebraically defined geometric objects, especially over fields other than the complex numbers. A noticeable emphasis will be put on fundamental groups and on K(pi, 1) spaces, which serve as building blocks for more complicated objects. The most important source of both motivation and methodology is my recent discovery of the K(pi, 1) property of affine schemes in positive characteristic and its relation to wild ramification phenomena.

The central goal is the study of etale homotopy types in positive characteristic, where we hope to use the aforementioned discovery to yield new results beyond the affine case and a better understanding of the fundamental group of affine schemes. The latter goal is closely tied to Grothendieck's anabelian geometry program, which we would like to extend beyond its usual scope of hyperbolic curves.

There are two bridges going out of this central point. The first is the analogy between wild ramification and irregular singularities of algebraic integrable connections, which prompts us to translate our results to the latter setting, and to define a wild homotopy type whose fundamental group encodes the category of connections.

The second bridge is the theory of perfectoid spaces, allowing one to pass between characteristic p and p-adic geometry, which we plan to use to shed some new light on the homotopy theory of adic spaces. At the same time, we address the related question: when is the universal cover of a p-adic variety a perfectoid space? We expect a connection between this question and the Shafarevich conjecture and varieties with large fundamental group.

The last part of the project deals with varieties over the field of formal Laurent series over C, where we want to construct a Betti homotopy realization using logarithmic geometry. The need for such a construction is motivated by certain questions in mirror symmetry.

Project End Date: **31-MAY-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802901	**MaMBoQ**	**PE1** Mathematics

Principal Investigator: **Dr. MARCELLO PORTA**
Host Institution: Scuola Internazionale Superiore Di Studi Avanzati, DE

Macroscopic Behavior of Many-Body Quantum Systems

This project is devoted to the analysis of large quantum systems. It is divided in two parts: Part A focuses on the transport properties of interacting lattice models, while Part B concerns the derivation of effective evolution equations for many-body quantum systems. The common theme is the concept of emergent effective theory: simplified models capturing the macroscopic behavior of complex systems. Different systems might share the same effective theory, a phenomenon called universality. A central goal of mathematical physics is to validate these approximations, and to understand the emergence of universality from first principles.

Part A: Transport in interacting condensed matter systems. I will study charge and spin transport in 2d systems, such as graphene and topological insulators. These materials attracted enormous interest, because of their remarkable conduction properties. Neglecting many-body interactions, some of these properties can be explained mathematically. In real samples, however, electrons do interact. In order to deal with such complex systems, physicists often rely on uncontrolled expansions, numerical methods, or formal mappings in exactly solvable models. The goal is to rigorously understand the effect of many-body interactions, and to explain the emergence of universality.

Part B: Effective dynamics of interacting fermionic systems. I will work on the derivation of effective theories for interacting fermions, in suitable scaling regimes. In the last 18 years, there has been great progress on the rigorous validity of celebrated effective models, e.g. Hartree and Gross-Pitaevskii theory. A lot is known for interacting bosons, for the dynamics and for the equilibrium low energy properties. Much less is known for fermions. The goal is fill the gap by proving the validity of some well-known fermionic effective theories, such as Hartree-Fock and BCS theory in the mean-field scaling, and the quantum Boltzmann equation in the kinetic scaling.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
805495	**LIMITS**	**PE1** Mathematics

Principal Investigator: **Dr. LUKASZ GRABOWSKI**
Host Institution: University Of Lancaster, UK

Limits of Structures in Algebra and Combinatorics

The project is concerned with Borel and measurable combinatorics, sparse graph limits, approximation of algebraic structures and applications to metric geometry and measured group theory. Our research will result in major advances in these areas, and will create new research directions in combinatorics, analysis and commutative algebra.
The main research objectives are as follows.
1) Study equidecompositions of sets and solve the Borel version of the Ruziewicz problem.
2) Give a new characterisation of amenable groups in terms of measurable Lovasz Local Lemma.
3) Study rank approximations of infinite groups and commutative algebras.

Project End Date: **31/janv./24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
817597	**IGOC**	**PE1** Mathematics

Principal Investigator: **Dr. XIN LI**
Host Institution: University Of Glasgow, UK

Interactions between Groups, Orbits, and Cartans

Recently, we discovered that the notion of Cartan subalgebras builds bridges between C*-algebras, topological dynamics, and geometric group theory. The goal of this research project is to develop our understanding of this concept in order to attack the following major open questions:

I. The UCT question
II. The Baum-Connes conjecture
III. The conjugacy problem for topological shifts
IV. Quasi-isometry rigidity for polycyclic groups

UCT stands for Universal Coefficient Theorem and is a crucial ingredient in classification. I want to make progress on the open question whether sufficiently regular C*-algebras satisfy the UCT, taking my joint work with Barlak as a starting point.
The Baum-Connes conjecture predicts a K-theory formula for group C*-algebras which has far-reaching applications in geometry and algebra as it implies open conjectures of Novikov and Kaplansky. My new approach to II will be based on Cartan subalgebras and the notion of independent resolutions due to Norling and myself.
Problem III asks for algorithms deciding which shifts are topologically conjugate. It has driven a lot of research in symbolic dynamics.
Conjecture IV asserts that every group quasi-isometric to a polycyclic group must already be virtually polycyclic. A solution would be a milestone in our understanding of solvable Lie groups.
To attack III and IV, I want to develop the new notion of continuous orbit equivalence which (as I recently showed) is closely related to Cartan subalgebras.

Problems I to IV address important challenges, so that any progress will result in a major breakthrough. On top of that, my project will initiate new interactions between several mathematical areas. It is exactly the right time to develop the proposed research programme as it takes up recent breakthroughs in classification of C*-algebras, orbit equivalence for Cantor minimal systems, and measured group theory, where measure-theoretic analogues of our key concepts have been highly successful.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850930	**FIBRING**	**PE1** Mathematics

Principal Investigator: **Dr. DAWID KIELAK**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Fibring of manifolds and groups

The study of manifolds that fibre over the circle has a long and exciting history at the core of modern manifold topology, starting with Farrell's work on the problem in high ('surgery') dimensions, and running through the celebrated work of Stallings and Thurston in dimension 3, to Agol's 2013 solution of Thurston's virtual fibring conjecture. Parallel developments in group theory have placed the study of Bieri-Neumann-Strebel (BNS) invariants, which emerged in the 1980s, at the heart of the subject; these invariants describe when a group fibres, i.e. admits a map onto Z with finitely generated kernel. In the research outlined here a powerful new set of algebraic invariants - agrarian polytopes - will be used to establish a new frontier in the theory of fibring. The main goal is to achieve a complete description of all possible fibrings over the circle for aspherical manifolds in surgery dimensions.

An agrarian polytope is a subset of the vector space H_1(X;R), where X is a group or a manifold. It is defined in the novel framework of agrarian invariants that I am developing, a theory that has already borne remarkable fruit. The theory provides algebraic counterparts to the (analytic) L2-invariants that have proved so powerful in geometric topology, group theory and global analysis over the last four decades.

The primary focus of the research proposed here lies in establishing new deep connections between the algebra of group rings and their completions, and global properties of aspherical manifolds and groups. Three further goals of the proposal are: to develop the theory of agrarian invariants in positive characteristic; to show that agrarian invariants are profinitely rigid; to apply the new technology to the study of dynamical zeta functions. Each of these goals promises a breakthrough in its respective domain.

Project End Date: **30-JUN-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850941	**LAHACODE**	**PE1** Mathematics

Principal Investigator: **Dr. KATHARINA ELISABETH SCHRATZ**
Host Institution: Sorbonne Universite, FR

Low-regularity and high oscillations: numerical analysis and computation of dispersive evolution equations

Partial differential equations (PDEs) play a central role in mathematics, allowing us to describe physical phenomena ranging from ultra-cold atoms (Bose–Einstein condensation) up to ultra-hot matter (nuclear fusion), from learning algorithms to fluids in the human brain. To understand nature we have to understand their qualitative behavior: existence and long time behavior of solutions, their geometric and dynamical properties – as well as to compute reliably their numerical solution. While linear problems and smooth solutions are nowadays well understood, a reliable description of 'non-smooth' phenomena remains one of the most challenging open problems in computational mathematics since the underlying PDEs have very complicated solutions exhibiting high oscillations and loss of regularity. This leads to huge errors, massive computational costs and ultimately provokes the failure of classical schemes. Nevertheless, 'non-smooth phenomena' play a fundamental role in modern physical modeling (e.g., blow-up phenomena, turbulences, high frequencies, low dispersion limits, etc.) which makes it an essential task to develop suitable numerical schemes. The overall ambition of LAHACODE is to make a crucial step towards closing this gap – addressing the fundamental question: How and to what extent can we reproduce the qualitative behavior of differential equations in a finite (discretized) world? LAHACODE is situated at the challenging frontiers of analysis and numerics. The main objective is to develop a novel class of numerical schemes for nonlinear PDEs with strong geometric structure at low regularity and high oscillations. The key idea in the construction of the new schemes is to tackle and deeply embed the underlying structure of resonances in the numerical discretizations. As in the continuous case, these terms are central to structure preservation, and provide the new schemes with remarkable properties – allowing reliable approximations where classical schemes fail.

Project End Date: **30-APR-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851701	**HSD**	**PE1** Mathematics

Principal Investigator: **Dr. SOBHAN SEYFADDINI**
Host Institution: Centre National De La Recherche Scientifique, FR

Homeomorphisms in symplectic topology and dynamics

The subject of this proposal is the field of continuous symplectic topology. This is an area of symplectic topology which defines and studies continuous analogues of smooth symplectic objects such as symplectic and Hamiltonian homeomorphisms and asks questions about persistence of various symplectic phenomena under uniform limits and perturbations.

Our aim is to explore, and further develop, continuous symplectic topology from two different perspectives: The first is a symplectic topological perspective which is informed by Gromov's soft and hard view of symplectic topology. The second is motivated by the recent interactions of continuous symplectic topology and dynamical systems and it falls under the new field of symplectic dynamics.

We outline an extensive research program in line with the above two viewpoints. On the one hand, we propose to develop new tools for the advancement of the field via the medium of barcodes which will serve as a replacement of Floer homology for homeomorphisms. On the other hand, we propose new approaches towards several important questions in the field including the symplectic four-sphere problem which asks if non-symplectic manifolds, such as the four-sphere, could admit the structure of a topological symplectic manifold, and the simplicity conjecture which asks if the group of compactly supported area-preserving homeomorphisms of the disc is a simple group.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865751	**RandomMultiScales**	**PE1** Mathematics

Principal Investigator: **Dr. DANIEL PETERSEIM**
Host Institution: Universitaet Augsburg, DE

Computational Random Multiscale Problems

Geometrically or statistically heterogeneous microstructures and high physical contrast are the key to astonishing physical phenomena such as invisibility cloaking with metamaterials or the localization of quantum waves in disordered media. Due to the complex experimental observation of such processes, numerical simulation has very high potential for their understanding and control. However, the underlying mathematical models of random partial differential equations are characterized by a complex interplay of effects on many non-separable or even a continuum of characteristic scales. The attempt to resolve them in a direct numerical simulation easily exceeds today's computing resources by multiple orders of magnitude. The simulation of physical phenomena from multiscale models, hence, requires a new generation of computational multiscale methods that accounts for randomness and disorder in a hierarchical and adaptive fashion.

This proposal concerns the design and numerical analysis of such methods. The main goals are connected to fundamental mathematical and algorithmic challenges at the intersection of multiscale modeling and simulation, uncertainty quantification and computational physics:

(A) Numerical stochastic homogenization beyond stationarity and ergodicity,

(B) Uncertainty quantification in truly high-dimensional parameter space,

(C) Computational multiscale scattering in random heterogeneous media,

(D) Numerical prediction of Anderson localization and quantum phase transitions.

These objectives base upon recent breakthroughs of deterministic numerical homogenization beyond periodicity and scale separation and its deep links to seemingly unrelated theories ranging all the way from domain decomposition to information games and their Bayesian interpretation. It is this surprising nexus of classical and probabilistic numerics that clears the way to the envisioned new computational paradigm for multiscale problems at randomness and disorder.

Project End Date: **31-JUL-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
883363	**Nonlocal-CPD**	**PE1** Mathematics

Principal Investigator: **Dr. JOSE A. CARRILLO**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Nonlocal PDEs for Complex Particle Dynamics: Phase Transitions, Patterns and Synchronization

This proposal focuses on the development of new mathematical tools to analyse theoretical, numerical and
modelling aspects of novel applications of nonlinear nonlocal aggregation-diffusion equations in Mathematical Biology and in classical problems of kinetic theory. Among the numerous areas of applications of kinetic modelling in Mathematical Biology, we will concentrate on phenomena identified, at the modelling stage, as systems involving a large number of "individuals" showing "collective behaviour" and how to obtain "averaged" information from them. Individuals behavior can be modelled via stochastic/deterministic ODEs from which one obtains mesoscopic/macroscopic descriptions based on mean-field PDEs leading to continuum mechanics, hydrodynamic and/or kinetic systems. Understanding the interplay between the interaction behaviour (nonlocal, nonlinear), the diffusion (nonlinear), the transport phenomena, and the synchronization is my main mathematical goal.
The proposed research is centred on developing tools underpinning the analysis of long time asymptotics, phase transitions, stability of patterns, consensus and clustering, and qualitative properties of these models. On the other hand, designing numerical schemes to accurately solve these models is key not only to understand theoretical issues but also crucial in applications. We will focus on the important case of the Landau equation with applications in weakly nonlinear plasmas by means of the gradient flow techniques. On the other hand, we showcase our tools in patterns and consensus by focusing on zebra fish patterning formation, as example of spontaneous self-organisation processes in developmental biology, and grid cells for navigation in mammals, as prototype for the synchronization of neural networks. This project connects with other areas of current interest in science and technology such as agent-based models in engineering: global optimization, clustering, and social sciences.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
883818	**GRAPHMODE**	**PE1** Mathematics

Principal Investigator: **Dr. MATHIAS DRTON**
Host Institution: Technische Universitaet Muenchen, DE

Graphical Models for Complex Multivariate Data

Modern science increasingly relies on insights gained from sophisticated analyses of large data sets. An ambitious goal of such data-driven discovery is to understand complex systems via statistical analysis of multivariate data on the activity of their interacting units. Probabilistic graphical models, the topic of this project, are tailored to the task. The models facilitate refined yet tractable data exploration by using graphs to represent complex stochastic dependencies between considered variables. Models based on directed graphs, in particular, provide the state-of-the-art approach for detailed exploration of cause-effect relationships. However, modern applications of graphical models face numerous challenges such as key variables being latent (i.e., unobservable/unobserved), lacking temporal resolution in studies of feedback loops, and limited experimental interventions. Often arising in combination, these issues generally result in observed stochastic structure that cannot be characterized using the established notion of conditional independence. As a result, we are left with only a partial understanding of which aspects of a system can be inferred from the available data, and we lack effective methods for fundamental problems such as inference in the presence of feedback loops. The aim of the new project is to move beyond conditional independence structure to obtain a deeper understanding of the inherent limitations on what can be inferred from imperfect measurements, and to design novel statistical methodology to infer estimable quantities. The unique feature of the proposed work is a focus on algebraic relations among moments of probability distributions and the subtle statistical issues arising when such relations are to be exploited in practical methodology.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681740	**HYMNS**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. CESAR DOMINGO PARDO**
Host Institution: Agencia Estatal Consejo Superior De Investigaciones Cientificas, ES

High-sensitivitY Measurements of key stellar Nucleo-Synthesis reactions

The origin of the heavy elements in the Universe is one of the main open questions in modern science. Beyond iron the two main mechanisms of nucleosynthesis are the slow (s) and rapid (r) neutron capture processes operating in giant stars and explosive stellar environments, respectively. Modern s-nucleosynthesis studies are based on the combination of i) stellar models, ii) observed abundances and iii) neutron capture rates measured over many years using several techniques. HYMNS is aimed at a paradigm shift in the sensitivity of s-process neutron capture measurements; The most advanced and accurate methods allow one to measure the neutron capture rate as a function of the neutron energy by combining the time-of-flight technique with radiation detectors, either calorimeters or total energy detectors. These systems are sensitive only to the radiation energy, which ultimately limits the attainable detection sensitivity. State-of-the-art detection systems require drastic innovation if we are to access the stellar (n,g) rates of several key radioactive nuclei, where only small amounts of sample material are available. Such unstable nuclides are of pivotal importance for nucleosynthesis studies because they act as branching points in the s-path and are thus extremely sensitive to the stellar physical conditions. The aim of HYMNS is to develop and apply a novel detection system in the field of (n,g) measurements called total-energy detector with imaging capability (i-TED), which is capable of measuring both the energy and the trajectory of the g-rays, thus enabling a superior level of background discrimination. HYMNS is structured to enable the first measurements for key s-process branching nuclei over the stellar energy range. The first application will be to determine the neutron capture cross section of 79Se, which will provide the most stringent constraint for the thermal conditions and their time-dependence in state-of-the-art evolution models of massive stars.

Project End Date: **31-MAY-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694920	**CHROMIUM**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. JENNIFER THOMAS**
Host Institution: University College London, UK

CHROMIUM

Why the Universe is void of anti-matter is one of the remaining Big Questions in Science.One explanation is provided within the Standard Model by violation of Charge Parity (CP) symmetry, producing differences between the behavior of particles and their anti-particles.CP violation in the neutrino sector could allow a mechanism by which the matter-anti matter asymmetry arose.The objective of this proposal is to enable a step change in our sensitivity to CP violation in the neutrino sector. I have pioneered the concepts and led the deployment of a small prototype using a novel approach which could eventually lead to the construction of a revolutionary Mega-ton scale Water Cherenkov (WC) neutrino detector.The goal of my research program is to demonstrate the feasibility of this approach via the construction of an intermediate sized prototype with an expandable fiducial mass of up to 10-20kt. It will use a low-cost and lightweight structure, filled with purified water and submerged for mechanical strength and cosmic ray shielding in a 60m deep flooded mine pit in the path of Fermilab's NuMI neutrino beam in N. Minnesota.The European contribution to this experiment will be profound and definitive.Applying the idea of fast timing and good position resolution of small photodetectors, already pioneered in Europe, in place of large-area photodetector, we will revolutionize WC design.The game-changing nature of this philosophy will be demonstrated via the proof of the detector construction and the observation of electron neutrino events form the NuMI beam.The successful completion of this R&D program will demonstrate a factor of up to 100 decrease in cost compared to conventional detectors and the proof that precision neutrino measurements could be made inside a few years rather than the presently needed decades. The project describes a five year program of work amounting to a total funding request of €3.5M, including an extra €1M of equipment funds.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714625	**NURE**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. MANUELA CAVALLARO**
Host Institution: Istituto Nazionale Di Fisica Nucleare, IT

Nuclear Reactions for Neutrinoless Double Beta Decay

Neutrinoless double beta decay (0νββ) is considered the best potential resource to determine the absolute neutrino mass scale. Moreover, if observed, it will signal that the total lepton number is not conserved and neutrinos are Majorana particles. Presently, this physics case is one of the most important research “beyond the Standard Model” and might guide the way towards a Grand Unified Theory of fundamental interactions.

Since the ββ decay process involves nuclei, its analysis necessarily implies nuclear structure issues. The 0νββ decay rate can be expressed as a product of independent factors: the phase-space factors, the nuclear matrix elements (NME) and a function of the masses of the neutrino species.Thus the knowledge of the NME can give information on the neutrino mass, if the 0νββ decay rate is measured.

The novel idea of NURE is to use nuclear reactions of double charge-exchange (DCE) as a tool to determine the ββ NME. In DCE reactions and ββ decay, the initial and final nuclear states are the same and the transition operators have the same spin-isospin structure. Thus, even if the two processes are mediated by different interactions, the NME are connected and the determination of the DCE cross-sections can give crucial information on ββ matrix elements.

NURE plans to carry out a campaign of experiments using accelerated beams on different targets candidates for 0νββ decay. The DCE channel will be populated using (18O,18Ne) and (20Ne,20O) reactions by the innovative MAGNEX large acceptance spectrometer, which is unique in the world to measure very suppressed reaction channels at high resolution. The complete net involving the single charge-exchange and multi-step transfers characterized by the same initial and final nuclei will be also measured to study the reaction mechanism. The absolute cross-sections will be extracted. The comparison with microscopic state-of-the-art calculations will give access to the NMEs.

Project End Date: **31-MAR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714788	**REINVENT**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. SIMONE ALIOLI**
Host Institution: Universita' Degli Studi Di Milano-Bicocca, IT

REsummation-Improved moNtecarlo eVEnt geNeraTor

With the start of the second run of the Large Hadron Collider and the discovery of a particle compatible with the Standard Model Higgs boson, the high-energy particle physics community faces the task to carry out precise measurements of the properties of this new particle, in order to establish its nature. At the same time, it will be equally important to keep looking for the yet elusive signs of New Physics. Both tasks rely on the ability to accurately predict the expected signals and to disentangle them from the known backgrounds. At hadronic colliders like the LHC, accurate modeling of the strong interactions is crucial to interpret the experimental outcomes.

The goal of this project is to push forward the frontier of precision QCD for event simulations. The key idea is to combine the three possible theoretical description (fixed-order perturbative expansion, resummed calculations and parton showers) into the same theoretical framework, in order to benefit from the advantages of each. The innovative approach proposed here improves over past efforts thanks to the inclusion of higher-logarithmic resummation, which bridges the gap between the perturbative description of hard radiation and the shower domain. This brings together three important advantages: the ability to use the best theoretical description in each region, the sizable reduction of the theoretical uncertainties gained by replacing the shower evolution with the higher-logarithmic resummation, and the ability to produce hadron-level events that can be directly interfaced to detector simulations.

By going beyond the state-of-the-art, REINVENT will obtain the most precise theoretical predictions for the LHC in an event generator form that allows for direct comparison to data, producing tools that will be used by both experimentalists and theorists. The technology developed for this project will also have important applications for precision studies at future lepton colliders.

Project End Date: **31-OCT-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716908	**TopoCold**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. NATHAN GOLDMAN**
Host Institution: Universite Libre De Bruxelles, BE

Manipulation of topological phases with cold atoms

Topological states of matter constitute one of the hottest disciplines in quantum physics, demonstrating a remarkable fusion between elegant mathematical theories and technological applications. However, solid-state experiments only provide a limited set of physical systems and probes that can reveal non-trivial topological order. It is thus appealing to seek for alternative setups exhibiting topological properties. Cold atoms in optical lattices constitute an instructive and complementary toolbox, being extremely versatile, clean and controllable. In fact, cold-atom theorists and experimentalists have recently developed new tools providing the building blocks for the exploitation of topological atomic gases.

TopoCold will propose realistic optical-lattice setups hosting novel topologically-ordered phases, based on those technologies that are currently developed in cold-atom experiments. The central goal of the project consists in identifying unambiguous manifestations of topological properties that are specific to the cold-atom framework. We will establish concrete methods to experimentally visualize these signatures, elaborating efficient schemes to detect the unique features of topological phases using available manipulation and imaging techniques. This central part of the TopoCold project will deepen our understanding of topological phenomena and guide ongoing experiments. We also plan to elaborate simple protocols to exploit topological excitations, based on the great controllability of atom-light coupling methods. Moreover, by tailoring the geometry and laser-coupling of optical-lattice setups, we will explore topological systems that are not accessible in solid-state devices. Finally, we will study the properties of topological phases that arise in the strongly-correlated regime of atomic gases. TopoCold will build a bridge between several communities, deepening our knowledge of topological phases from an original and interdisciplinary perspective.

Project End Date: **31-JAN-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724473	**SMARTIES**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. SYLVAIN GIGAN**
Host Institution: Centre National De La Recherche Scientifique, FR

Scattering Media as a Resource Towards Information Processing and Sensing

Scattering of light in complex environments has long been considered a nuisance and an inescapable limitation to imaging and sensing alike, ranging from astronomical observation, biomedical imaging, spectroscopy, etc. In the last decade, wavefront shaping techniques have revolutionized this view, by allowing light focusing and imaging even deep in the multiple scattering regime. This principle is embodied in the possibility—that I pioneered—to access the transmission matrix of a complex medium.

In SMARTIES, I will go one major conceptual step further, by exploiting directly the inherent property of a complex medium to mix perfectly and deterministically the information carried by the light. This mixing is actually a processing step. Along this general idea, SMARTIES will explore two synergistic directions:

—Classical and quantum optical computing: Thanks to the highly multimode nature and the strong mixing properties of complex material, I will aim at demonstrating high performance classical computing tasks in the context of randomized algorithms. As a platform for quantum information processing, this will be relevant for high dimension quantum computing algorithms, and quantum machine learning.

—Generalized imaging and sensing: Rather than tediously focusing and imaging through a scattering material, computational approaches can significantly improve and simplify the imaging process. I also aim to show that the relevant information can be directly and optimally extracted from the scattered light without imaging, using machine-learning algorithms.

From a methodological standpoint, SMARTIES will require bridging knowledge from mesoscopic physics, light-matter interaction, linear and non-linear optics, with algorithms and signal processing concepts. It will deliver a whole new class of optical methods and devices, based on disorder. Its applications range from big data analysis, quantum technologies, to sensors and deep imaging for biology and neuroscience.

Project End Date: **31-MAR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725039	**HyperMu**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. ALDO ANTOGNINI**
Host Institution: Paul Scherrer Institut, CH

Hyperfine splittings in muonic atoms and laser technology

The proton radius extracted from the measurements of the 2S-2P energy splitting in muonic hydrogen (μp) has attracted great attention because of a 7σ discrepancy with the values extracted from electron scattering and hydrogen (H) spectroscopy. Hundreds of publications have been devoted to the so called “proton radius puzzle” ranging from studies of physics beyond the standard model, to reanalysis of electron scattering data, refinements of bound-state QED calculations, new theories describing the proton structure, and proposals for new scattering and H spectroscopy experiments. As next step, I plan two new (i.e., never before attempted) measurements: the ground-state hyperfine splitting (1S-HFS) in both μp and μ3He+ with 1 ppm relative accuracy by means of pulsed laser spectroscopy. From these measurements the nuclear-structure contributions (two-photon-exchange) can be extracted with a relative accuracy of 100 ppm which in turn can be used to extract the corresponding Zemach radii (with a relative accuracy of 0.1%) and polarizability contributions. The Zemach radii can provide magnetic radii when form-factor data or models are assumed. These radii are benchmarks for lattice QCD and few-nucleon theories. With the polarizability contribution they impact our models of the proton and of the 3He nucleus. Moreover, the μp measurement can be used to solve the discrepancy between the magnetic radii values as extracted from polarized and unpolarized electron scattering and to further test bound-state QED predictions of the 1S-HFS in H. These two experiments require a muon beam line, a target with an optical cavity, detector, and laser systems. As weak M1 transitions must be probed, large laser-pulse energies are needed, thus cutting-edge laser technologies (mainly thin-disk laser and parametric down-conversion) need to be developed. Laser schemes of potentially high industrial impact that I have just patented will be implemented and refined.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
726276	**PUMA**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. ALEXANDRE OBERTELLI**
Host Institution: Technische Universitaet Darmstadt, DE

antiProton Unstable Matter Annihilation

One of the most fascinating quantum phenomena in nuclear physics is the occurrence of neutron halos and neutron skins in very neutron rich atomic nuclei. Thick neutron skins and halos, not yet evidenced in medium mass nuclei, would be unique low-density neutron matter accessible in the laboratory. Nuclear shell structure is also known to change with the number of protons and neutrons. The nuclear structure of very heavy nuclei at and above Z=100 is barely known, and the existence of new long-lived heavy isotopes is still an open question. The above fundamental phenomena related to the unbalance of neutron and protons in unstable nuclei are essential to understand the complex nature of nuclei and related astrophysical processes.

We propose a new physics program to determine the neutron over proton densities at the nuclear surface for the most exotic nuclei that can be produced today, to evidence and to characterize neutron halos and skins in medium and heavy mass regions. PUMA will also allow the spectroscopy of single-particle states in heavy-nuclei above Z=100 will offer a new insight into the unknown shell structure at the top of the nuclear landscape. To address these questions, PUMA explores a new way to study radioactive nuclei produced at very low kinetic energy: the interaction of antiprotons with unstable nuclei.

PUMA is based on a new apparatus: a transportable magnetic trap to store antiprotons and maximize their interaction with slow rare isotopes in order to trigger annihilations and measure the following radiations. The PUMA methodology is based on two steps. (i) The storage of antiprotons will be performed at the new AD/ELENA facility of CERN in collaboration with the GBAR collaboration. (ii) The PUMA physics program is to take place at CERN/ISOLDE and, on a later stage beyond the ERC grant period, at the new SPIRAL2 facility in Europe. PUMA will open new horizons for nuclear structure research.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
740006	**NNNPDF**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. STEFANO FORTE**
Host Institution: Universita Degli Studi Di Milano, IT

Proton strucure for discovery at the Large Hadron Collider

The objective of this project is to revolutionize the way the structure of the proton is accessed, determined, and used in the computation of physical processes at hadron colliders such as the Large Hadron Collider (LHC) of CERN. At a hadron accelerator, predictions require a precise, detailed, and accurate description and understanding of the structure of the colliding protons, as encoded in parton distributions (PDFs) - the distributions of quarks and gluons. At the LHC, PDFs are at present the major source of uncertainty, and in the near future they will be the main hurdle for discovery. The vision of this project is to remove this hurdle by attacking the problem using recent results from artificial intelligence (AI). I will lead a research team of two staff scientists, four postdocs and three PhD students, who will apply to PDF determination the recent methods of deep reinforcement learning and Q-learning, which will be coupled with deep residual networks to achieve a fully parameter- and bias-free understanding of proton structure. I will bring into high-energy physics a methodology so far used for object recognition in self-driving cars and automatic game playing, leading both to new physics, and new computational techniques. The application of these techniques to PDFs will enable me to reach two secondary goals. The first is theoretical: the full use for PDF determination of recent high perturbative order (next-to-next-to leading order or NNLO) computations, which will be integrated by means of a new approximation method which relies on combining known exact results with all-order information in various kinematic limits to extend the scope of the former to a more detailed ("more exclusive") description of the final state.The second is phenomenological: the integration in PDF determination of the Monte-Carlo event generators which are used to turn field theoretical prediction into a realistic description which may be directly compared to experimental data.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
756966	**CounterLIGHT**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. PASCAL DEL HAYE**
Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Interaction and Symmetry Breaking of Counterpropagating Light

Light is generally expected to travel through media independent of its direction. Exceptions can be achieved through polarization changes induced by magnetic fields (known as the Faraday effect) together with polarization-sensitive birefringent materials. However, light can also be influenced by the presence of a counterpropagating light wave. We have recently shown that this leads to the surprising consequence that light sent into tiny glass rings (microresonators) can only propagate in one direction, clockwise or counterclockwise, but not in both directions simultaneously. When sending exactly the same state of light (same power and polarization) into a microresonator, the interaction induces a spontaneous symmetry breaking in the propagation of light. In this proposal we plan to investigate the fundamental physics and a variety of ground-breaking applications of this effect. In one proposed application, this effect will be used for optical nonreciprocity and the realization of optical diodes in integrated photonic circuits that do not rely on magnetic fields (an important key element in integrated photonics). In another proposed experiment we plan to use the spontaneous symmetry breaking to demonstrate microresonator-based optical gyroscopes that have the potential to beat state-of-the-art sensors in both size and sensitivity. Additional research projects include experiments with all-optical logic gates, photonic memories, and near field sensors based on counterpropagating light states. Finally, we plan to demonstrate a microresonator-based system for the generation of dual-optical frequency combs that can be used for real-time precision spectroscopy in future lab-on-a-chip applications. On the fundamental physics side, our experiments investigate the interaction of counterpropagating light in a "box" with periodic boundary conditions. The fundamental nature of this system has the potential to impact other fields of science far beyond optical physics.

Project End Date: **28-FEB-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758752	**MicroMOUPE**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. THOMAS JUFFMANN**
Host Institution: Universitaet Wien, AT

Microscopy - Making optimal use of photons and electrons

The sensitivity of modern microscopy is limited by shot-noise. It limits the accuracy of measurements of specimen properties as well as the spatial resolution of electron microscopes when imaging sensitive specimens, such as proteins or DNA. But the shot-noise limit is not a fundamental limit. A technologically feasible and optimal approach to overcoming the shot-noise limit is to have each probe particle interact with the specimen multiple times. We recently introduced this concept to microscopy using self-imaging cavities.

Within this project, I want to demonstrate post-selection free sub-shot noise microscopy with both photons and electrons. Optically this will be possible by introducing a fast electro-optical switch into a multi-pass microscope, evading the need for temporal post-selection. After this proof-of principle experiment, the sensitivity enhancement offered by multi-pass microscopy shall be applied to the detection of nanometric particles, such as single molecules, proteins and metal nanoparticles. Linear signal enhancement with the number of interactions is expected for bright-field microscopy. For dark-field microscopy a quadratic enhancement is expected, due to coherent build-up of scattered fields. Finally, adaptive optics will be used to optimize multi-pass microscopy for the study of cells.

Multi-pass electron microscopy will be realized in collaboration with Stanford University. It will require several novel electron optical elements that will be designed and tested both at Stanford University and at the University of Vienna. One of these elements will be a pattern generator for electrons based on ponderomotive potentials. The required potential landscapes will be created using adaptive optics to shape intense laser pulses. With this novel electron optics tool fast beam-blanking, a phase plate for Zernike phase microscopy, arbitrary pattern creation and aberration correction will be demonstrated.

Project End Date: **28-FEB-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758759	**HHQM**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. BLAISE GOUTÉRAUX**
Host Institution: Ecole Polytechnique, FR

Hydrodynamics, holography and strongly-coupled quantum matter

The dynamics of weakly-coupled quantum matter can be solved by techniques deriving from perturbative quantum field theory. Conventional metals are described by long-lived quasiparticles (Fermi liquids). No such methods are available for strongly-coupled quantum matter where quasiparticles are short-lived, like the Quark-Gluon-Plasma, high Tc superconductors (HTCs) or graphene near the charge neutrality point.

In HTCs, it has been argued the interaction timescale is the fastest scale in the system, which warrants a hydrodynamic description. In a recent series of remarkable theoretical and experimental developments, hyrodynamics signatures have been discovered in several strongly-coupled quantum systems such as graphene, delafossites and HTCs. Further theoretical progress is impeded by the lack of symmetry: momentum is only approximately conserved, which complicates the use of hydrodynamics as an effective low-energy theory; and the strange metallic phenomenology of HTCs, believed to originate from a quantum critical point, is not captured by conventional scaling arguments. New ideas are required to move beyond the current state of the art.

Gauge/Gravity duality is a radically new approach which links a relativistic strongly-coupled quantum field theory to a classical theory of gravity. The hydrodynamic regime of the QGP has been very successfully described by these methods, which predict a shear viscosity very close to experimental values.

Our focus in this proposal is to use holography to consistently model hydrodynamics with momentum relaxation and study its interplay with unconventional quantum criticality. This is crucial for a better understanding of the phenomenology in strongly-coupled quantum matter. As many systems are not relativistic, we will also consider hydrodynamics in non-relativistic holographic theories, thus enhancing our understanding of holographic dualities beyond the original Anti de Sitter/Conformal Field Theory correspondence.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771036	**MAIDEN**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. ANU KANKAINEN**
Host Institution: Jyvaskylan Yliopisto, FI

Masses, isomers and decay studies for elemental nucleosynthesis

About half of the elements heavier than iron have been produced via the rapid neutron capture process, the r process. However, its astrophysical site remains unknown and is one of the biggest outstanding questions in physics. Neutrino-driven winds from proto-neutron stars created in core-collapse supernovae were long considered as the most favourable site for the r process. Recently, neutron-star mergers have become increasingly promising candidates, and new exciting observations from these compact objects, such as gravitational waves, are expected in the coming years. In order to constrain the astrophysical site for the r process, nuclear binding energies (i.e. masses) of exotic neutron-rich nuclei are needed because they determine the path for the process and therefore have a direct effect on the final isotopic abundances. In this project, high-precision mass measurements will be performed in three regions relevant for the r process, employing novel production and measurement techniques at the IGISOL facility in JYFL-ACCLAB. Long-living isomeric states, which also play a role in the r process, will be resolved from the ground states to obtain accurate mass values. Post-trap decay spectroscopy will be performed to confirm which state has been measured in order to avoid systematic uncertainties in the mass values. The new data will be compared with theoretical mass models and included in r-process calculations performed for various astrophysical sites. MAIDEN will advance our knowledge of nuclear structure far from stability and reduce nuclear data uncertainties in the r-process calculations, which can potentially constrain the astrophysical site for the r process and lead to a scientific breakthrough in our understanding of the origin of elements heavier than iron in the universe.

Project End Date: **31-MAY-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771642	**SELDOM**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. NICOLA NERI**
Host Institution: Universita Degli Studi Di Milano, IT

Search for the electric dipole moment of strange and charm baryons at LHC

SELDOM explores a new experimental method to decisively boost the study of the electric dipole moment (EDM) and magnetic dipole moment (MDM) of baryons at the LHCb experiment at CERN.
We will be able to guide the first search of charm baryons EDM: any observation would represent a signature of new physics. With the strange baryon EDM measurement, we will push forward the sensitivity on the Lambda baryon EDM to an unprecedented precision. Thus, we will set new constraints to extensions of the Standard Model of particle physics.
To date no search was performed for short-lived charm baryon EDM, as it must be determined studying the spin precession in intense magnetic fields before the decay - a major challenge for these unstable particles. SELDOM will overcome this limitation, using as key ingredient a bent crystal attached to a fixed target. Short-lived charm baryons produced in the target will be channelled into the crystal: the intense electromagnetic field between its atomic planes will induce fast spin precession; events are reconstructed with the LHCb detector.
Conversely, spin precession in long-lived strange baryons (produced from charm baryon decays from beam-beam collisions), will be induced by the magnetic field of the LHCb tracking system. Strange baryons decaying at the end of the magnet will be reconstructed with “ad-hoc" tracking algorithms developed in SELDOM. Together with the experimental setup itself, this is one of the major challenges of the project.
Our experimental approach will also unlock measurements of the charm baryon MDM and of the strange baryon and anti-baryon MDM, allowing a test of CPT symmetry.
SELDOM will be a crucial piece in the puzzle to explain the absence of antimatter in the Universe, and it has the potential to shorten the path to new physics discoveries opening up new research opportunities.

Project End Date: **31-MAR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771891	**QSIMCORR**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. LODE POLLET**
Host Institution: Ludwig-Maximilians-Universitaet Muenchen, DE

Quantum Simulation of Strongly-Correlated Systems

A major challenge in theoretical physics is to develop novel methods without systematic errors. The scope of this proposal is the numerical control over strongly correlated phases in the thermodynamic limit through two main developments:
First, for bosonic systems, we aim to obtain reliable phase diagrams for optical flux lattices, combining topology with interactions. In particular, we study the competition between superfluid order and (fractional) Chern insulators, which may harbor (non-)abelian anyonic excitations. This is achieved by a major improvement on our current selfenergy-based cluster methods through non-local interactions, vertex corrections and momentum cluster extensions. This also enables access to out-of-equilibrium dynamics, relevant to study quench-type experiments. In the presence of disorder, we can then answer whether many-body-localization exists in higher dimensions and address the fundamental puzzle of how and when systems thermalize.
Second, for fermionic systems with long-range interactions, such as warm dense matter, the electron gas, and cold gases with Rydberg interactions, the diagrammatic Monte Carlo method is uniquely situated to compute thermal exchange correlation energies over the entire density range, essential to any calculation in condensed matter physics, astro physics and plasma physics. It employs a universal language but needs further algorithmic refinements for improving its convergence and sign properties. Extensions are towards (frustrated) spin systems, providing an alternative route to the realization of strongly correlated phases.
At all stages analytical derivations must be supplemented with coding and large-scale computation. We address what new types of quantum systems can efficiently be computed on a classical computer, and how. Simultaneously, we seek to extend the paradigm of quantum simulation by comparing the results of our novel methods with cold gas experiments in challenging regimes, where possible.

Project End Date: **28-FEB-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772676	**QUEM-CHEM**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. STEFANIE GRÄFE**
Host Institution: Friedrich-Schiller-Universitat Jena, DE

Time- and space- resolved ultrafast dynamics in molecular-plasmonic hybrid systems

This project aims at developing theoretical and numerical methods to simulate space- and time-resolved ultrafast dynamics in novel hybrid molecular-metal nanoparticle systems. The excitation of collective electron dynamics inside the metallic nanoparticles induced by external light fields leads to strongly re-shaped electromagnetic near-fields with complex spatial and temporal profile. The interaction of these modified and enhanced near-fields with molecules located in close vicinity to the metallic nanoparticle is the origin of many astonishing physical and chemical phenomena, such as the formation of new quasi-particles, new mechanisms for chemical reactions or the ultra-high spatial resolution and selectivity in molecular detection.. Besides being of fundamental interest, this interplay between near-fields and molecules promises great potential on the application side, potentially enabling revolutionary breakthrough in new emerging technologies in a broad range of research fields, such as nanophotonics, energy and environmental research, biophotonics, light-harvesting energy sources, highly sensitive nano-sensors etc. This necessitates a solid theoretical understanding and simulation of these hybrid systems.

The goal of project QUEM-CHEM is the development of new approaches and methods beyond the state of the art, aiming at a synergy of existing but independently applied methods:

- Quantum chemistry (QU) in order to calculate the quantum nature of the molecule-metallic nanoparticle moiety,
- Electro-dynamic simulations (EM) describing the complex evolution of the light fields and the near fields around nanostructures, as well as
- Dynamical methods to incorporate the response of the molecule to the near-fields

Thus, the possible outcome of this highly interdisciplinary project will provide new knowledge in both, physics and chemistry, and might have impact on a large variety of new arising critical technologies.

Project End Date: **30-APR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787331	**HiggsSelfCoupling**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. CIGDEM ISSEVER**
Host Institution: Humboldt-Universitaet Zu Berlin, DE

Uncovering the Origins of Mass: Discovery of the di-Higgs Process and Constraints on the Higgs Self-Coupling

The Standard Model of particle physics describes the elementary constituents of matter and their interactions. In 2012, its last ingredient, the Higgs boson, was discovered at the Large Hadron Collider (LHC). The exploration of the Higgs boson is now one of the most exciting avenues to explore for New Physics beyond the Standard Model and allows some of the most pressing problems in theoretical physics to be addressed, such as the origins of the electroweak symmetry breaking mechanism. This important mechanism gives elementary particles their masses but the nature of this mechanism remains a mystery.

A particularly crucial measurement is the production cross-section of Higgs boson pairs, which provides unique information on the Higgs self-coupling and on the underlying nature of the electroweak symmetry breaking mechanism. Most feasibility studies of the Higgs self-coupling conclude that there will be insufficient data for this measurement in the coming decade. However, my recent feasibility studies indicate that by using the Higgs pair production process with four bottom quarks in the final state, the discovery of the di-Higgs process and its cross section measurement can be made much earlier. This project aims to develop and complete the first measurement of the di-Higgs cross section and most stringent bounds on the Higgs self-coupling before 2023.
To achieve this goal I will develop new experimental techniques to improve the background reduction rates and enhance the signal. The objectives are the development of novel bottom quark energy reconstruction algorithms, new bottom quark and Higgs identification techniques, and neural network analysis tools. Analysis of ATLAS data will then enable searches for New Physics and ultimately the di-Higgs cross section measurement to constrain the Higgs self-coupling. This landmark measurement will lead to the confirmation of how particles acquire mass and open new avenues to understand what lies beyond the Standard Model.

Project End Date: **31-MAY-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788781	**IAXOplus**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. IGOR GARCIA IRASTORZA**
Host Institution: Universidad De Zaragoza, ES

Towards the detection of the axion with the International Axion Observatory

The nature of the Dark Universe is an outstanding question in modern science, and is connected with our understanding of the reality at the most fundamental level. Despite the enormous success of the Standard Model (SM) of particle physics, a number of shortcomings of the theory and the fact that it does not account for the Dark Matter and Energy, prompt theorists to propose possible hypothetical extensions.

Some of these extensions predict the existence of very-light and very-weakly-coupled axions (or axion-like particles, ALPs). Recent theoretical and phenomenological work is sharpening the physics case of these particles. They are now considered as very motivated portals for physics beyond the SM, and in particular as very plausible Dark Matter candidates. In addition, some intriguing astrophysical observations might be interpreted as hints for their existence.

The International Axion Observatory IAXO is one of the most ambitious proposals to find the axion. Its baseline configuration relies on the search for solar axions, but could also host relic axion detectors. IAXO will go well beyond current experiments' sensitivity and will probe a large fraction of the -still unexplored- parameter space of the axion and ALPs. The scope of the present proposal encompasses the realization of a first complete intermediate experimental stage, BabyIAXO, including prototypes of the IAXO magnet and detection systems. It will already provide relevant physics outcome in the time-frame of the current grant, while preparing the ground for, and extending the physics reach of, the full IAXO. In particular, BabyIAXO will already be able to test a number of axion and ALP models that are invoked by the aforementioned astrophysical hints and therefore already at this stage there is potential for discovery. The detection of a new fundamental pseudoscalar -potentially solving the DM problem- would lead to a breakthrough in Particle Physics, Cosmology and Astrophysics.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802729	**PeV-Radio**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. FRANK SCHRÖDER**
Host Institution: Karlsruher Institut Fuer Technologie, DE

Digital Radio Detectors for Galactic PeV Particles

The most energetic particles in our Galaxy are accelerated by yet unknown sources to energies much beyond the reach of human-made accelerators such as LHC at CERN. The detection of PeV photons from such a natural Galactic accelerator will be a fundamental breakthrough. For this purpose I propose a digital radio array for air showers at South Pole building on my proven expertise in successfully setting up and managing an antenna array in Siberia. Recently, we have discovered that by using higher radio frequencies than before the energy threshold can be lowered dramatically from 100 PeV to about 1 PeV. The new radio array will significantly enhance the present PeV particle detectors at South Pole in both, accuracy and aperture towards lower elevations. One of the most promising candidates for the origin of cosmic rays, the Galactic Center presently outside of the field of view, will be observable 24/7 with the radio array. The extrapolation of classical TeV observations predicts more than twenty PeV photons to be detected by the radio array within three years. Since the radio array is sensitive simultaneously to cosmic photons and charged particles from all directions of the sky, the search for any photon sources can be done in parallel to cosmic-ray physics with unprecedented accuracy and exposure in the energy range of 1 PeV to 1 EeV. Thus, this radio array will create highest impact in astroparticle physics by the following scientific objectives all targeting the most energetic particles in our Galaxy: PeV photons and their correlation with sources of neutrinos and charged cosmic rays, mass separation of cosmic rays, search for mass-dependent anisotropies, particle physics beyond the reach of LHC. This timely proposal is a unique chance for European leadership in this novel technique. It provides the chance for scientific breakthrough by detection of the first PeV photons ever, and by the discovery of natural accelerators of multi-PeV particles.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803740	**NEXT**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. JULIA EVEN**
Host Institution: Rijksuniversiteit Groningen, NL

Neutron-rich, EXotic, heavy nuclei produced in multi-nucleon Transfer reactions

The heaviest element which has been found in nature is uranium with 92 protons. So far, the elements up to atomic number 118 (oganesson) have been discovered in the laboratory. All transuranium elements are radioactive and their production rates decrease with increasing number of protons. An Island of Stability, where the nuclei have relatively long half-lives, is predicted at the neutron number 182 and, depending on the theoretical model, at the proton number 114, 120 or 126. Current experimental techniques do not allow to go so far to the neutron-rich side close to the Island of Stability.

The observation of gravitational waves as well as electromagnetic waves originating from a neutron star merger has been published on October 16, 2017 and is a first proof of the nucleosynthesis of heavy elements in the r-process. It still remains an open question if superheavy nuclei have been formed in our universe. To answer these questions, we need insight into the nuclear properties of the heaviest elements and how these properties evolve when one moves toward to the neutron-rich side on the nuclear chart.

In the NEXT project, I will set out to discover new, Neutron-rich, EXotic heavy nuclei using multi-nucleon Transfer reactions. I will measure their masses and, thus, pin down the ground state properties of these nuclei. These studies provide insight into the evolution of nuclear shells in the heavy element region. Furthermore, I will measure the fission half-lives of these isotopes. In order to realize the NEXT project, I will built a novel spectrometer, which is a combination of a solenoid separator and Multi-Reflection Time-of-Flight Mass Spectrometer.

The broad experience in heavy element research and mass measurements that I have acquired over the years, and the unique infrastructure at my home institute that houses the AGOR accelerator, makes it so that I am ideally placed to start and lead the NEXT project.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804305	**StrEnQTh**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. PHILIPP HAUKE**
Host Institution: Universita Degli Studi Di Trento, IT

Strong Entanglement in Quantum many-body Theory

This project addresses a frontier of modern quantum physics, entanglement in strongly correlated many-particle systems. At present, despite its importance for fundamental phenomena and potential applications, many-body entanglement is poorly understood theoretically and eludes experimental investigations. Three fundamental challenges are blocking further progress: there are infinitely many classes of many-body entangled states, the calculation of real-time quantum dynamics is inherently difficult, and the quantification of many-particle entanglement remains a hard experimental challenge.

StrEnQTh adopts a radically novel approach to force a breakthrough in each of these challenges, concentrating on specific targets motivated by next-generation AMO setups. 1. By designing a dedicated quantum resource theory, I will establish a novel framework for topological long-range entanglement. 2. By implementing crucial improvements on a tensor-network method, thermalization dynamics in gauge theories becomes tractable, especially hydrodynamization after heavy-ion collisions. 3. By exploiting the untapped potentials of time-reversing quantum dynamics and measuring high-order correlations, mixed-state entanglement becomes accessible. Further, by introducing a new paradigm of detection by dissipation, unequal-time correlators become available as a novel toolset for witnessing many-body entanglement.
To achieve these goals, StrEnQTh builds on (i) my expertise at the interface of quantum optics and information with quantum many-body theory; (ii) previous works and preliminary results that minimize risks; (iii) fruitful synergies between the goals; (iv) a high versatility of the developed methods.

The impact of this project will reach far beyond its immediate field. It will elucidate fundamental theoretical questions of relevance to strongly correlated matter at large, and it will deliver a new generation of detection tools that can find application in other platforms.

Project End Date: **31-OCT-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
805162	**3D-FIREFLUC**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. ELEONORA VIEZZER**
Host Institution: Universidad De Sevilla, ES

Taming the particle transport in magnetized plasmas via perturbative fields

Wave-particle interactions are ubiquitous in nature and play a fundamental role in astrophysical and fusion plasmas. In solar plasmas, magnetohydrodynamic (MHD) fluctuations are thought to be responsible for the heating of the solar corona and the generation of the solar wind. In magnetically confined fusion (MCF) devices, enhanced particle transport induced by MHD fluctuations can deteriorate the plasma confinement, and also endanger the device integrity. MCF devices are an ideal testbed to verify current models and develop mitigation / protection techniques.

The proposed project paves the way for providing active control techniques to tame the MHD induced particle transport in a fusion plasma. A solid understanding of the interaction between energetic particles and MHD instabilities in the presence of electric fields and plasma currents is required to develop such techniques. I will pursue this goal through innovative diagnosis techniques with unprecedented spatio-temporal resolution. Combined with state-of-the-art hybrid MHD codes, a deep insight into the underlying physics mechanism will be gained. The outcome of this research project will have a major impact for next-step MCF devices as I will provide ground-breaking control techniques for mitigating MHD induced particle transport in magnetized plasmas.

The project consists of 3 research lines which follow a bottom-up approach:
(1) Cutting-edge instrumentation, aiming at the new generation of energetic particle and edge current diagnostics.
(2) Unravel the dynamics of energetic particles, electric fields, edge currents and MHD fluctuations.
(3) From lab to space weather: The developed models will revolutionize our understanding of the observed particle acceleration and transport in the solar corona.

Based on this approach, the project represents a gateway between the fusion, astrophysics and space communities opening new avenues for a common basic understanding.

Project End Date: **30-APR-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
817719	**TheHiggsAndThe7Tops**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. YVONNE PETERS**
Host Institution: The University Of Manchester, UK

Mirror Mirror on the Wall, which Higgs is the oddest of them all: Exploring the Top-Higgs Interconnection with ATLAS

With the ground-breaking discovery of a new scalar particle, the Higgs boson, in 2012 by ATLAS and CMS, the standard model (SM) of particle physics has been completed. Despite this success, many open questions on the fundamental laws of nature remain unanswered. Among these are how exactly particles acquire their mass and why there is more matter than antimatter in the universe.

One of the most promising avenues to approach these questions is to explore the relation between the Higgs boson and the heaviest known elementary particle: the top quark. Due to its large mass, the top is expected to play a special role in the mechanism of electroweak symmetry breaking. In order to shed light onto this mechanism, understanding the coupling between the top and the Higgs in great detail and exploring the charge and parity (CP) nature of the Higgs are essential. While the SM Higgs boson is CP-even, many models beyond the SM require a CP-odd component. Higgs-top couplings are expected to provide an unambiguous probe of CP-mixed states.

I will explore for the first time all processes in which a direct determination of the top-Higgs interconnection is feasible, in particular events where the Higgs is produced in association with 1, 2 and 4 top quarks. These are among the most challenging channels at the LHC. I will pioneer a comprehensive programme, consisting of the development of powerful event-reconstruction methods and improved boosting techniques, allowing the first exploitation of novel variables in a beyond-state-of-the-art cross-process analysis, thus unravel the CP-properties in the top-Higgs interaction.

The ultimate goal of the project is the precise direct measurement of the top-Higgs Yukawa coupling, and the first determination of the CP-nature of the Higgs boson in fermion interactions. Confronting these results with the SM and models that go beyond the SM will yield an unprecedented insight into the origin of mass of elementary particles.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818195	**IONPEN**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. JONATHAN HOME**
Host Institution: Eidgenoessische Technische Hochschule Zurich, CH

Trapped-ion quantum information in 2-dimensional Penning trap arrays

This project will develop a new platform for quantum computation and quantum simulation based on scalable two-dimensional arrays of ions in micro-fabricated Penning traps. It builds upon the rapid advances demonstrating high precision quantum control in micro-fabricated radio-frequency ion traps while eliminating the most problematic element - the radio-frequency potential - using a uniform magnetic field. This offers a significant advantage: since the magnetic field is uniform it provides confinement at any position for which a suitable static quadrupole can be generated. By contrast, r.f. potentials only provide good working conditions along a line. This changed perspective provides access to dense two-dimensional strongly interacting ion lattices, with the possibility to re-configure these lattices in real time. By combining closely-spaced static two-dimensional ion arrays with standard laser control methods, the project will demonstrate previously inaccessible many-body interacting spin Hamiltonians at ion numbers which are out of the reach of classical computers, providing a scalable quantum simulator with the potential to provide new insights into the links between microscopic physics and emergent behavior. Through dynamic control of electrode voltages, reconfigurable two-dimensional arrays will be used to realize a scalable quantum computing architecture, which will be benchmarked through landmark experiments on measurement-based quantum computation and high error-threshold surface codes which are natural to this configuration. Realizing multi-dimensional connectivity between qubits is a major problem facing a number of leading quantum computing architectures including trapped ions. By solving this problem, the proposed project will pave the way to large-scale universal quantum computing with impacts from fundamental physics through to chemistry, materials science and cryptography.

Project End Date: **31-MAR-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
832219	**ANDLICA**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. ROBIN KAISER**
Host Institution: Centre National De La Recherche Scientifique, FR

Anderson Localization of Light by Cold Atoms

I propose to use large clouds of cold Ytterbium atoms to observe Anderson localization of light in three dimensions, which has challenged theoreticians and experimentalists for many decades.
After the prediction by Anderson of a disorder-induced conductor to insulator transition for electrons, light has been proposed as ideal non interacting waves to explore coherent transport properties in the absence of interactions. The development in experiments and theory over the past several years have shown a route towards the experimental realization of this phase transition.
Previous studies on Anderson localization of light using semiconductor powders or dielectric particles have shown that intrinsic material properties, such as absorption or inelastic scattering of light, need to be taken into account in the interpretation of experimental signatures of Anderson localization. Laser-cooled clouds of atoms avoid the problems of samples used so far to study Anderson localization of light. Ab initio theoretical models, available for cold Ytterbium atoms, have shown that the mere high spatial density of the scattering sample is not sufficient to allow for Anderson localization of photons in three dimensions, but that an additional magnetic field or additional disorder on the level shifts can induce a phase transition in three dimensions.
The role of disorder in atom-light interactions has important consequences for the next generation of high precision atomic clocks and quantum memories. By connecting the mesoscopic physics approach to quantum optics and cooperative scattering, this project will allow better control of cold atoms as building blocks of future quantum technologies. Time-resolved transport experiments will connect super- and subradiant assisted transmission with the extended and localized eigenstates of the system.
Having pioneered studies on weak localization and cooperative scattering enables me to diagnostic strong localization of light by cold atoms.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833801	**NOQIA**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. MACIEJ LEWENSTEIN**
Host Institution: Fundacio Institut De Ciencies Fotoniques, ES

NOvel Quantum simulators – connectIng Areas

Quantum simulators (QS) are experimental systems that allow mimic hard to simulate models of condensed matter, high energy physics and beyond. QS have various platforms: from ultracold atoms and ions to superconducting qubits. They constitute the important pillar of quantum technologies (QT), and promise future applications in chemistry, material science and optimization problems. Over the last decade, QS were particularly successful in mimicking topological effects in physics (TEP) and in developing accurate quantum validation/certification (QVC) methods. NOQIA is a theory project, aimed at introducing the established field of QS+TEP+QVC into two novel areas: physics of ultrafast phenomena and attoscience (AS) on one side, and quantum machine learning (ML) and neural networks (NN) on the other. This will open up new horizons/opportunities for research both in AS and in ML/NN. For instance, in AS we will address the question if intense laser physics may serve as a tool to detect topological effects in solid state and strongly correlated systems. We will study response of matter to laser pulses carrying topological signatures, to determine if they can induce topological effects in targets. We will design/analyze QS using trapped atoms to understand and detect TEP in the AS. On the ML/NN side, we will apply classical ML to analyze, design and control QS for topological systems, in order to understand and optimize them. Conversely, we will transfer many-body techniques to ML in order to analyze and possibly improve performance of classical machine learning. We will design and analyze quantum neural network devices that will employ topology in order to achieve robust quantum memory or information processing. We will design/study attractor neural networks with topological stationary states, or feed-forward networks with topological Floquet and time-crystal states. Both in AS and ML/NN, NOQIA will rely on quantum validation and certification protocols and techniques.

Project End Date: **30-JUN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834266	**CERQUTE**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. ANTONIO ACÍN**
Host Institution: Fundacio Institut De Ciencies Fotoniques, ES

Certification of quantum technologies

Given a quantum system, how can one ensure that it (i) is entangled? (ii) random? (iii) secure? (iv) performs a computation correctly? The concept of quantum certification embraces all these questions and CERQUTE's main goal is to provide the tools to achieve such certification. The need of a new paradigm for quantum certification has emerged as a consequence of the impressive advances on the control of quantum systems. On the one hand, complex many-body quantum systems are prepared in many labs worldwide. On the other hand, quantum information technologies are making the transition to real applications. Quantum certification is a highly transversal concept that covers a broad range of scenarios –from many-body systems to protocols employing few devices– and questions –from theoretical results and experimental demonstrations to commercial products–. CERQUTE is organized along three research lines that reflect this broadness and inter-disciplinary character: (A) many-body quantum systems: the objective is to provide the tools to identify quantum properties of many-body quantum systems; (B) quantum networks: the objective is to characterize networks in the quantum regime; (C) quantum cryptographic protocols: the objective is to construct cryptography protocols offering certified security. Crucial to achieve these objectives is the development of radically new methods to deal with quantum systems in an efficient way. Expected outcomes are: (i) new methods to detect quantum phenomena in the many-body regime, (ii) new protocols to benchmark quantum simulators and annealers, (iii) first methods to characterize quantum causality, (iv) new protocols exploiting simple network geometries (v) experimentally-friendly cryptographic protocols offering certified security. CERQUTE goes at the heart of the fundamental question of what distinguishes quantum from classical physics and will provide the concepts and protocols for the certification of quantum phenomena and technologies.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834878	**CanISeeQG**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. JAN DE BOER**
Host Institution: Universiteit Van Amsterdam, NL

Can I see Quantum Gravity?

The interplay between two of the most important building blocks of nature, quantum mechanics and gravity, has been a great source of inspiration for theoretical physics, leading to discoveries such as the Hawking radiation of black holes and the development of string theory. In turn, the following picture emerged: physics at the most fundamental level is governed by the rules of quantum mechanics while gravity is some effective coarse-grained description of the underlying microscopic theory. Given that the microscopic degrees of freedom are non-local, standard techniques such as the renormalization group and effective field theory a priori do not apply. Nevertheless, we use effective field theories that incorporate general relativity to describe our observations.

With the discovery of gravitational waves and the various ongoing and upcoming experiments that will put general relativity to the test, it has become urgent to assess the validity of the standard framework of effective field theory for describing observable quantum gravity effects. Recent developments in resolving the information loss paradox and the quantum nature of black holes concluded that effective field theory must be modified in a way that uniquely incorporates quantum gravity. The main purpose of this proposal is to describe this modification in a precise and quantitative way, ultimately connecting it to potential experimental discoveries.

In order to achieve this goal, I will approach the problem using a combination of thermodynamics, hydrodynamics and quantum information theory, mostly in the context of the AdS/CFT correspondence, where a precise description of quantum gravity is available. As a by-product of identifying observational features of quantum gravity, I will also make substantial progress in several foundational problems. My broad track record and expertise, and the fact that I have already obtained promising preliminary results, makes me uniquely qualified to lead this endeavor.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850463	**Bug-Flash**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. MIKKEL BRYDEGAARD**
Host Institution: Lunds Universitet, SE

Coherent Back-Lasing from Atmospheric Insects

I received I received the prestigious Inaba award by the lidar community for advancing lidar entomology. Our Scheimpflug lidar can be implemented at 1% of the conventional cost and weight. It allows atmospheric observation with unpreceded sensitivity and spatiotemporal resolution. The kHz sampling rates can exceed the round-trip time of the light and reveal the modulation spectra for classifying free flying insect species over ground. The method has infinite focal depth and efficiently profiles sparse organisms in the airspace with 100000 observations per day. This tool is of key importance for tackling challenges related to pollinator diversity, agricultural pests and pesticides and malaria disease vectors. As in radar entomology, in situ lidar monitoring apparently has inevitable limitations: 1) Detection limit deteriorate with range, and far observations are biased towards larger organisms, 2) It takes several wing-beats, and therefore time, beam-width and energy to retrieve a modulation spectrum for classifying species. I propose to remove range biasing and classify insects by a microsecond flash of light. Back-lasing in air has been a dream of physicists for half a century. I now intend to capture specular reflexes from flat wing membranes. When the surface normal coincides with the lidar transect, collimated back-propagating laser light is accomplished. This flash of light is spectrally fringed and can report on the membrane thickness for target classification purpose. This project has three ambitious milestones of increasing challenge with in situ campaigns:

A) Polarimetric kHz lidar: Verification of specular flashes, investigation of range dependence, properties and likelihood.

B) Remote nanoscopy: Spectral analysis of remotely retrieved flashes for membrane thickness assessment and optimization of back-scatter resonance.

C) Farfetched flatness: I will enhance apparent surface roughness and collimated back-scatter from diffuse specimen by infrared methods

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850899	**NEQuM**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. MAKSYM SERBYN**
Host Institution: Institute Of Science And Technology Austria, AT

Non-Ergodic Quantum Matter: Universality, Dynamics and Control

In this project we propose to build the theory of non-ergodic quantum matter – isolated quantum systems that avoid thermal equilibrium. To this end, we will study the established non-ergodic phases, search for new phases, and seek to understand their common properties and dynamics. Recently non-ergodic systems that avoid the fate of thermal equilibrium were realized experimentally in quantum simulators. Specific examples include many-body localized phases, glassy and kinetically constrained models, and systems with weak ergodicity breaking. Freedom from the laws of equilibrium statistical mechanics opens up a host of possible unexpected behaviors prohibited in equilibrium. The ability of non-ergodic systems to stay quantum on longer timescales has potential for practical applications. This calls for the development of a general theory of non-ergodic quantum systems. In order to develop such theory, in this project we will seek to address the questions: What are the possible ways to avoid attaining thermal equilibrium? What are the universal properties of such non-ergodic systems? What is the nature of their long time dynamics and their steady state? How can we put their properties to use? The PI will leverage his expertise in studies of many-body localization to lead a coherent research program aimed at (i) describing universal properties of highly-excited eigenstates and their entanglement; (ii) developing new methods to simulate non-ergodic dynamics and reveal its experimental signatures; and (iii) using such quantum phases for many-body state preparation and optimal control. The theory delivered by this project will ultimately provide useful insights into quantum thermalization, thus establishing the first steps towards a general theory of non-equilibrium quantum systems. On the practical side, such theory will guide the experimental search for non-ergodic phases, and open the door to their application in more efficient quantum information storage and processing.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851810	**QUREP**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. TIM SCHRÖDER**
Host Institution: Humboldt-Universitaet Zu Berlin, DE

Quantum Repeater Architectures Based on Quantum Memories and Photonic Encoding

At the heart of all anticipated network-based quantum applications lies the requirement to establish quantum communication between individual network nodes over long distances. Quantum communication exceeding 100 km requires so-called quantum repeaters to extend communication beyond this limit. Mainly two types of quantum repeater schemes are being investigated: Quantum-memory-based schemes for long-distant entanglement generation and photonic encoding-based schemes for fast secure quantum communication. To date, both schemes have only been considered individually, however, a hybrid approach could overcome their distinct limitations and benefit from individual advantages. How such a system could be realized remains an open question.

This project addresses the challenges, benefits, and resource requirements for a hybrid architecture of interconnected photonic-cluster-state-based and quantum-memory-based quantum repeaters. In a theoretical study, cost parameters of such a hybrid quantum repeater for realistic system properties will be determined for the first time. Experimentally, electron spin coupled quantum dot single photon sources will be employed as resource for multi-photon cluster state generation. In parallel, a new type of quantum memory—the SnV defect in diamond, will serve to demonstrate remote entanglement. Finally, these two disparate systems will be interconnected via frequency conversion and Bell-measurements—to demonstrate cross-platform entanglement. Investigating for the first time an interconnected system of two disparate solid-state resources for quantum communication will stimulate ground-breaking research towards hybrid quantum repeater architectures.

All three objectives will benefit from the PI's recent expertise in spectroscopy, spin control, and nanofabrication of gallium arsenide quantum dots and diamond defect centres in integrated photonic structures.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852016	**SHADES**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. ANDREAS BEST**
Host Institution: Universita Degli Studi Di Napoli Federico Ii, IT

Scintillator-He3 Array for Deep-underground Experiments on the S-process

A crucial source of neutrons in stars is the nuclear reaction Ne-22(alpha,n)Mg-25, of major importance for the synthesis of heavy elements. Currently there is an established picture of the astrophysical scenario but only limited availability of reliable experimental data, with several key ingredients under dispute. SHADES will perform a direct measurement of the reaction to resolve the main. The goal is to decrease the uncertainty in the astrophysical reaction rate in the relevant temperature range by at least one order of magnitude, providing a significant leap ahead from the state of the art. SHADES will deliver an increase in sensitivity of more than two orders of magnitude over the state of the art. We will gather direct experimental data over the entire astrophysically relevant energy range. We will construct a neutron detector specifically designed for this measurement. Beam-induced background, a severe problem in the past, will be discriminated by measuring the neutron energy while still maintaining a very detection high efficiency. In recent years research on capture-gated techniques and combinations of different detector types to measure neutron energies has increased greatly. The novel detector array will perfectly fit this profile and find a large field of applications also outside of nuclear astrophysics. The main measurements will be done with the new accelerator LUNA MV, allowing long-term high-intensity, high-energy resolution alpha bombardments. An extended, recirculating gas target will guarantee target stability under intense ion beams. The location of the experiment deep underground will drastically reduce the external background, the main limiting factor so far for low-energy measurements. In my team there will be also leading experts in the field to update the current stellar models using the new dataset to provide a greatly improved and much more robust picture of this important branch of stellar nucleosynthesis.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852845	**SENSE**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. SUSANNE MERTENS**
Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Sterile neutrino search in tritium beta decay

What is the nature of Dark Matter? What is the origin of the neutrino mass? These are two of the most compelling mysteries, physics is facing today. Despite its tremendous success, the Standard Model of Particle Physics does not provide an answer to these questions.

Since the Nobel-prize awarded discovery of the neutrino oscillations, which proofs that neutrinos have a mass, the existence of right-handed partners to the known left-handed neutrinos is a basic assumption. This minimal extension of the Standard Model provides a natural mechanism to generate neutrino masses and can lead to the existence of new types of neutrinos, so-called sterile neutrinos.

With a mass in the kilo-electron-volt (keV) regime, sterile neutrinos are a prime dark matter candidate. This dark matter type is especially appealing as it can act as warm dark matter, the existence of which would mitigate problems in our understanding of large-scale structures in the cosmos. The existence of sterile neutrinos with a mass in the eV-volt (eV) regime can resolve puzzling experimental anomalies observed in short-baseline neutrino oscillation experiments.

With SENSE, I aim to probe the existence of eV – keV sterile neutrino in a laboratory-based experiment with world-leading sensitivity. A unique way to perform this search is via high-precision beta spectroscopy. The novel idea of SENSE is to develop a beyond-the-state-of-the-art Silicon-Drift-Detector system, which, combined with the large-scale Karlsruhe Tritium Neutrino (Katrin) experiment, will open the window to sterile neutrino signals not accessible elsewhere.

My role as analysis coordinator of the Katrin experiment and the expertise in semi-conductor detector technology of my independent Max-Planck-Research group put me in the ideal position to conduct this ambitious research project.

The discovery of sterile neutrinos would be a breakthrough in science with far-reaching consequences for our understanding of matter and the universe.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
853443	**mlQuDyn**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. MARKUS HEYL**
Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Machine learning quantum dynamics

A key scope of quantum many-body theory is the identification of universal behavior in quantum matter, where macroscopic properties become independent of microscopic details. In recent years the quest for phases with novel universal properties has been revolutionized by forcing systems out of equilibrium, which has opened up a universe of unexplored phenomena and new dynamical paradigms. These developments not only hold the promise to theoretically uncover unrecognized universal dynamical behavior, but are also driven by the enormous advances in quantum simulators such as ultra-cold atoms, which have nowadays achieved unique capabilities in generating and probing such nonequilibrium quantum states. Still, their theoretical description is facing severe challenges. It is the aim of this proposal to take the theoretical understanding and predictive power of quantum many-body theory to a new level by an crossdisciplinary approach at the interface between quantum dynamics and machine learning.

The central element of this approach is to encode time-evolved quantum states into artificial neural networks, which have been remarkably successful in storing and recognizing complex structures in computer science. In order to reach the main goal we have identified three main challenges which form the core of the program: (i) to design efficient artificial network structures based on fundamental principles of quantum many-body systems such as locality and causality; (ii) to utilize concepts of many-body theory and statistical physics to understand the physical properties of artificial neural networks; (iii) to explore fundamental but yet inaccessible dynamical quantum phenomena and universal behavior in quantum dynamics. The successfully conducted research program will lift the description and understanding of quantum many-body dynamics to a new level, impacting significantly both quantum theory as well as future experiments.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864583	**NP-QFT**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. FRANCESCO BENINI**
Host Institution: Scuola Internazionale Superiore Di Studi Avanzati, IT

Non-perturbative dynamics of quantum fields: from new deconfined phases of matter to quantum black holes

When the degrees of freedom that constitute a quantum physical system are strongly coupled among each other, their collective low-energy behaviour can exhibit a plethora of exotic, surprising and unconventional phenomena. At the same time, however, our most sophisticated tool to describe the quantum world - quantum field theory - becomes extremely difficult to use. This problem appears across the board in many areas, from particle physics, to condensed matter physics, to astrophysics: strong coupling is an intrinsic complexity of quantum systems, whose solution can benefit disparate fields. A large variety of examples is provided by deconfined quantum states of matter, in which the collective behaviour gives rise to emergent low-energy degrees of freedom, often strongly coupled. Another context in which decrypting strong coupling can be the key to a breakthrough is quantum gravity: by the celebrated AdS/CFT correspondence, we can describe gravity in Anti-de-Sitter space in a fully-consistent quantum fashion, in terms of an ordinary - but strongly coupled - quantum field theory in one dimension less.
The ambitious goal of this project is twofold: first, to develop innovative techniques to tame strong coupling; second, to exploit those techniques to discover new deconfined phases of matter on one side, and to unravel mysteries of quantum gravity and the quantum physics of black holes on the other side.
I will follow several avenues in the quest for new computational tools at strong coupling, such as refining the concept of symmetry, developing supersymmetric localization, probing Borel summability of certain gauge theories. Applying these and other methods, I will systematically explore three-dimensional gauge theories with bosons and fermions, landscaping their phase diagrams and deconfined critical points. Meanwhile, I will extract the quantum entropy and other properties of black holes, exploring signatures of quantum effects to be compared with future experiments.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864950	**LightAtLHC**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. MATTHIAS SCHOTT**
Host Institution: Johannes Gutenberg Universitaet Mainz, DE

Search for Axion-Like Particles at the LHC

Axions and other very light axion-like particles (ALPs) appear in many extensions of the Standard Model and are well motivated theoretically: ALPs can solve the well-known strong CP problem, act as a dark matter candidate and could also explain the famous muon (g-2) discrepancy. The experimental effort to search for ALPs as dark matter candidates is ongoing and has been considerably intensified in recent years, leading to the proposal and construction of a wide range of dedicated experiments. However, none of these dedicated experiments is sensitive to those ALPs that can explain low-energy anomalies such as (g-2). I propose therefore to pioneer an alternative search strategy for axion-like particles via their decay into two photons, using data collected at the Large Hadron Collider. This approach requires fundamental innovations on the photon identification capabilities of the current detectors as well as radically new analysis strategies.

Within the LightAtLHC project, I will study proton-proton and lead-lead collisions, collected during LHC Run-3, and search for Higgs Boson decays in two ALPs as well as the direct production of ALPs via photon fusion and their subsequent decay into two low-energy photons. To achieve the required sensitivity, I will develop highly specialized photon reconstruction algorithms for the ATLAS detector.

These efforts will largely cover the relevant parameter space, leaving out only a small region. To also close this gap, I will extend the upcoming FASER experiment at the LHC by an innovative presampler detector, which allows for an unambiguous ALPs detection. By the end of the LightAtLHC project, I can either rule out the most promising ALP models in a mass range from 10 MeV to 1 TeV, or discover a new elementary particle.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865844	**BINGO**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. CLAUDIA NONES**
Host Institution: Commissariat A L Energie Atomique Et Aux Energies Alternatives, FR

Bi-Isotope 0n2b Next Generation Observatory

BINGO will set the grounds for a large-scale bolometric experiment searching for neutrinoless double beta decay with a background index of about 10-5 counts/(keV kg y) and with very high energy resolution – of the order of 1.5‰ – in the region of interest. These features will enable a search for lepton number violation with unprecedented sensitivity. The BINGO approach can lead to the demonstration of the Majorana nature of neutrino even in the unfavourable case of direct ordering of neutrino masses.

BINGO is based on luminescent bolometers for the rejection of the dominant alpha surface background. It will focus on two extremely promising isotopes – 100Mo and 130Te – that have complementary merits and deserve to be both considered for future large-scale searches.

The project will bring three original ingredients to the well-established technology of hybrid heat-light bolometers: i) the light-detector sensitivity will be increased by an order of magnitude thanks to Neganov-Luke amplification; (ii) a revolutionary detector assembly will reduce the total surface radioactivity contribution by at least one order of magnitude; (iii) for the first time in an array of macrobolometers, an internal active shield, based on ultrapure ZnWO4 scintillators with bolometric light readout, will suppress the external gamma background. These challenging technologies will be extensively tested in a two-isotope demonstrator, dubbed MINI-BINGO, which will be located in an underground laboratory in a dedicated cryogenic infrastructure built with ERC funds.

The BINGO approach can be implemented in the next-generation search CUPID, a proposed follow up of the CUORE experiment. BINGO can improve dramatically the sensitivity of CUPID, using two isotopes at the same time and providing the demonstration of its background goal. Subsequently, the intrinsic modularity of the bolometric technique would make sensible to proceed to further expansions, capable of penetrating the direct-ordering band.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865877	**NeXource**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. BERNHARD HIDDING**
Host Institution: University Of Strathclyde, UK

Next-generation Plasma-based Electron Beam Sources for High-brightness Photon Science

High-quality electron beams are required for advanced light sources and for high energy physics. Engines of discovery such as free-electron-lasers (FELs) and other bright light sources, are driven by electron beams today produced in km-long state-of-the-art linear accelerators (linacs). A complementary alternative are cm-scale plasma-based accelerators, which are feasible in university-lab scale environments. The NeXource project aims at combining key advantages of both types of accelerators to realize hybrid plasma-based accelerators orders of magnitude smaller and at the same time with electron beam quality orders of magnitude better than state-of-the-art. This has far-reaching impact as it will enable the construction of table-top coherent hard x-ray sources with extreme brightness.

This project is motivated by experimental breakthroughs obtained in the E210 collaboration at the linac-driven plasma accelerator facility FACET at the Stanford Linear Accelerator Center (SLAC) and by the progress at laser-plasma-accelerator facilities, combined with novel conceptual approaches towards beams with unprecedented 6D-brightness by using tailored beamloading in plasma-based photocathodes.

A dedicated setup for plasma photocathode prototyping and hybrid plasma acceleration will be established at the Scottish Centre for the Application of Plasma-based Accelerators (SCAPA) to develop beam brightness transformers. This R&D will be complemented by campaigns at SLAC, DESY, Daresbury Laboratory and laser-plasma-accelerator labs in Europe. Start-to-end simulations indicate that hard x-ray FEL's with ultrahigh gain and other advanced light sources can be realised with such electron beams in university-scale labs, which would have transformative impact on photon science and a wide range of natural, life and material science.

Project End Date: **31-MAR-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
883425	**BARB**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. MARCO DURANTE**
Host Institution: Gsi Helmholtzzentrum Fuer Schwerionenforschung Gmbh, DE

Biomedical Applications of Radioactive ion Beams

Cancer remains one of the main causes of death worldwide. In 2018, >50% cancer patients in Europe underwent radiotherapy. While over 80% were treated using high-energy X-rays, the number of patients receiving accelerated protons or heavy ions (charged particle therapy: CPT) is rapidly growing, with nearly 200,000 patients treated up till now. Although CPT offers a better depth-dose distribution compared to common X-ray based techniques, range uncertainty and poor image guidance still limit its application.

Improving accuracy is key to broadening the applicability of CPT. In BARB, we will open a new paradigm in the clinical use of CPT by using high-intensity radioactive ion beams (RIB), produced at GSI/FAIR-phase-0 in Darmstadt, for simultaneous treatment and visualization. This will reduce range uncertainty and extend the applicability of CPT to treatment of small lesions (e.g. metastasis and heart ventricles) with unprecedented precision.

The Facility for Antiprotons and Ion Research (FAIR) is currently under construction at GSI. RIB are one of the main tools for basic nuclear physics studies in the new facility. As part of the ongoing FAIR-phase-0, an intensity upgrade will increase the light ion currents in the existing SIS18 synchrotron. Within this project BARB, we will study four b+ emitters (10,11C, and 14,15O) and build an innovative hybrid detector for online positron emission tomography (PET) and g-ray imaging. This novel detector will acquire both prompt g-rays during the beam-on phase of the pulsed synchrotron beam delivery, and the delayed emission from b+ annihilation during the pulse intervals. The technique will be further validated in vivo by applying it to treatment of small tumors in a mouse model.

BARB will exploit the potential of the Bragg peak in medicine. The project will tweak RIB production in nuclear physics and validate the therapeutic potential of RIB therapy in vivo by empowering simultaneous treatment and visualization.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
884447	**MONOLITH**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. GIUSEPPE IACOBUCCI**
Host Institution: Universite De Geneve, CH

Monolithic Multi-Junction Picosecond Avalanche Detector for future physics experiments and applications

Particle-physics, space research and several other fields of basic and applied science necessitate the production of thin sensors capable to provide excellent position and time resolution at the same time.

The diode structure of present silicon pixel sensors strongly penalises the enormous potential of silicon-based time measurement: the ~30 ps intrinsic limit of diodes was already reached in sensors with internal gain with pad sizes of 1 mm2. Therefore, new ideas are needed to improve by another order of magnitude and reach the picosecond level.

This project introduces a novel silicon-sensor structure devised to overcome the intrinsic limits of present sensors and simultaneously provide picosecond timing and high spatial resolution in a monolithic implementation. This goal is achieved by the introduction of a fully depleted multi-junction. The remarkable performance of this new sensor, combined with the simplified assembly process and reduced production cost offered by the monolithic implementation in standard CMOS processes, represent the required breakthrough.

In addition to the novel multi-junction sensor, the cornerstones of the project are the low-noise very-fast SiGe HBT frontend and the patented TDC with robust synchronisation method that the PI has already produced in preliminary versions.

The monolithic detector proposed here will offer a sustainable solution for the next generation of experiments at hadron colliders, in nuclear physics and for space-borne experiments in cosmic-ray physics and solar physics. Besides the primary goal of basic science, it will represent an extraordinary enabling technology for the large spectrum of high-tech applications that benefits of picosecond-level Time-Of-Flight measurements. The innovative monolithic detector introduced here will also offer a starting point for further progress in the field of light detection.

European industrial partners have been contacted for commercial exploitation of the detector.

Project End Date: **30-JUN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
884676	**QU-BOSS**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. FABIO SCIARRINO**
Host Institution: Universita Degli Studi Di Roma La Sapienza, IT

QUantum advantage via non-linear BOSon Sampling

After decades of progress in quantum information science, it is widely expected that in the next few years the field will start to yield practical applications in quantum chemistry, materials and pharmaceutical research, information security, and finance. For these applications to pan out, a crucial intermediate goal is to reach the quantum advantage regime, where quantum devices experimentally outperform classical computers in some computational task. The Boson Sampling problem is an example of a task that is computationally hard for classical computers, but which can be solved with a specialized quantum device using single photons interfering in a multimode linear interferometer. The aim of QU-BOSS is to experimentally push towards the quantum advantage regime with integrated photonic technology. The key innovative ingredient is the introduction of non-linearities acting at the single photon level embedded within the Boson Sampling interferometer. We plan to provide an experimental research breakthrough along three main directions, including both “hardware” and “software” components. First, we will use complementary approaches to map out how the addition of non-linearity boosts the device´s complexity, making it harder to simulate classically. We will use different approaches to implement these devices with hybrid integrated quantum photonics, a versatile and flexible route to the manipulation of high-dimensional quantum photonic states. Finally, we will deploy the developed technology to implement two different architectures demonstrating quantum machine learning: a hybrid model of quantum computation and an optical quantum neural network. QU- BOSS aims to position integrated photonics into the NISQ (noisy, intermediate-scale quantum) era, opening up truly new scientific horizons at the frontier of quantum information, quantum control, machine learning and integrated photonics.

Project End Date: **31-JUL-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
885281	**KILONOVA**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. GABRIEL MARTINEZ-PINEDO**
Host Institution: Gsi Helmholtzzentrum Fuer Schwerionenforschung Gmbh, DE

Probing r-process nucleosynthesis through its electromagnetic signatures

The lightest chemical elements –Hydrogen and Helium– were created about a minute after the Big Bang. Elements up to Iron are forged by fusion reactions in stars. Heavy elements between Iron and Uranium are produced by a sequence of neutron captures and beta-decays known as rapid neutron capture or r process. The freshly synthesized r-process elements undergo radioactive decay through various channels depositing energy in the ejecta that powers an optical/infrared transient called “kilonova” whose basic properties like luminosity and its dependence on ejecta mass, velocity, radioactive energy input, and atomic opacities I contributed to determine for the first time. Our predictions have been dramatically confirmed by the observation of a kilonova electromagnetic transient associated with the gravitational wave signal GW170817 providing the first direct indication that r-process elements are produced in neutron-star mergers. Additional events are expected to be detected in the following years, representing a complete change of paradigm in r-process research as for the first time we will be confronted with direct observational data. To fully exploit such opportunity it is fundamental to combine an improved description of exotic neutron-rich nuclei involved in the r-process with sophisticated astrophysical simulations to provide accurate prediction of r-process nucleosynthesis yields and their electromagnetic signals to be confronted with observational data. Based on my broad knowledge and expertise in all the relevant areas, and the unique experimental capabilities of the GSI/FAIR facility, I am in prime position to advance our understanding of r-process nucleosynthesis and determine the contribution of mergers to the chemical enrichment of the galaxy in heavy elements.

Project End Date: **31-DEC-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
		PE2 Fundamental Constituents of Matter
885414	**Ampl2Einstein**	

Principal Investigator: **Dr. DAVID KOSOWER**
Host Institution: Commissariat A L Energie Atomique Et Aux Energies Alternatives, FR

Scattering Amplitudes for Gravitational Wave Theory

Four years ago, the LIGO/Virgo observation of a black-hole binary merger heralded the dawn of gravitational-wave astronomy. The promise of future observations calls for an invigorated effort to underpin the theoretical framework and supply the predictions needed for detecting future signals and exploiting them for astronomical and astrophysical studies. Ampl2Einstein will take ideas and techniques from recent years' dramatic advances in Quantum Scattering Amplitudes, creating new tools for taking their classical limits and using it for gravitational physics. The powerful `square root' relation between gravity and a generalization of electrodynamics known as Yang-Mills theory will play a key role in making this route simpler than direct classical calculation. We will transfer these ideas to classical General Relativity to compute new perturbative orders, spin-dependent observables, and the dependence on the internal structure of merging objects. We will exploit symmetries and structure we find in order to extrapolate to even higher orders in the gravitational theory. We will make such calculations vastly simpler, pushing the known frontier much further in perturbation theory and in complexity of observables. These advances will give rise to a new generation of gravitational-wave templates, dramatically extending the observing power of detectors. They will allow observers to see weaker signals and will be key to resolving long-standing puzzles about the internal structure of neutron stars.

We will apply novel technologies developed for scattering amplitudes to bound-state calculations in both quantum and classical theory. Our research will also lead to a deeper understanding of the classical limit of quantum field theory, relevant to gravitational-wave observations and beyond. The transfer of ideas to the new domain of General Relativity will dramatically enhance our ability to reveal new physics encoded in the subtlest of gravitational-wave signals.

Project End Date: **31-DEC-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
885479	**DoMInIon**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. ROLAND WESTER**
Host Institution: Universitaet Innsbruck, AT

Dynamics of Molecular Interactions with Ions

Being able to clarify the atomistic dynamics of molecular collisions and chemical reactions has been a central research goal for decades. For reactions of charged particles in particular, the importance of quantum dynamics is barely understood, as quantum state-resolved experiments beyond total cross section measurement are very challenging and most theoretical descriptions still rely on quasi-classical approaches. In particular, quantum scattering resonances, known by now to be relevant in a few well-studied neutral molecule reactions, have never been observed for ion-molecule collisions up to now. In the past years we have spearheaded research on crossed-beam reactive scattering of ions with neutral molecules. Our measured differential scattering cross sections could provide detailed insight into the dynamics of polyatomic reactions and allowed us to discover several new reaction mechanisms. In this project, we propose a novel experimental approach to achieve a multifold improved resolution for the scattering images, which will allow us to answer several key questions: Which product quantum states are populated in molecular ions that are produced in three- and four-atom reactions? How do quantum scattering resonances influence the collision dynamics and the product state distribution? Which momentum vector correlations govern the three-body break-up in ion-neutral reactions and which transition states are responsible for these dynamics? How are ionic reactions contributing to the radiation damage of biological molecules in cells? Our proposed experimental approach can answer these questions and will thereby reach a new domain for the investigation of ion-molecule reactions with unprecedented quantum state control for three- and four-atom reactions and highly differential insight into polyatomic reactions.

Project End Date: **31-DEC-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714235	**AQSuS**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. GERHARD KIRCHMAIR**
Host Institution: Universitaet Innsbruck, AT

Analog Quantum Simulation using Superconducting Qubits

AQSuS aims at experimentally implementing analogue quantum simulation of interacting spin models in two-dimensional geometries. The proposed experimental approach paves the way to investigate a broad range of currently inaccessible quantum phenomena, for which existing analytical and numerical methods reach their limitations. Developing precisely controlled interacting quantum systems in 2D is an important current goal well beyond the field of quantum simulation and has applications in e.g. solid state physics, computing and metrology.
To access these models, I propose to develop a novel circuit quantum-electrodynamics (cQED) platform based on the 3D transmon qubit architecture. This platform utilizes the highly engineerable properties and long coherence times of these qubits. A central novel idea behind AQSuS is to exploit the spatial dependence of the naturally occurring dipolar interactions between the qubits to engineer the desired spin-spin interactions. This approach avoids the complicated wiring, typical for other cQED experiments and reduces the complexity of the experimental setup. The scheme is therefore directly scalable to larger systems. The experimental goals are:

1) Demonstrate analogue quantum simulation of an interacting spin system in 1D & 2D.
2) Establish methods to precisely initialize the state of the system, control the interactions and readout single qubit states and multi-qubit correlations.
3) Investigate unobserved quantum phenomena on 2D geometries e.g. kagome and triangular lattices.
4) Study open system dynamics with interacting spin systems.

AQSuS builds on my backgrounds in both superconducting qubits and quantum simulation with trapped-ions. With theory collaborators my young research group and I have recently published an article in PRB [9] describing and analysing the proposed platform. The ERC starting grant would allow me to open a big new research direction and capitalize on the foundations established over the last two years.

Project End Date: **31-MAR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714692	**UNIGLASS**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. ANDREW FEFFERMAN**
Host Institution: Centre National De La Recherche Scientifique, FR

The Enigmatic Universality of Glass

The explanation for the distinct low temperature behavior of amorphous solids (glasses) is a long-standing open question. Specific puzzles include the nature of the low energy excitations (LEEs) that are responsible for their low temperature thermal and mechanical behavior and the origin of the remarkable universality of their low temperature mechanical dissipation. The phenomenological tunneling model proposes that the LEEs are atomic-scale tunneling two level systems (TLSs) and successfully explains much of the low temperature behavior of glass, but not the universality. Recently, individual TLSs were probed in the amorphous tunnel junction of superconducting qubits, but such dielectric measurements might not access the LEEs responsible for universality. In contrast, I propose to search for individual TLSs using purely mechanical measurements. The glass samples containing the TLSs will be nanomechanical resonators, and the strain coupling between the mechanical mode and the TLS will be used to control the quantum state of the latter. This strain coupling allows coherent state transfer between the mechanical mode and the TLS. Identifying individual TLSs and controlling their quantum state in this manner will demonstrate that the LEEs responsible for the characteristic low temperature properties of glass are indeed TLSs. Furthermore, these measurements will reveal the characteristics of individual TLSs and their interactions with their environment, in contrast to bulk measurements in which, according to the model, the effects of many TLSs are averaged. The results of the proposed study may therefore strongly support the tunneling model. This would require reconsideration of potential explanations for universality which are thought to be inconsistent with the existence of TLSs. Alternatively, if the hypothesized TLSs are absent, then the tunneling model must be replaced by a new interpretation of the low temperature properties of glass.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714870	**MMUSCLES**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. JOHANNES FEIST**
Host Institution: Universidad Autonoma De Madrid, ES

Modification of Molecular structure Under Strong Coupling to confined Light modES

Understanding and controlling the properties of matter is one of the overarching goals of modern science. A powerful way to achieve is this by using light, usually in the form of intense laser beams. However, modern advances in nanophotonics allow us to confine light modes so strongly that their effect on matter is felt even when no external fields are present. In this regime of “strong coupling” or “vacuum Rabi splitting”, the fundamental excitations of the coupled system are hybrid light-matter states which combine the properties of both constituents, so-called polaritons. Little attention has been paid to the fact that strong coupling can also affect internal structure, such as nuclear motion in molecules. First experimental indications for this effect have been found, but current theory cannot explain or predict such changes. We will thus develop theoretical methods that can treat the modification of molecular structure under strong coupling to confined light modes. This will require advances in the microscopic description of the molecules under strong coupling by explicitly including their rovibrational degrees of freedom, as well as techniques to incorporate the influence of these modes in the macroscopic setting of collective strong coupling. In order to achieve this, we will adapt well-known techniques from quantum chemistry and combine them with the concepts of polariton physics. We will investigate what level of control can be gained through this approach, and whether confined light modes could act as a “photonic catalyst” to control molecular dynamics without requiring an active ingredient. This could present a novel tool to control photochemical reactions that are of paramount importance in the biological mechanisms of vision and photosynthesis, and hold great interest for use in memories, photoswitching devices, light-driven actuators, or solar energy storage. Consequently, this work could have wide-ranging impact on many different fields of science.

Project End Date: **31-MAR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715452	**MAGNETIC-SPEED-LIMIT**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. STEFANO BONETTI**
Host Institution: Stockholms Universitet, SE

Understanding the speed limits of magnetism

While the origin of magnetic order in condensed matter is in the exchange and spin-orbit interactions, with time scales in the subpicosecond ranges, it has been long believed that magnetism could only be manipulated at nanosecond rates, exploiting dipolar interactions with external magnetic fields. However, in the past decade researchers have been able to observe ultrafast magnetic dynamics at its intrinsic time scales without the need for magnetic fields, thus revolutionising the view on the speed limits of magnetism. Despite many achievements in ultrafast magnetism, the understanding of the fundamental physics that allows for the ultrafast dissipation of angular momentum is still only partial, hampered by the lack of experimental techniques suited to fully explore these phenomena. However, the recent appearance of two new types of coherent radiation, single-cycle THz pulses and x-rays generated at free electron lasers (FELs), has provided researchers access to a whole new set of capabilities to tackle this challenge. This proposal suggests using these techniques to achieve an encompassing view of ultrafast magnetic dynamics in metallic ferromagnets, via the following three research objectives: (a) to reveal ultrafast dynamics driven by strong THz radiation in several magnetic systems using table-top femtosecond lasers; (b) to unravel the contribution of lattice dynamics to ultrafast demagnetization in different magnetic materials using the x-rays produced at FELs and (c) to directly image ultrafast spin currents by creating femtosecond movies with nanometre resolution. The proposed experiments are challenging and explore unchartered territories, but if successful, they will advance the understanding of the speed limits of magnetism, at the time scales of the exchange and spin-orbit interactions. They will also open up for future investigations of ultrafast magnetic phenomena in materials with large electronic correlations or spin-orbit coupling.

Project End Date: **31-JAN-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715496	**2DNANOPTICA**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. PABLO ALONSO-GONZÁLEZ**
Host Institution: Universidad De Oviedo, ES

Nano-optics on flatland: from quantum nanotechnology to nano-bio-photonics

Ubiquitous in nature, light-matter interactions are of fundamental importance in science and all optical technologies. Understanding and controlling them has been a long-pursued objective in modern physics. However, so far, related experiments have relied on traditional optical schemes where, owing to the classical diffraction limit, control of optical fields to length scales below the wavelength of light is prevented. Importantly, this limitation impedes to exploit the extraordinary fundamental and scaling potentials of nanoscience and nanotechnology. A solution to concentrate optical fields into sub-diffracting volumes is the excitation of surface polaritons –coupled excitations of photons and mobile/bound charges in metals/polar materials (plasmons/phonons)-. However, their initial promises have been hindered by either strong optical losses or lack of electrical control in metals, and difficulties to fabricate high optical quality nanostructures in polar materials.

With the advent of two-dimensional (2D) materials and their extraordinary optical properties, during the last 2-3 years the visualization of both low-loss and electrically tunable (active) plasmons in graphene and high optical quality phonons in monolayer and multilayer h-BN nanostructures have been demonstrated in the mid-infrared spectral range, thus introducing a very encouraging arena for scientifically ground-breaking discoveries in nano-optics. Inspired by these extraordinary prospects, this ERC project aims to make use of our knowledge and unique expertise in 2D nanoplasmonics, and the recent advances in nanophononics, to establish a technological platform that, including coherent sources, waveguides, routers, and efficient detectors, permits an unprecedented active control and manipulation (at room temperature) of light and light-matter interactions on the nanoscale, thus laying experimentally the foundations of a 2D nano-optics field.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715730	**MiTopMat**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. PHILIP MOLL**
Host Institution: Ecole Polytechnique Federale De Lausanne, CH

Microstructured Topological Materials: A novel route towards topological electronics

Topological semi-metals such as Cd3As2 or TaAs are characterized by two bands crossing at isolated points in momentum space and a linear electronic dispersion around these crossing points. This linear dispersion can be mapped onto the Dirac- or Weyl-Hamiltonian, describing relativistic massless fermions, and thus relativistic phenomena from high-energy physics may appear in these materials. For example, the chirality, $\chi=\pm1$, is a conserved quantity for massless fermions, separating the electrons into two distinct chiral species. A new class of topological electronics has been proposed based on chirality imbalance and chiral currents taking the role of charge imbalance and charge currents in electronics. Such devices promise technological advances in speed, energy efficiency, and quantum coherent processes at elevated temperatures.

We will research the basic physical phenomena on which topological electronics is based: 1) The ability to interact electrically with the chiral states in a topological semi-metal is an essential prerequisite for their application. We will investigate whether currents in the Fermi arc surface states can be induced by charge currents and selectively detected by voltage measurements. 2) Weyl materials are more robust against defects and therefore of interest for industrial fabrication. We will experimentally test this topological protection in high-field transport experiments in a wide range of Weyl materials. 3) Recently, topological processes leading to fast, tuneable and efficient voltage inversion were predicted. We will investigate the phenomenon, fabricate and characterize such inverters, and assess their performance. MiTopMat thus aims to build the first prototype of a topological voltage inverter.

These goals are challenging but achievable: MiTopMat's research plan is based on Focused Ion Beam microfabrication, which we have successfully shown to be a promising route to fabricate chiral devices.

Project End Date: **30-NOV-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715939	**NanoPhennec**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. NORBERTO DANIEL LANZILLOTTI KIMURA**
Host Institution: Centre National De La Recherche Scientifique, FR

Nanophononic devices: from phonon networks to phonon CQED

Phonons (quanta of vibration) play a major role in many of the physical properties of condensed matter. One of the most striking features of acoustic phonons is their ability to interact with virtually any other excitation in solids. Recent progress in the design, fabrication and control of nanomechanical systems has paved the way to explore new frontiers in the classical and quantum worlds. Devices based on semiconductor quantum dots (QDs) have been recently demonstrated to perform as near-ideal single photon sources, a very promising platform for developing a solid-state quantum network. The phonon engineering, however, remains an unexplored knob in the quantum information toolbox.

The goal of this project is to explore new horizons in nanophononics by developing novel phononic networks with full control on the phonon dynamics, and unprecedented structures capable of acoustically interact with single QDs, bridging the gap between nanophononics and semiconductor QD quantum optics.

AlGaAs based semiconductor cavities are capable of confining simultaneously photons and phonons. The building blocks of the proposed research are semiconductor pillar microcavities and single QDs deterministically positioned to maximize their interaction with the confined electromagnetic and elastic fields. To achieve our main goal we set three major objectives: 1) To develop novel one- and three-dimensional optophononic resonators and develop appropriate phononic measuring techniques; 2) To engineer nanophononic networks working in the tens-of-GHz range; and 3) To demonstrate first phonon cavity quantum electrodynamics phenomena for a single artificial atom coupled to a phononic cavity. Shaping the phononic environment opens exciting perspectives for solid state quantum applications, by providing a full control over the main source of decoherence and actually using it as a powerful resource to eventually transfer the quantum information.

Project End Date: **31-JAN-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724881	**3D-BioMat**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. VIRGINIE CHAMARD**
Host Institution: Centre National De La Recherche Scientifique, FR

Deciphering biomineralization mechanisms through 3D explorations of mesoscale crystalline structure in calcareous biomaterials

The fundamental 3D-BioMat project aims at providing a biomineralization model to explain the formation of microscopic calcareous single-crystals produced by living organisms. Although these crystals present a wide variety of shapes, associated to various organic materials, the observation of a nanoscale granular structure common to almost all calcareous crystallizing organisms, associated to an extended crystalline coherence, underlies a generic biomineralization and assembly process. A key to building realistic scenarios of biomineralization is to reveal the crystalline architecture, at the mesoscale, (i. e., over a few granules), which none of the existing nano-characterization tools is able to provide.

3D-BioMat is based on the recognized PI's expertise in the field of synchrotron coherent x-ray diffraction microscopy. It will extend the PI's disruptive pioneering microscopy formalism, towards an innovative high-throughput approach able at giving access to the 3D mesoscale image of the crystalline properties (crystal-line coherence, crystal plane tilts and strains) with the required flexibility, nanoscale resolution, and non-invasiveness.

This achievement will be used to timely reveal the generics of the mesoscale crystalline structure through the pioneering explorations of a vast variety of crystalline biominerals produced by the famous Pinctada mar-garitifera oyster shell, and thereby build a realistic biomineralization scenario.

The inferred biomineralization pathways, including both physico-chemical pathways and biological controls, will ultimately be validated by comparing the mesoscale structures produced by biomimetic samples with the biogenic ones. Beyond deciphering one of the most intriguing questions of material nanosciences, 3D-BioMat may contribute to new climate models, pave the way for new routes in material synthesis and supply answers to the pearl-culture calcification problems.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
741121	**MajoranaTopIn**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. YOICHI ANDO**
Host Institution: Universitaet Zu Koeln, DE

Majorana Fermions in Topological Insulator Platforms

Majorana fermions were recently discovered in topological superconductors as exotic quasiparticles having the curious property of being their own antiparticles. They are not only interesting as novel relativistic quasiparticles, but are also useful for realizing fault-tolerant quantum computers. However, currently available platforms to materialize Majorana fermions are limited, and the existing platforms have respective drawbacks for actually building qubits for a scalable quantum computer. Also, various unusual properties are predicted for Majorana fermions, but few have been experimentally addressed. To make a leap in the Majorana-fermion research which is technically highly demanding, one needs to grow state-of-the-art materials and tightly combine them with mesoscopic device research. By performing such an integrated research efforts in the same laboratory, this project aims to explore new platforms for Majorana qubits and to establish new methodologies to address peculiar physics of Majorana fermions. As new platforms, we pursue (i) three-dimensional topological-insulator nanoribbons and (ii) ferromagnetic topological-insulator thin films, both of which will be proximity-coupled to an s-wave superconductor. Each of them allows for conceiving Majorana qubits based on different principles, which will be tested in this project. Also, by developing new methodologies, we will elucidate (i) non-Abelian statistics probed by interferometry and (ii) quantized/universal heat transport phenomena probed by thermal conductance. These works will be complemented by materials growth efforts involving molecular beam epitaxy and detailed characterizations of the local electronic states using scanning tunnelling spectroscopy. If successful, this project will not only contribute to the realization of scalable quantum computers, but also elucidate the non-Abelian statistics, which is a fundamentally new property of particles and is ground breaking in physics.

Project End Date: **30-APR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
741734	**4-TOPS**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. LAURENS MOLENKAMP**
Host Institution: Julius-Maximilians Universitaet Wuerzburg, DE

Four experiments in Topological Superconductivity.

Topological materials have developed rapidly in recent years, with my previous ERC-AG project 3-TOP playing a major role in this development. While so far no bulk topological superconductor has been unambiguously demonstrated, their properties can be studied in a very flexible manner by inducing superconductivity through the proximity effect into the surface or edge states of a topological insulator. In 4-TOPS we will explore the possibilities of this approach in full, and conduct a thorough study of induced superconductivity in both two and three dimensional HgTe based topological insulators. The 4 avenues we will follow are:

-SQUID based devices to investigate full phase dependent spectroscopy of the gapless Andreev bound state by studying their Josephson radiation and current-phase relationships.
-Experiments aimed at providing unambiguous proof of localized Majorana states in TI junctions by studying tunnelling transport into such states.
-Attempts to induce superconductivity in Quantum Hall states with the aim of creating a chiral topological superconductor. These chiral superconductors host Majorana fermions at their edges, which, at least in the case of a single QH edge mode, follow non-Abelian statistics and are therefore promising for explorations in topological quantum computing.
-Studies of induced superconductivity in Weyl semimetals, a completely unexplored state of matter.

Taken together, these four sets of experiments will greatly enhance our understanding of topological superconductivity, which is not only a subject of great academic interest as it constitutes the study of new phases of matter, but also has potential application in the field of quantum information processing.

Project End Date: **31-MAY-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
742222	**PHOTMAT**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. WILLIAM BARNES**
Host Institution: The University Of Exeter, UK

Photonically fused molecular materials

Molecular materials are ubiquitous, encompassing smart phone displays, plastic electronics and the molecular machinery of photosynthesis. Many of these remarkable uses depend on interactions between the molecules. Until now these interactions have been electric in character, and have been dictated by how electric charge is distributed over the molecules. PHOTMAT will transform the world of molecular materials by adding a new ingredient – photons. I will fuse photons and molecules together to create new hybrid states – part molecule and part photon – that are dramatically different from those of the constituent molecules and photons. The idea of coupling molecules with photons is a radical new approach with implications that reach across physics, quantum information, chemistry, materials science, nanotechnology and biology.

I propose a pioneering research programme that will catalyse the transition from embryonic early results to the creation of a new conceptual framework to unveil a new frontier in nanoscience and nanotechnology. We will perform new experiments that will provide clear proof-of-principle demonstrations of the incredible opportunities opened up by coupling molecules with photons. As examples, we will show how the range over which energy (excitons) can be transport may be extended by a factor of 1000, and we will show how the process of photosynthesis can be modified and controlled. This research has enormous potential, from transforming artificial photosynthesis for clean fuel production to inspiring a new generation of molecular metamaterials.

My goal is to explore the rich array of possibilities that arise when photons are made an integral part of molecular materials. At present much of the underlying physics is unclear and controversial. I will resolve the important open questions and show how photonic coupling of molecules leads to new molecular materials, new ways to control chemical and biological processes, and a new type of nanophotonics.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757553	**ODDSUPER**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. ANNICA BLACK-SCHAFFER**
Host Institution: Uppsala Universitet, SE

New mechanisms and materials for odd-frequency superconductivity

Odd-frequency superconductivity is a very unique superconducting state that is odd in time or, equivalently, frequency, which is opposite to the ordinary behavior of superconductivity. It has been realized to be the absolute key to understand the surprising physics of superconductor-ferromagnet (SF) structures and has also enabled the whole emerging field of superconducting spintronics. This project will discover and explore entirely new mechanisms and materials for odd-frequency superconductivity, to both generate a much deeper understanding of superconductivity and open for entirely new functionalities. Importantly, it will generalize and apply my initial discoveries of two new odd-frequency mechanisms, present in bulk multiband superconductors and in hybrid structures between topological insulators and conventional superconductors, respectively. In both cases odd-frequency superconductivity is generated without any need for ferromagnets or interfaces, completely different from the situation in SF structures. The result will be a significant expansion of the concept and importance of odd-frequency superconductivity to a very wide class of materials, ranging from multiband, bilayer, and nanoscale superconductors to topological superconductors. The project will also establish the connection between topology and odd-frequency pairing, which needs to be addressed in order to understand topological superconductors, as well as incorporate new materials and functionality into traditional SF structures. To achieve these goals the project will develop a novel methodological framework for large-scale and fully quantum mechanical studies with atomic level resolution, solving self-consistently for the superconducting state and incorporating quantum transport calculations.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757720	**3DMOSHBOND**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. ADAM SWEETMAN**
Host Institution: University Of Leeds, UK

Three-Dimensional Mapping Of a Single Hydrogen Bond

All properties of matter are ultimately governed by the forces between single atoms, but our knowledge of interatomic, and intermolecular, potentials is often derived indirectly.

In 3DMOSHBOND, I outline a program of work designed to create a paradigm shift in the direct measurement of complex interatomic potentials via a fundamental reimagining of how atomic resolution imaging, and force measurement, techniques are applied.

To provide a clear proof of principle demonstration of the power of this concept, I propose to map the strength, shape and extent of single hydrogen bonding (H-bonding) interactions in 3D with sub-Angstrom precision. H-bonding is a key component governing intermolecular interactions, particularly for biologically important molecules. Despite its critical importance, H-bonding is relatively poorly understood, and the IUPAC definition of the H-bond was changed as recently as 2011- highlighting the relevance of a new means to engage with these fundamental interactions.

Hitherto unprecedented resolution and accuracy will be achieved via a creation of a novel layer of vertically oriented H-bonding molecules, functionalisation of the tip of a scanning probe microscope with a single complementary H-bonding molecule, and by complete characterisation of the position of all atoms in the junction. This will place two H-bonding groups “end on” and map the extent, and magnitude, of the H-bond with sub-Angstrom precision for a variety of systems. This investigation of the H-bond will present us with an unparalleled level of information regarding its properties.

Experimental results will be compared with ab initio density functional theory (DFT) simulations, to investigate the extent to which state-of-the-art simulations are able to reproduce the behaviour of the H-bonding interaction. The project will create a new generalised probe for the study of single atomic and molecular interactions.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758403	**ODYSSEY**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. JOHN GOOLD**
Host Institution: The Provost, Fellows, Foundation Scholars & The Other Members Of Board Of The College Of The Holy & Undivided Trinity Of Queen Elizabeth Near Dublin, IE

Open dynamics of interacting and disordered quantum systems

This research proposal focuses on the open quantum system dynamics of disordered and interacting many- body systems coupled to external baths. The dynamics of systems which contain both disorder and interactions are currently under intense theoretical investigation in condensed matter physics due to the discovery of a new phase of matter known as many-body localization. With the experimental realization of such systems in mind, this proposal addresses an essential issue which is to understand how coupling to external degrees of freedom influences dynamics. These systems are intrinsically complex and lie beyond the unitary closed system paradigm, so the research proposed here contains interdisciplinary methodology beyond the mainstream in condensed matter physics ranging from quantum information to quantum optics. The project has three principal objectives each of which would represent a major contribution to the field:

O1. To describe the dynamics of a interacting, disordered many-body systems when coupled to external baths.
O2. To perform a full characterization of spin and energy transport in their non-equilibrium steady state.
O3. To explore the system capabilities as steady state thermal machine from a systematic microscopic perspective.

This will be the first comprehensive study of the open system phenomenology of disordered interacting many-body
systems. It will also allow for the systematic study of energy and spin transport and the exploration of the potential of these systems as steady state thermal machines. In order to successfully carry out the work proposed here, the applicant will build a world class team at Trinity College Dublin. Due to his track record and interdisciplinary background in many-body physics, quantum information and statistical mechanics combined with his personal drive and ambition the applicant is in a formidable position to successfully undertake this task with the platform provided by this ERC Starting Grant.

Project End Date: **30-JUN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771346	**ISCQuM**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. FABRIZIO CARBONE**
Host Institution: Ecole Polytechnique Federale De Lausanne, CH

Imaging, Spectroscopy and Control of Quantum states in advanced Materials

Atomic confinement in 2D materials, topological protection in strong spin-orbit coupling systems or chiral magnets, all result in spin/charge textured states of matter. For example skyrmions, a whirling distribution of spins, behave as individual particles which controlled creation/annihilation/motion is of great importance in spintronics. To achieve control over skyrmions, or more generally over the constituents of disordered elastic media (vortices in superconductors, domain walls in magnets to name a few), the fundamental interplay between short-range and long-range interactions, influenced by topological protection, disorder and confinement, has to be understood and manipulated. This project aims at controlling with electromagnetic pulses a handful of charges and spins in nanostructured materials to be filmed with nm/fs resolution by time-resolved Transmission Electron Microscopy. I propose to image and shape confined electromagnetic fields (plasmons) in nanostructured novel materials. With this ability, we will implement/demonstrate the ultrafast writing and erasing of individual skyrmions in topological magnets. These experiments will enable the fundamental investigation of defects in topological networks and possibly seed new ideas for application in ultradense and ultrafast data storage devices. Similarly, pinning of vortices in type II superconductors will be controlled by light and imaged, gaining new insights into out of equilibrium superconductivity. In my laboratory, shaping and filming plasmonic fields down to the nm-fs scales have been demonstrated, as well as laser-writing and imaging skyrmions in nanostructures. ISCQuM will allow implementing crucial advances: i) extending our photoexcitation to the far-infrared for creating few-cycles electromagnetic pulses and exciting structural or electronic collective modes; ii) upgrading our detection to higher sensitivity and spatial resolution, extending our ability to image spin and charge distributions.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772108	**DarkSERS**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. STEPHANIE REICH**
Host Institution: Freie Universitaet Berlin, DE

Harvesting dark plasmons for surface-enhanced Raman scattering

Metal nanostructures show pronounced electromagnetic resonances that arise from localized surface plasmons. These collective oscillations of free electrons in the metal give rise to confined electromagnetic near fields. Surface-enhanced spectroscopy exploits the near-field intensity to enhance the optical response of nanomaterials by many orders of magnitude.

Plasmons are classified as bright and dark depending on their interaction with far-field radiation. Bright modes are dipole-allowed excitations that absorb and scatter light. Dark modes are resonances of the electromagnetic near field only that do not couple to propagating modes. The suppressed photon emission of dark plasmons makes their resonances spectrally narrow and intense, which is highly desirable for enhanced spectroscopy as well as storing and transporting electromagnetic energy in nanostructures. The suppressed absorption, however, prevents us from routinely exploiting dark modes in nanoplasmonic systems.

I propose using spatially patterned light beams to excite dark plasmons with far-field radiation. By this I mean a beam profile with varying polarization and intensity that will be matched to the dark electromagnetic eigenmode. My approach activates the excitation of dark modes, while their radiative decay remains suppressed. I will show how to harvest dark modes for surface-enhanced Raman scattering providing superior intensity and an enhancement that is tailored to a specific vibration. Another feature of dark modes is their strong coupling to the vibrations of nanostructures. I will use this to amplify vibrational modes and, ultimately, induce phonon lasing.

The proposed research aims at an enabling technology that unlocks a novel range of nanoplasmonic properties. It will put dark plasmons on par with the well-recognized bright modes to be used in fundamental science and for applications in analytics, optoelectronic, and nanoimaging.

Project End Date: **31-MAR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772257	**MechaDynA**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. FELIX RICO**
Host Institution: Universite D'Aix Marseille, FR

Multi-scale mechanics of dynamic leukocyte adhesion

Leukocytes, white blood cells, patrol the vascular wall of our vessels in search of sites of inflammation. In the so-called leukocyte adhesion cascade, leukocytes flowing at high velocities (up to mm/s) impact the vessel wall, roll at µm/s, and finally migrate at nm/s to the site of inflammation. They are thus subjected to mechanical forces from sub-msec to several minutes. Complete understanding of the physical processes behind leukocyte adhesion requires an approach over multiple length and time scales, from single protein molecules to the whole cell. This is far from being established due, in part, to the lack of techniques covering the wide range of length and time scales involved. We have recently implemented high-speed atomic force microscopy (HS-AFM) to perform force spectroscopy measurements on biological samples with microsec time resolution. The novel acoustic force spectroscopy (AFS) traps hundreds of particles in parallel allowing hours-long measurements on single molecules.

MechaDynA proposes to develop and apply these two novel nanotools to allow force measurements on living cells with the goal of obtaining a complete, multi-scale picture of the physics behind the leukocyte adhesion cascade over the widest dynamic range (µs-min). This will require development of HS-AFM technology and coupling with advanced optical microscopy. We will probe the binding strength of single adhesion complexes, and membrane and cytoskeleton mechanics at physiologically relevant time scales not explored so far. Technologically, it will establish HS-AFM and AFS as force measurement tools for living cells covering the widest temporal range. This will open the door to unexplored physical phenomena in cell biology, biological physics and soft condensed matter. Biomedically, the expected outcomes will provide a mechanistic description of the physical phenomena in leukocyte immune response that may lead to better diagnosis and therapeutics.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788185	**E-DESIGN**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. PETER LILJEROTH**
Host Institution: Aalto-Korkeakoulusaatio, FI

Artificial designer materials

Constructing designer materials where the atomic geometry, interactions, magnetism and other relevant parameters can be precisely controlled is becoming reality. I will reach this aim by positioning every atom with the tip of a scanning probe microscope, or by using molecular self-assembly to reach the desired structures. I will realize and engineer several novel quantum materials hosting exotic electronic phases: 2D topological insulators in metal-organic frameworks (MOF) and 2D topological superconductors in hybrid molecule-superconductor structures. These classes of materials have not yet been experimentally realized but could enable novel spintronic and quantum computing devices. In addition, we will realize a tuneable platform for quantum simulation in solid-state artificial lattices, which could open a whole new area in this field.

I will employ a broad experimental approach to reach the above targets by utilizing molecular self-assembly and scanning probe microscopy -based atom/molecule manipulation. The systems are characterized using low-temperature atomic force microscopy (AFM) and scanning tunneling microscopy (STM). My group is one of the leading groups in these topics globally. We have initial results on the topics discussed in this proposal and are thus in a unique position to make ground-breaking contributions in realizing designer quantum materials.

The artificial designer materials we study are characterized by the engineered electronic response with atomically precise geometries, lattice symmetries and controlled interactions. Such ingredients can result in ultimately controllable materials that have large, robust and quick responses to small stimuli with applications in nanoelectronics, flexible electronics, high-selectivity and high-sensitivity sensors, and optoelectronic components. Longer term, the biggest impact is expected through a profound change in the way we view materials and what can be achieved through designer materials approach.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
801770	**ANGULON**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. MIKHAIL LEMESHKO**
Host Institution: Institute Of Science And Technology Austria, AT

Angulon: physics and applications of a new quasiparticle

This project aims to develop a universal approach to angular momentum in quantum many-body systems based on the angulon quasiparticle recently discovered by the PI. We will establish a general theory of angulons in and out of equilibrium, and apply it to a variety of experimentally studied problems, ranging from chemical dynamics in solvents to solid-state systems (e.g. angular momentum transfer in the Einstein-de Haas effect and ultrafast magnetism).

The concept of angular momentum is ubiquitous across physics, whether one deals with nuclear collisions, chemical reactions, or formation of galaxies. In the microscopic world, quantum rotations are described by non-commuting operators. This makes the angular momentum theory extremely involved, even for systems consisting of only a few interacting particles, such as gas-phase atoms or molecules.

Furthermore, in most experiments the behavior of quantum particles is inevitably altered by a many-body environment of some kind. For example, molecular rotation – and therefore reactivity – depends on the presence of a solvent, electronic angular momentum in solids is coupled to lattice phonons, highly excited atomic levels can be perturbed by a surrounding ultracold gas. If approached in a brute-force fashion, understanding angular momentum in such systems is an impossible task, since a macroscopic number of particles is involved.

Recently, the PI and his team have shown that this challenge can be met by introducing a new quasiparticle – the angulon. In 2017, the PI has demonstrated the existence of angulons by comparing his theory with 20 years of measurements on molecules rotating in superfluids. Most importantly, the angulon concept allows one to gain analytical insights inaccessible to the state-of-the-art techniques of condensed matter and chemical physics. The angulon approach holds the promise of opening up a new interdisciplinary research area with applications reaching far beyond what is proposed here.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
801847	**WIREDETECT**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. JESPER WALLENTIN**
Host Institution: Lunds Universitet, SE

High resolution X-ray detectors based on nanowire arrays

In this project I will develop ultra-high resolution X-ray detectors based on semiconductor nanowires, whose spatial resolution will be radically better than the current state of the art. In X-ray detectors the primary X-ray absorption induces a cascade of secondary electrons and photons which are measured at the front or back of the detector, but during the long transport to the point of detection these can spread orthogonally to the optical axis. This limits the resolution in present bulk detectors.
My novel concept is to create a nanostructured detector based on an array of semiconductor nanowires, which will confine and physically prevent spreading of the secondary electrons and photons. In a nanowire array, the pixel size is the diameter of the nanowire, which can be as low as 10 nm, while the nanowires can be as long as the X-ray absorption length. The very high aspect ratio of nanowires allows detectors with simultaneously very high spatial resolution and sensitivity. I will investigate both direct detectors and scintillators, in which the secondary electrons and photons are detected, respectively.
The objective is to create detectors based on arrays of 10 nm-diameter nanowires. Time- and temperature resolved measurements will be used to improve understanding of the X-ray physics in these nanodevices, with strong quantum confinement of electrons and phonons and high surface to volume ratio. I will test the detectors within an imaging project targeting the neural connectome, and compare the nanowire detectors with commercial ones. This novel detector concept could revolutionize high-resolution imaging of samples on the nanoscale, maintaining the unique ability of X-rays to study samples in realistic conditions: DNA within live cells, the strained channel in single operational transistors or individual nanoparticles in a charging battery. High resolution detectors could also be employed in X-ray spectroscopy and diffraction.

Project End Date: **31-JUL-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802130	**NanoBeam**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. NAHID TALEBI SARVARI**
Host Institution: Christian-Albrechts-Universitaet Zu Kiel, DE

Quantum Coherent Control: Self–Interference of Electron Beams with Nanostructures

NanoBeam will develop new directions in electron microscopy, materials, and optical sciences to control and characterize the ultrafast responses of polaritons and electronic states in materials. This will be achieved by (i) a ubiquitous control of slow and fast electron wave packets and (ii) realization of fully coherent light sources using shaped electron wave packets interacting with nanostructures. Quantum coherent control traditionally employs a sequence of optical pulses to direct the response of condensed matter systems towards a desired state, as a tool for novel quantum technologies. This control system has been only recently implemented in electron microscopes, by combining lasers and photoemission electron guns. However, this field is still it its infancy because it does not provide us with important aspects of the sample response such as spectral phase and time-energy evolution of electronic states in samples, which happens at the attosecond time scale.

NanoBeam aims at quantum coherent control within electron microscopes by triggering both electron wave packets and their mechanisms of radiation, using carefully engineered nanostructures. This innovative and unconventional control system is to be achieved by an unprecedented combination of theory and experiment. On the theoretical side, I plan to develop a Maxwell-Schrödinger self-consistent numerical toolbox, to fully understand the interaction of electron wave packets with light and nanostructures beyond the routinely used adiabatic approximations, but also to utilize our expertise in theoretical modelling to propose novel methodologies for coherent control and shaping of the electron beams. On the experimental side, I intend to develop a novel spectral interferometry technique with the ability to retrieve and control the spectral phase in a scanning electron microscope to overcome the challenges in meeting both nanometer spatial and attosecond time resolution.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803937	**InterActive**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. JAAKKO TIMONEN**
Host Institution: Aalto-Korkeakoulusaatio, FI

Interacting with Active Particles

Active particles refer to out-of-equilibrium self-propulsive objects such as biological microswimmers and engineered colloidal particles that can form various fascinating collective states. Active particles are easy to observe experimentally but notoriously difficult to interact with due to their fast and stochastic dynamics at both single-particle and collective state levels. In this project, I aim at scientific breakthrough in both instrumentation that allows direct interaction with active particles and using the methodology to progress substantially our understanding of dynamics and phase transitions of active particles.

The first part focuses on rendering active particles, including E. coli, C. reinhardtii and Quincke rollers, permanently magnetized and designing suitable hardware for controlling them in real time. These particles are rendered “intelligent” by programming their behavior based on real-time image analysis (long-range vision) and steering with external magnetic field. I will program these particles to reveal the limits of using local dissipative hydrodynamic near-fields to guiding active particles, and demonstrate unambiguously the extent to which a single active particle within a collective state can control the collective behaviour.

The second part aims at realizing tuneable magnetic traps and other conservative potential energy landscapes for non-magnetic active particles by using magnetophoresis in superparamagnetic fluids. I will use the technique to establishing confinement-activity phase diagrams for both biological (C. reinhardtii) and synthetic (Quincke rollers) active particles in quadratic confinements. I will further reveal the role of dimensionality (1D vs 2D vs 3D) in the phase transitions of active particles and carry out the seminal investigation of active particles in periodic potentials.

The results and methodologies will have a major impact, both immediately and in long-term, on experimental physics of active particles.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804988	**SiMS**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. ATTILA GERESDI**
Host Institution: Chalmers Tekniska Hoegskola Ab, SE

Simulated Majorana states

Quantum computation using topologically protected Majorana bound states is a promising direction towards scalable quantum architectures due to their inherent noise immunity provided by the nonlocal storage of quantum information. Thus far, Majorana states have mostly been investigated in superconductor-semiconductor heterostructures which rely on induced superconductivity in a quasi-one-dimensional conductor. However, despite tremendous efforts in material development, these devices are still limited by uncontrolled local fluctuations due to disorder and it is unclear if future developments will solve these problems. Furthermore, disorder may even mimic the transport signatures of topological ordering, hindering an unambiguous identification of the Majorana states.

Here I propose a way to overcome these limitations: I will work towards the direct quantum simulation of the one dimensional topological superconductor with Majorana bound states. I will use chains of semiconductor quantum dots, which is an emerging platform to simulate exotic many-body electron states. Building on this platform, I will be able to demonstrate for the first time the emergence of coherent, non-local superconducting states bound to the entire device similarly to the Kitaev chain model of topological superconductivity.

To demonstrate quantum coherence of the chain, we will build the first Andreev molecule quantum bit, which, while not topologically protected, will already combine advantages of superconducting and semiconductor qubits. Going one step further, we will investigate the simulated Kitaev chain. Upon establishing the presence of the simulated Majorana states, we will work towards a simple braiding protocol to demonstrate the non-Abelian nature of the edge modes.

This research direction, combining the scalability of semiconductor structures and the topological protection of Majorana states, will open new avenues towards universal quantum computation.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
811234	**ENFORCE**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. PIETRO TIERNO**
Host Institution: Universitat De Barcelona, ES

ENgineering FrustratiOn in aRtificial Colloidal icEs: degeneracy, exotic lattices and 3D states

Geometric frustration, namely the impossibility of satisfying competing interactions on a lattice, has recently become a topic of considerable interest as it engenders emergent, fundamentally new phenomena and holds the exciting promise of delivering a new class of nanoscale devices based on the motion of magnetic charges. With ENFORCE, I propose to realize two and three dimensional artificial colloidal ices and investigate the fascinating manybody physics of geometric frustration in these mesoscopic structures. I will use these soft matter systems to engineer novel frustrated states through independent control of the single particle positions, lattice topology and collective magnetic coupling. The three project work packages (WPs) will present increasing levels of complexity, challenge and ambition: (i) In WP1, I will demonstrate a way to restore the residual entropy in the square ice, a fundamental longstanding problem in the field. Furthermore, I will miniaturize the square and the honeycomb geometries and investigate the dynamics of thermally excited topological defects and the formation of grain boundaries. (ii) In WP2, I will decimate both lattices and realize mixed coordination geometries, where the similarity between the colloidal and spin ice systems breaks down. I will then develop a novel annealing protocol based on the simultaneous system visualization and magnetic actuation control. (iii) In WP3, I will realize a three dimensional artificial colloidal ice, in which interacting ferromagnetic inclusions will be located in the voids of an inverse opal, and arranged to form the FCC or the pyrochlore lattices. External fields will be used to align, bias and stir these magnetic inclusions while monitoring in situ their orientation and dynamics via laser scanning confocal microscopy. ENFORCE will exploit the accessible time and length scales of the colloidal ice to shed new light on the exciting and interdisciplinary field of geometric frustration.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
815869	**NonlinearTopo**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. BINGHAI YAN**
Host Institution: Weizmann Institute Of Science, IL

Nonlinear Optical and Electrical Phenomena in Topological Semimetals

In the past decade, the band-structure topology and related topological materials have been intensively studied mostly by revealing their unique surface states. The current proposal sets a new paradigm by focusing on nonlinear optical phenomena in topological semimetals (TSMs). I aim to investigate the photocurrent and second-harmonic generation, as well as to discover novel nonlinear effects. The strength of TSMs lies in the fact that the giant Berry curvature in their band-crossing regions (e.g., Weyl points) can strongly boost these nonlinear effects, such as inducing a colossal photocurrent. Current understanding of the photocurrent is based on a model that considers the two-band transition within a Weyl cone. In the field of nonlinear optics, however, it is known that the photocurrent largely comes from three-band virtual transitions. Unfortunately, the nonlinear optics theory cannot be simply applied to TSMs due to the unphysical divergence of the photocurrent at band-crossing points. Therefore, I propose to bring the concept of three-band transitions to TSMs by reformulating the photocurrent theory framework. The new methodology represents the challenging and ground-breaking nature of the current proposal. Beyond the optical excitation, I further propose to explore exotic nonlinear electric and thermoelectric phenomena at the zero-frequency limit. I aim to build up a diagnostic tool that explores the nonlinear phenomena in a vast number of real TSM materials and directly probe the bulk topology by investigating their nonlinear properties. For example, my recent results have exposed a new group of Weyl points in a well-known Weyl semimetal by analysing the photocurrent distribution in its band structure. External perturbations can sensitively modify the TSM band structure, hence tune the induced photocurrent. This controllable photocurrent opens the door for novel device concepts, such as an optoelectronic transistor controlled by an external magnetic field.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818751	**MesoPhone**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. EDWARD LAIRD**
Host Institution: University Of Lancaster, UK

Vibrating carbon nanotubes for probing quantum systems at the mesoscale

Many fascinating quantum behaviours occur on a scale that is intermediate between individual particles and large ensembles. It is on this mesoscopic scale that collective properties, including quantum decoherence, start to emerge.

This project will use vibrating carbon nanotubes – like guitar strings just a micrometre long – as mechanical probes in this intermediate regime. Nanotubes are ideal to explore this region experimentally, because they can be isolated from thermal noise; they are deflected by tiny forces; and they are small enough that quantum jitter significantly affects their behaviour. To take advantage of these properties, I will integrate nanotube resonators into electromechanical circuits that allow sensitive measurements at very low temperature.

First, I will study the motional decoherence of the nanotube itself, by using it as the test particle in a new kind of quantum interferometer. This experiment works by integrating the nanotube into a superconducting qubit, and will represent a test of quantum superposition on a larger mass scale than ever before. It will answer a longstanding question of physics: can a moving object, containing millions of particles, exist in a superposition of states?

Second, I will use the nanotube device as a tool to study superfluid helium 3 – the mysterious state of matter that may emulate the interacting quantum fields of the early universe. By measuring an immersed nanotube viscometer, I will be able to measure the behaviour of superfluid excitations on a scale where bulk superfluidity begins to break down.

Third, I will add to the device a nanomagnet on nanotube springs, creating an ultra-sensitive magnetic force sensor. This offers a way to perform nuclear magnetic resonance on a chip, ultimately creating a microscopy tool that could image for example single viruses.

Project End Date: **29-FEB-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
820196	**QTONE**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. CHRISTOPHE GALLAND**
Host Institution: Ecole Polytechnique Federale De Lausanne, CH

Quantum Plasmomechanics with THz Phonons and Molecular Nano-junctions

QTONE aims at discovering new quantum phenomena involving THz vibrational modes, and at gaining control over them using novel concepts inspired from cavity quantum optomechanics and new techniques developed for nano-plasmonics and molecular break-junctions. The three main goals of the project are:

(i) Perform optomechanical quantum information processing with THz phonons in low-dimensional systems, using a combination of ultrafast spectroscopy and time-correlated photon counting to measure quantum correlations mediated by non-classical vibrational states.

(ii) Demonstrate the feasibility of dynamical backaction amplification of THz phonons by coupling molecules and nanomaterials to plasmonic cavities and by leveraging exciton-phonon coupling to realize exciton-assisted optomechanics.

(iii) Interrogate and drive a single-molecule inside a plasmonic nanocavity using simultaneous inelastic electron tunneling and Raman spectroscopies in a molecular break-junction with engineered plasmonic resonance.

I anticipate that this project will have widespread impacts on our understanding of quantum phenomena in molecular-scale oscillators, and will foster the excellence of Europe in fields ranging from fundamental science to quantum technologies and molecular electronics.

Project End Date: **31-JUL-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
820254	**2D4QT**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. CHRISTOPH STAMPFER**
Host Institution: Rheinisch-Westfaelische Technische Hochschule Aachen, DE

2D Materials for Quantum Technology

Since its discovery, graphene has been indicated as a promising platform for quantum technologies (QT). The number of theoretical proposal dedicated to this vision has grown steadily, exploring a wide range of directions, ranging from spin and valley qubits, to topologically-protected states. The experimental confirmation of these ideas lagged so far significantly behind, mostly because of material quality problems. The quality of graphene-based devices has however improved dramatically in the past five years, thanks to the advent of the so-called van der Waals (vdW) heteostructures - artificial solids formed by mechanically stacking layers of different two dimensional (2D) materials, such as graphene, hexagonal boron nitride and transition metal dichalcogenides. These new advances open now finally the door to put several of those theoretical proposals to test.

The goal of this project is to assess experimentally the potential of graphene-based heterostructures for QT applications. Specifically, I will push the development of an advanced technological platform for vdW heterostructures, which will allow to give quantitative answers to the following open questions: i) what are the relaxation and coherence times of spin and valley qubits in isotopically purified bilayer graphene (BLG); ii) what is the efficiency of a Cooper-pair splitter based on BLG; and iii) what are the characteristic energy scales of topologically protected quantum states engineered in graphene-based heterostructures.

At the end of this project, I aim at being in the position of saying whether graphene is the horse-worth-betting-on predicted by theory, or whether it still hides surprises in terms of fundamental physics. The technological advancements developed in this project for integrating nanostructured layers into vdW heterostructures will reach even beyond this goal, opening the door to new research directions and possible applications.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833078	**ANYONIC**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. MOTY HEIBLUM**
Host Institution: Weizmann Institute Of Science, IL

Statistics of Exotic Fractional Hall States

Since their discovery, Quantum Hall Effects have unfolded intriguing avenues of research, exhibiting a multitude of unexpected exotic states: accurate quantized conductance states; particle-like and hole-conjugate fractional states; counter-propagating charge and neutral edge modes; and fractionally charged quasiparticles - abelian and (predicted) non-abelian. Since the sought-after anyonic statistics of fractional states is yet to be verified, I propose to launch a thorough search for it employing new means. I believe that our studies will serve the expanding field of the emerging family of topological materials.

Our on-going attempts to observe quasiparticles (qp's) interference, in order to uncover their exchange statistics (under ERC), taught us that spontaneous, non-topological, 'neutral edge modes' are the main culprit responsible for qp's dephasing. In an effort to quench the neutral modes, we plan to develop a new class of micro-size interferometers, based on synthetically engineered fractional modes. Flowing away from the fixed physical edge, their local environment can be controlled, making it less hospitable for the neutral modes.

Having at hand our synthetized helical-type fractional modes, it is highly tempting to employ them to form localize para-fermions, which will extend the family of exotic states. This can be done by proximitizing them to a superconductor, or gapping them via inter-mode coupling.

The less familiar thermal conductance measurements, which we recently developed (under ERC), will be applied throughout our work to identify 'topological orders' of exotic states; namely, distinguishing between abelian and non-abelian fractional states.

The proposal is based on an intensive and continuous MBE effort, aimed at developing extremely high purity, GaAs based, structures. Among them, structures that support our new synthetic modes that are amenable to manipulation, and others that host rare exotic states, such as v=5/2, 12/5, 19/8, and 35/16.

Project End Date: **30-APR-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833895	**PrISMoID**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. ULLRICH STEINER**
Host Institution: Universite De Fribourg, CH

Photonic Structural Materials with Controlled Disorder

Structural colour reflected by photonic materials is typically attributed to highly ordered nanostructures with periodicities on the 100-nm length scale. When investigating structural colour in animals and plants, it is however becoming increasingly evident that brilliant photonic colour can also arise from seemingly disordered morphologies. This is surprising as uncontrolled disorder in photonic materials usually severely degrades their colour response. While some recent theories exist, the emergence of structural colour from disordered morphologies is fundamentally not understood. It is clear however that these disordered morphologies must possess "hidden correlations", which enable the formation of a photonic band gap.

This project will uncover the design rules that underlie disordered photonic morphologies, thereby contributing to the fundamental understanding of photonic materials. The project has a strong nature-inspired component, but will go beyond the examination of natural photonic materials. WP1 and WP2 will examine 3D and 2D disordered photonic morphologies in animals and plants, respectively. The structural analysis of these materials will uncover hidden correlations in seemingly random morphologies. WP2 and WP3 will manufacture materials that implement these correlations to recreate the optical signatures of the biological model organisms. This will test the statistical analysis of WP1 and WP2 and shed light on the \textit{in vivo} synthesis of the disordered photonic morphologies. WP4 ties WP1-WP3 together by performing optical experiments and computer simulations. By analysing both the far- and near-field results of the simulations and comparing them with the structural correlations and optical experiments, the four WPs will not only provide a fundamental understanding of the interplay of structural correlations with optical interference in disordered materials, it will also establish design rules allowing their facile manufacture.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
835117	**NoMaMemo**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. ROLAND NETZ**
Host Institution: Freie Universitaet Berlin, DE

Non-Markovian Memory-Based Modelling of Near- and Far-From-Equilibrium Dynamical Systems

Time series characterize diverse systems, examples in this proposal are: i) Proton motion in an inhomogeneous aqueous environment, ii) folding and unfolding of a peptide described by a suitably chosen reaction coordinate, iii) migration of a living cell on a substrate, iv) US Dollar / Yen exchange rate. Examples i) and ii) are close-to-equilibrium, iii) is a far from equilibrium since energy is constantly dissipated, while example iv) at first sight defies the classification into equilibrium or non-equilibrium.

For the understanding, comparison, classification and forecasting of time series data, stochastic differential equations, diverse random walk models, and more recently, machine-learning algorithms are commonly used. But fundamental questions remain unanswered: Is a unified description of such diverse systems possible? What is the relation between different proposed models? Can the non-equilibrium degree of a time series be estimated?

NoMaMemo provides a unified description of generic time series data in terms of non-linear integro-differential stochastic equations based on memory functions that are extracted from data. NoMaMemo accounts for non-linear and non-equilibrium effects as well as for non-Gaussian noise and connects with fundamental concepts such as equilibrium statistical mechanics, response theory and entropy production. The general formulation contains previously proposed models and thus allows their comparison, forecasting quality will be compared with modern machine-learning algorithms. NoMaMemo creates a generic platform to analyse, understand, compare, classify and predict time series data and to optimize stochastic systems with respect to search efficiency, barrier-crossing speed or other figures of merit. NoMaMemo will significantly advance the understanding of chemical reaction and protein folding kinetics, the interpretation of THz and IR spectroscopy of liquids and the analysis of living matter and socio-economic data.

Project End Date: **30-NOV-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
835279	**CATCH-22**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. NIGEL HUSSEY**
Host Institution: University Of Bristol, UK

High temperature superconductivity and the Catch-22 conundrum

CATCH-22 sets out to resolve the mystery of the cuprate high temperature superconductors. Hailed as one of the major discoveries of the 20th Century, its central mysteries – the pairing mechanism, the origin of the 'pseudogap' and the nature of the 'strange metal' phase, have remained elusive for over 30 years. Typically, what scatters electrons also binds them into pairs, and in the cuprates, the strong pairing interaction manifests itself in the strange metal phase as intense scattering, so strong in fact that it drives the electronic states required for pairing incoherent. In other words, what first promotes high temperature superconductivity ultimately destroys it! This logical paradox is the Catch-22 conundrum.

CATCH-22, the program, comprises three parts. Part 1 will explore the fate of electronic states within the strange metal phase by studying how the metallic response diminishes across universal bounds, both as a function of temperature and interaction strength, through momentum-averaged electrical conductivity and thermal diffusivity studies and momentum-resolved photoemission spectroscopy. Part 2 will seek to access the ground state of optimally doped cuprates for the first time, by applying intense current and laser pulses to ultra-thin samples in a high magnetic field. The latter, if successful, will open up a new frontier in which intense THz light and intense magnetic fields combine to access the terra incognita of hidden phases. Finally, Part 3 will explore the origins of the strange metal at the edge of the superconducting dome and search for manifestations of incoherence in other strange metals in an attempt to unify the governing principles. Given that the central mysteries are intertwined – the strange metal is a precursor to the pseudogap which in turn leads to superconductivity - CATCH-22 will aim to bring significant new insight into all three and pave the way, finally, for a coherent phenomenological model for cuprate superconductivity.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851143	**Cell-Lasers**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. MATJAZ HUMAR**
Host Institution: Institut Jozef Stefan, SI

Intracellular lasers: Coupling of optical resonances with biological processes

Recently, micro-sized lasers have been integrated into biological systems including cells and tissues. Currently the most frequently used techniques to study complex processes in live cells employ fluorescent probes. However, fluorescent probes have several disadvantages including photobleaching, sensitivity to environmental factors, potential phototoxicity and broad emission spectrum, which limits their sensitivity, multiplexing ability and imaging capabilities in biological tissues. The transition from detecting laser emission from bio-integrated lasers instead of fluorescence represents a paradigm shift. Due to narrow emission linewidth, high coherence, large intensity and highly nonlinear output from lasers, they open huge opportunities in ultrasensitive sensing, spectral multiplexing and microscopy. The applicant has recently for the first time demonstrated a laser completely embedded inside a live human cell. However, to date it has only been demonstrated that laser light can be generated within the cell, but not how is the laser output coupled to the biophysical and biochemical processes inside cells. The goal of Cell-Lasers is to study these intimate interactions including forces acting within cells, properties of natural cavities in lipid droplets and the intracellular chemical environment. Since the spectral positions of laser lines do not change with propagation through scattering and absorbing media, the cell lasers will enable multiplexed sensing, tracking and localization of cells embedded deep inside tissues. In the long term Cell-Lasers aims to transform the bio-integrated lasers from being a pure scientific curiosity into powerful tool for the study of biophysical and biochemical processes taking place on a single cell level.

Project End Date: **30-APR-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851173	**OptimHist**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. ANNE-FLORENCE BITBOL**
Host Institution: Ecole Polytechnique Federale De Lausanne, CH

Optimization and historical contingency in living systems: a biophysical approach

Populations of living organisms are pushed to optimality by evolution, but may also be shaped by the contingency of their evolutionary history. The recent explosion of sequence data gives us access to the outcomes of molecular evolution, and controlled microbial evolution experiments allow us to analyze the predictability of evolution. In this exciting context, I aim to explore quantitatively the importance of optimization and contingency both at the molecular scale and at the scale of populations of microorganisms, using a theoretical biophysical approach.

First, I will assess how functional optimization and evolutionary history, i.e. phylogeny, shape protein sequences. Importantly, correlations arising from phylogeny are a double-edged sword, often confounding signal from functional optimization, but sometimes providing useful complementary information. I will improve sequence-based predictions for protein-protein interactions by exploiting information both from phylogeny and from the required complementarity of interacting residues. I will disentangle the collective modes of correlations in protein sequences due to optimization from those due to phylogeny, and investigate the importance of functional sectors as an organizing principle of proteins. This will be a breakthrough in our understanding of the sequence-function relationship of proteins.

Second, I will analyze the impact of optimization and contingency on the evolution of microbial populations. I will study microorganisms with a rugged fitness landscape presenting several optima. In these realistic cases, populations tend to remain trapped in local optima. However, most real populations possess specific geographic structures. I will quantitatively study how structure helps populations to explore model and real rugged fitness landscapes. I will build a universal model of structured populations. I will then focus on important applications to antimicrobial resistance evolution and to expanding populations.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852050	**MAGSHAKE**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. ROSTISLAV MIKHAYLOVSKIY**
Host Institution: University Of Lancaster, UK

Shaken and stirred: Terahertz electric field control of magnetism

The rapid move to wireless devices and the advent of cloud-based technologies in the 21st century's digital economy call for denser, faster and more energy efficient data storage. However, the heat produced by modern data centres has already become a serious limitation to further increase their performance. At present, the data industry lacks a solution for this problem, which is expected to contribute greatly to the global warming and energy crisis in the near future.

With MAGSHAKE I aim to pave the way towards a memory device characterized by very low energy consumption and switching times of one trillionth of a second. Very short pulses of electro-magnetic radiation at a terahertz (THz) frequency (i.e. thousand times faster than that in current data communication and processing standards) are among the shortest stimuli in condensed matter physics. These pulses are made from light particles (photons), with their energies naturally matching those of elementary quantum magnets, 'spins'. These are used to store information in common magnetic hard disk drives. Hence, such THz photons can excite spins on their own energy scale without releasing any significant heat into the surrounding medium.

MAGSHAKE will explore the manipulation of spins by a THz electric field, which can modulate the spin-orbit and exchange interactions which are responsible for magnetic ordering. These interactions are orders of magnitude stronger than the Zeeman energy due to an applied magnetic field. Therefore, the THz electric 'shaking' of the spins is expected to be strong enough to induce switching of the spins' orientations, representing an elementary act of writing a bit of information. The proposed research programme aims to investigate the fundamentals of the electric field-driven nonlinear spin dynamics and to explore the basic requirements for the fastest and most energy-efficient spin switching in broad classes of magnetic materials.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852428	**QBusSi**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. JUHA MUHONEN**
Host Institution: Jyvaskylan Yliopisto, FI

Optomechanical quantum bus for spins in silicon

Silicon has been the material underpinning the modern information technology revolution. I would argue that it might be the most important material of the coming quantum technology age as well. This will be of tremendous advantage to the diffusion of quantum technologies as they can then leverage the existing infrastructure of silicon electronics and photonics. My project is aimed at unlocking the quantum potential of silicon technologies. It is aimed at enabling a not too distant future where silicon chips encompassing quantum enabled sensors and/or quantum computing processors are widely available and only require push-of-a-button coolers and laser light to operate.

Qubits are of fundamental interest not only for the tantalizing prospect of building a quantum computer but also because they can work as powerful quantum sensors. In this project, I will advance a novel emerging physical implementation of qubits: donor spin states in silicon. These states are now known to be excellent qubits with the longest single qubit coherence times demonstrated in solid state. This is a significant advantage for both quantum sensing and quantum information applications.

However, at the moment the application potential of silicon donor qubits is hindered by two related obstacles: current readout techniques require nanoelectric connections, millikelvin temperatures and high magnetic fields, and - most importantly - there are no scalable methods to couple multiple qubits.

This project will realize an optomechanical quantum bus for spins in silicon in order to enable optical and mechanical coupling and readout mechanisms for the donor spins and hence overcome all these obstacles. The created quantum bus will not only allow integrating the spin qubits with existing silicon photonics and NEMS platforms for integrated quantum circuits and optically readable practical quantum sensors but will also provide a solid-state on-chip testbed for creating and studying macroscopic quantum states.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852674	**AngstroCAP**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. RADHA BOYA**
Host Institution: The University Of Manchester, UK

Fundamental and Applied Science using Two Dimensional Angstrom-scale capillaries

I will construct and apply next generation capillary devices as an exciting experimental platform to enable ground-breaking investigation of structure and dynamics of water at the ultimate molecular scale. These devices are in a lab-on-a-chip type configuration with angstrom-scale channels and atomically smooth walls. I am making them by scrupulous assembly tools in a controllable and reproducible fashion and they are extremely stable. Myself and my team will assemble capillaries of a few microns in length, by sandwiching two blocks of layered crystals, e.g., mica, graphite, boron nitride, separated by an atomically thin 2D-crystal spacer. Inside these channels, we will image water condensation along with simultaneous structure analysis by spectroscopy, under in-situ (temperature, pressure) environments. Another key aim of the project is to produce 2D slit-like pores on a large scale by slicing the pre-made 2D capillaries using sharp diamond knives, and explore their applications in size selective separation and biomolecular translocation. This ambitious research program is only possible because of my extensive angstrom-scale fabrication expertise, coupled with world leading fabrication capabilities at the University of Manchester.

Objectives

1: To utilize angstrom-scale capillaries constructed out of two-dimensional (2D) materials as a versatile platform for studying confinement effect on structure and dynamics of water.

2: To construct new types of angstrom-scale 2D-pores from these capillaries for studying size-selective molecular separation, biomolecular sequencing and translocation.

The project will have a lasting impact in understanding what the angstrom-scale confinement offers in terms of active control of molecular transport. Such confinement effects are efficiently utilized in various natural systems (e.g., protein channels) and the results could even aid in designing elementary building blocks of stimuli responsive artificial fluidic circuitry

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852925	**STRAIN2EXTREME**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. MOSHE BEN SHALOM**
Host Institution: Tel Aviv University, IL

Straining electromechanical coupling in layered crystals to new extremes

Inherent stability of layered 2D materials supports a remarkably large strain along the plane of these 1-atom-thick crystals. For example, graphene and MoS2 can stretch, in principle, by 20% - ten times more than the typical intrinsic breakdown strain of 3D crystals. Such extreme deformations of the interatomic distance can drive exciting structural phase transitions, support fascinating electronic orders, and pro-foundly impact the electronic or optical response.

Individually, however, pulling these ultimately thin materials to reliably approach their intrinsic limit poses great challenge. Cracks, defects, and out-of-plane motion all motivate early rupture, that prevented ap-plicable demonstration of extreme strains so far.

STRAIN2EXTREME, instead, relies on recent advances in Van-der-Waals (VdW) structures; Sandwiched between thin impermeable layers the mechanical stability is reinforced, while suppressing unwanted chemistry and contamination at these "all-surface" materials. Notably, the minute amount of defects, dangling bonds, and disorder, do not pin-down the strain to relax locally to the rigid substrate as in com-mon interfaces. It results in a nearly frictionless sliding between the weakly interacting layers.

Based on this finding, I set forward an entirely new approach to pull the structures while supporting them on a “super-lubricant” substrate. This support allows us to gradually narrow the shape into sub-micrometre constrictions, and "focus" a moderate pulling force to induce extreme local strains reliably. Moreover, we directly control the gradient of the strain in space by the precise shape. Remarkably, fixed strain gradients, can induce uniform “pseudo-vector-potentials” of extreme strength.

Using the unique mechanics and outstanding lubricity of VdW structure, I intend to realize highly ballistic time-reversal-protected transport, demonstrate a new "pseudo-Hall" effect, and explore crystal-induced electromagnetic fields in moire' super-lattices.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
853387	**Ph.D.**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. SERIM KAYACAN İLDAY**
Host Institution: Bilkent Universitesi Ulusal Nanoteknoloji Arastirma Merkezi - Unam, TR

Phase map of dynamic, adaptive colloidal crystals far from equilibrium

We recently reported the first observation of dynamic adaptive colloidal crystals exhibiting characteristics similar to those commonly associated with living organisms: self-replication, self-healing, adaptation, competition, motility. Here, I propose to do the first experiments to clarify precisely how dynamic adaptive behavior arises far from equilibrium and how to control it. The key to both is a fundamental question at the heart of condensed matter, statistical and nonlinear physics: When far from equilibrium, in the presence of fluctuations and faced with multiple steady states with small energy differences, how does a system evolve? Specifically, my objectives are (1) to form crystals with periodic and aperiodic patterns, e.g. 2D Bravais lattices, quasicrystals, using passive identical particles, (2) to quantify their formation energies through the effective temperature of Brownian particles, (3) to identify the conditions for emergence and control of adaptive behavior. Then, I will draw a complete phase map of these dynamic adaptive colloidal crystals using fitness landscapes to characterize each pattern. I will further ask to what extent this control is extendable down to the few-nm scale, where fluctuations are even stronger and if and how these findings change when using nonidentical, in size or shape, but still passive particles. My system comprises quasi-2D-confined pure-polystyrene 500-nm spheres suspended in water. An energy flux to drive the system far from equilibrium and sustain it there is supplied by an ultrafast laser. My method exploits only three physical tenets, nonlinearity, fluctuations and positive/negative feedback mechanisms acting on identical passive particles, yet generates extremely rich emergent dynamics. A full understanding of how such dynamics arise from so few basic ingredients will advance our understanding of complex systems in addition to numerous practical applications to self-assembly, microfluidics, nanoscience and biology.

Project End Date: **31-OCT-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
863487	**UNIQUE**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. YANKO TODOROV**
Host Institution: Centre National De La Recherche Scientifique, FR

Ultra-strong light-matter coupling in quantum infrared detectors

In the majority of optoelectronic devices emission and absorption of light are considered as perturbative phenomena. The objective of my project is to explore the ultra-strong light-matter coupling regime in a new type of optoelectronic semiconductor-based devices operating in the THz and MIR frequency range (lambda=3-300µm). These devices will allow the first time experimental observation of intrinsically quantum features of the ultra-strong coupling regime, such as quantum vacuum radiation (dynamical Casimir effect) and squeezing of polaritons states. In these devices, generically acting as detectors, the light-matter coupled states (polaritons) will be efficiently converted into electrical signals. The matter excitation is based on the electronic transitions in semiconductor quantum wells, where the light-matter interaction is strongly enhanced owe to collective effects. To achieve the ultra-strong coupling regime, the collective electronic excitation is coupled with metamaterial nano-resonator acting as high frequency inductor-capacitive circuit. In such resonator, very high electric field intensity is achieved into effective volume of sizes comparable with the electron De Broglie wavelength. The photoconductivity of such detectors will be dominated by polariton–assisted fermionic transport. The metamaterial detectors will be supplied with sensitive read-out based on the single-electron transistor concept, which will allow the observation of quantum vacuum radiation as well as the non-classical photo-counting statistics of polaritons. In these device architectures I will also implement the dynamical Coulomb blockade, where the single electron charging energy $e^2/2C$ becomes comparable with the metamaterial resonator energy $\hbar\omega$. This effect will be exploited as a disruptive approach to sense the quantum-optical properties of light-matter coupled states by all-electronic means.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
863691	**ATRONICS**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. DENNIS MEIER**
Host Institution: Norges Teknisk-Naturvitenskapelige Universitet Ntnu, NO

Creating building blocks for atomic-scale electronics

Interfaces in oxide materials offer amazing opportunities for fundamental and applied research, giving a new dimension to functional properties, such as magnetism, multiferroicity and superconductivity. Ferroelectric domain walls recently emerged as a new type of interface, where the dynamic characteristics of ferroelectricity introduce the element of spatial mobility, allowing for the real-time adjustment of position, density and orientation of the walls. This mobility adds an additional degree of flexibility that enables domain walls to take an active role in future devices and hold great potential as functional 2D systems for electronics.
Up to now, application concepts rely on injecting and deleting domain walls in micrometer-size devices to control electric conductivity. While this approach achieves a step beyond conventional interfaces by utilizing the wall mobility, it does not break the mould of classical device architectures. Completely new strategies are required to functionalize the versatile electronic properties and atomic-scale feature size of ferroelectric domain walls.

ATRONICS will establish a new conceptual approach for developing domain-wall-based technology. At the length scale of only a few atoms, we will use individual walls in improper ferroelectrics to emulate key electronic components such as diodes, transistors and logic gates. Crucially, as the functionality of the components is intrinsic to the domain walls, the walls themselves are the devices, instead of the previous approach of writing and erasing domain walls within a much larger classical device architecture. Beyond demonstrating individual devices, we will integrate multiple domain-wall devices, and develop quasi-2D circuitry and networks with a higher order of complexity then is currently achievable. ATRONICS will represent a major advancement in 2D functional materials for future technologies and play an essential role in the transition from nano- to atomic-scale electronics.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865570	**FRACTAL**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. INGMAR SWART**
Host Institution: Universiteit Utrecht, NL

Electrons in Fractal Geometries

The development of two-dimensional materials has enabled the discovery of new physical phenomena and led to the development of devices that are of crucial importance to our society. For example, we now base the definition of electrical resistance on the quantum Hall effect, a phenomenon exclusive to two dimensions. Similarly, the transistor that underpins every electronic device in use today relies on the manipulation of a two-dimensional electron gas.

The realization that a material can have very different properties in two-dimensions compared to three-dimensions was a huge conceptual leap. Here, I propose a similar leap: from integer (0,1,2,3) to non-integer, or fractional, dimensions. Specifically, I will study the properties of electrons in geometric fractals with dimension between 2 and 1. Fractals are objects that are self-similar on different length scales with two unique properties (i) a non-integer dimension and (ii) expansion symmetry but no periodicity. Studying fractals will not only allow me to verify the existence of predicted exotic properties but also to address urgent questions related to the interplay of dimensionality and symmetry on the one hand and the existence of exotic states of matter (e.g. long-range entangled states, topological phases) on the other.

Building on a recently published proof-of-concept, I will assemble geometric fractals atom-by-atom in a scanning tunnelling microscope. A unique advantage of this approach is that it provides control over all relevant parameters: type of fractal, its size and symmetry, the coupling strength, whether or not spin-orbit coupling and electron correlation are included, defects. My extensive experience with creating and characterising such systems makes me uniquely suited to develop the nascent field of electronic fractals. My results will provide engineering rules for truly novel electronic materials that are based on fractal geometries (e.g. fabricated by lithographic patterning of semiconductors)

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865826	**HiggS2**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. MARIE-AUDE MEASSON**
Host Institution: Centre National De La Recherche Scientifique, FR

Higgs mode in Superconductors

Collective modes are witnesses of their underlying quantum order, such as superconductivity. Experimental observations of the collective amplitude mode of the superconducting state, named the Higgs mode due to its analogy with the high energy particle, are still scarce and controversial, despite being a fundamental outcome of the theory of superconductivity. Besides, many crucial questions remain open, like the mechanism of its observability, its mere existence in two-dimensional or unconventional superconductors, to name a few. Similarly to the Higgs boson, its detection remains a challenge for physicists.

I identified a potential mechanism of observability making the Higgs mode detectable by Raman spectroscopy, based on the interplay between an adjacent quantum order and superconductivity. I propose here to unravel and investigate the full capability of this mechanism, and to develop a new framework for the quest of the Higgs mode. A first objective is to unveil the key ingredients of this observability by diversifying the type of adjacent order. A second objective is to explore the Higgs mode observability and nature in unconventional situations; in exotic superconductors and in the proximity of quantum criticality. As third objective, I change the dimensionality of the systems and investigate the Higgs mode stability in two-dimensional superconductors. I propose to monitor the detectability and nature of the Higgs mode in this careful selection of situations using advanced Raman spectroscopic techniques under extreme conditions at very low temperature, under lattice-density tuning or high magnetic field.

This project will establish definitive examples of the observation and mechanism of observability of the Higgs mode in superconductors, while developing its phenomenology to address major problems at the frontier of quantum materials research, with impact beyond mere superconductivity and even condensed matter.

Project End Date: **30-NOV-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866365	**SUPERGRAPH**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. BENJAMIN SACÉPÉ**
Host Institution: Centre National De La Recherche Scientifique, FR

Topological Superconductivity in Graphene

In recent years, a considerable stream of work from the condensed matter community has been focusing on hybrid systems coupling superconductors to various topological states of matter. Such a heterogeneous coupling is pivotal in enabling the emergence of new excitations –the Majorana or parafermion— that could be used as quantum bits (qubits) with unique properties of non-locality and immunity to external perturbations, essential to encode and manipulate quantum information in a robust and stable fashion. Nevertheless, topological insulators that can be efficiently hybridized with superconductors and enable reliable coherent manipulation are still missing.

This project aims at demonstrating a new topological insulator, the quantum Hall topological insulator that emerges in graphene as an unusual quantum spin Hall phase, as the ideal platform for topological superconductivity. Its novelty hinges on an unprecedented substrate engineering that profoundly modifies the quantum Hall ground state of neutral graphene. The ensuing robust quantum Hall phase harbors spin-filtered, helical edge states that can be easily coupled to superconducting electrodes for investigating novel hybrid superconducting quantum circuits. The versatility of graphene enables designing locally gated quantum devices, tunnelling experiments, and coupling to a photon cavity for time-resolved spectroscopy to unveil Majoranas or parafermions in unprecedented fashion.

Ultimately, quantum coherent manipulation of Majorana qubits in hybrid devices will be performed, providing a major breakthrough in the way of fault-tolerant quantum computers. Moreover, the identification of parafermions will constitute a considerable conceptual advance that will open a totally new horizon for topological superconductivity and quantum computing technologies.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
883684	**LoopingDNA**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. CEES DEKKER**
Host Institution: Technische Universiteit Delft, NL

Bottom up biophysics approach to resolve the looping structure of chromosomes

How is DNA spatially organized in our cells? What are the mechanisms that shape chromosomes and how does their 3D architecture direct their function? Recent years have shown that the spatial structure of the genome is of pivotal importance for its biological function. Yet, the basic physics of the formation and regulation of its 3D structure has remained unclear. This proposal aims to understand the fundamental structure of chromosomes using a bottom up biophysics approach, from looping at the single-molecule level to higher levels of complexity. We focus on so-called SMC protein complexes (SMC = Structural Maintenance of Chromosomes). These ring-shaped proteins are a unique new type of molecular motors that can extrude large loops of DNA that are thought to be the basis of chromosome structure. Our group's recent breakthrough discovery of the looping motor function of condensin SMC paved the way to now answer major open questions, such as the motor mechanism of SMCs; how SMCs handle realistic chromosomal fibers loaded with DNA-binding proteins; how looping relates to gene expression; and whether it is evolutionary conserved from bacteria to man. By answering these questions using single-molecule assays, we will resolve the basic mechanics of the SMC-induced looping of DNA. We will extend this to even build a chromosome from the bottom up, in a 'genome-in-a-box' approach where we will take genome-length bare DNA and add SMC protein complexes and other DNA-processing proteins. Such a well-controlled bottom-up approach – which to our knowledge is unique – can be expected to generate a radically new understanding of the physical forces and protein systems that shape chromosomes. We are confident that our powerful single-molecule biophysics tools, in collaboration with working with the world's best biochemists, will enable to disentangle the fundamental looping architecture of chromosomes that is so essential to all of life.

Project End Date: **30-JUN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
884902	**SoftML**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. MARJOLEIN DIJKSTRA**
Host Institution: Universiteit Utrecht, NL

Rational Design of Soft Hierarchical Materials with Responsive Functionalities: Machine learning Soft Matter to create Soft Machines

Nature displays fascinating examples of self-assembled materials that reconfigure and respond to external stimuli, e.g. chameleons change color for camouflage, pine cones release seeds upon a change in humidity. Advances in colloid synthesis have resulted in a diversity of self-assembled nanostructures with interesting functional properties. These nanostructures are however passive!
The aim of this project is to explore the new physics that emerges when static nanostructures are elastically coupled to a soft elastic matrix or hydrogel, e.g. nanoparticles with (cross-linked) ligands, core-shell microgel particles. These hydrogels can be actuated by pH, temperature, light, resulting in a (de)swelling of the gel and a reconfiguration of the nanostructure.
Reconfigurable dynamic materials are interesting for applications, but their rational design remains a major challenge as it requires a detailed comprehension of the highly non-trivial coordination of dynamic behaviors of materials across different time and length scales.
Using extensive simulations, coarse-graining and machine learning, I propose to unravel the microscopic origin of the structural and dynamic behavior of soft reconfigurable materials. I will build coarse-grained models at multiple levels to study the structure and properties of these soft materials. I will then investigate the dynamics and shape transformation kinetics of the nanostructure and hydrogel upon actuation.
The final goal is to reverse-engineer using evolutionary algorithms new classes of soft responsive materials from the atomic scale by designing colloids that self-assemble at the mesoscale into large-scale structures, to the macroscopic scale by tailoring the shape-morphing properties.
This research will produce unprecedented insight, novel simulation methods, and fundamental models for the rational design of soft responsive materials that arise from the hierarchical assembly of structures and their dynamic behaviors across scales.

Project End Date: **31-DEC-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647107	**SEMICOMPLEX**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. MICHELE CEOTTO**
Host Institution: Universita Degli Studi Di Milano, IT

Divide and conquer ab initio semiclassical molecular dynamics for spectroscopic calculations of complex systems

Given the continuing revolution in “nano” and “bio” technologies, it is urgent for chemists to be able to carry out reliable quantum dynamics simulations of complex molecular systems. The goal of this project is to fill the gap between theory and experiment and provide the community with a user-friendly computational tool for nuclear spectra (IR, vibro-electronic, etc.) calculations of very complex systems.

Present theoretical methodologies are hampered either by artificial nuclear potential interactions or by local potential perturbation assumptions. The semiclassical molecular dynamics method that I have been pioneering is not affected by these limitations because it is based on ab initio classical trajectories. The nuclear forces can be calculated by any electronic structure software and trajectories can explore the entire potential surface. The remaining challenge is to overcome the exponential scaling of computational power.

I will adopt a divide-and-conquer strategy to beat the curse of dimensionality. Firstly, the ab initio classical molecular dynamics is performed for the entire complex system. Then, partial spectra are calculated by using the semiclassical information derived by the projection of the trajectories onto lower dimensional spaces. Vibrational modes are not artificially decoupled. Finally, the entire spectrum is reconstructed piece by piece. This method allows chemists to have a more reliable spectral interpretation in a wider context up to the nanoscale. With the help of my own previous experience and my collaborations, I will simulate pollutant photodegradation for environmental remediation and the vibro-electronic spectra of carcinogenic molecules adsorbed on TiO2. I will also reproduce the spectroscopic properties of molecular nano-texturing of titania films for outdoor cultural heritage preservation.

A new generation of semiclassical fellows will be educated to put Europe on the leading edge of quantum simulations for spectroscopy.

Project End Date: **30-APR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679001	**NetMoDEzyme**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. SILVIA OSUNA**
Host Institution: Universitat De Girona, ES

Network models for the computational design of proficient enzymes

Billions of years of evolution have made enzymes superb catalysts capable of accelerating reactions by several orders of magnitude. The underlying physical principles of their extraordinary catalytic power still remains highly debated, which makes the alteration of natural enzyme activities towards synthetically useful targets a tremendous challenge for modern chemical biology. The routine design of enzymes will, however, have large socio-economic benefits, as because of the enzymatic advantages the production costs of many drugs will be reduced and will allow industries to use environmentally friendly alternatives. The goal of this project is to make the routine design of proficient enzymes possible. Current computational and experimental approaches are able to confer natural enzymes new functionalities but are economically unviable and the catalytic efficiencies lag far behind their natural counterparts. The groundbreaking nature of NetMoDEzyme relies on the application of network models to reduce the complexity of the enzyme design paradigm and completely reformulate previous computational design approaches. The new protocol proposed accurately characterizes the enzyme conformational dynamics and customizes the included mutations by exploiting the correlated movement of the enzyme active site residues with distal regions. The guidelines for mutation are withdrawn from the costly directed evolution experimental technique, and the most proficient enzymes are easily identified via chemoinformatic models. The new strategy will be applied to develop proficient enzymes for the synthesis of enantiomerically pure β-blocker drugs for treating cardiovascular problems at a reduced cost. The experimental assays of our computational predictions will finally elucidate the potential of this genuinely new approach for mimicking Nature's rules of evolution.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715900	**REDOX SHIELDS**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. NICOLAS PLUMERE**
Host Institution: Ruhr-Universitaet Bochum, DE

Protection of Redox Catalysts for Cathodic Processes in Redox Matrices.

Biological or molecular catalysts built from Earth-abundant elements are envisioned as economically viable alternatives to the scarce noble metals that are currently used in renewable energy conversion. However, their fragility and O2 sensitivity have been obstacles to their adoption in industry. We have recently proposed O2 quenching matrices for protecting intrinsically O2-sensitive catalysts for use in anodic (oxidative) processes. We have demonstrated that even hydrogenases, the highly sensitive metalloenzymes that oxidize H2, can be used under the harsh conditions encountered in operating fuel cells. However, attempts to reverse the concept for the protection of cathodic (reductive) processes, such as H2 evolution, have been unsuccessful so far. In this case, the electrode generates the reducing agents in the form of electrons, which are needed for both H2 generation and reductive O2 quenching. The competition between the two reactions results in insufficient protection from O2 and deactivation of the catalyst.

The objective is to design an alternative electron pathway that relies on H2 as a charge carrier to efficiently shuttle the reductive force to the matrix boundaries and quench the incoming O2. We will develop novel electron mediators with dual functionalities to enable the reversible H2/H+ interconversion and to achieve the complete reduction of O2 to water. We will focus on organic systems, as well as metal complexes based on Earth-abundant elements with tunable ligand spheres, to adjust their redox potentials for the desired direction of the electron flow and toward fast O2 reduction kinetics. The synthetic efforts will be supported by electrochemical modelling to predict the required properties of the redox matrix for efficient protection. After establishing the protection principle, we will demonstrate its practical use for implementing sensitive bio-catalysts for electrochemical H2 evolution under conditions relevant to energy conversion processes.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716142	**GreenOnWaterCat**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. THOMAS KÜHNE**
Host Institution: Universitaet Paderborn, DE

Unravelling the Nature of Green Organic "On-Water" Catalysis via Novel Quantum Chemical Methods

The target of the research program, GreenOnWaterCat, is to revolutionize the understanding of green "on-water" catalysis and to unravel its microscopic origin. To enable these goals to be reached, several novel theoretical methods will be developed and implemented that will enable for unprecedented large-scale quantum molecular dynamics simulations, where both the electronic and nuclear Schrödinger equations are solved simultaneously. In addition, these methods will also allow the efficient computation of various state-of-the-art vibrational spectroscopies "on-the-fly", at essentially no additional computational cost. Furthermore, new analysis techniques permit to assign the spectra and explain their correlation with the atomic structure in order to gain invaluable insights and eventually grasp the relationships between the dynamics and structure of "on-water" catalysis and vibrational spectroscopies. Since the latter offers a convenient connection to experiment, the unique results are of utmost value in order to explain the experimental findings. In consequence, new synthetic processes based on the "on-water" phenomenon will be proposed and investigated. The expected results will be most helpful so that water will soon become not only a viable, but also very attractive solvent in the design of novel synthetic processes and to make it even more useful for industrial applications.
Beside the development and implementation of novel computational methods, which will be made publicly available, the additional outcomes expected are as follows:

- To conclusively explain the underlying mechanism of the "on-water" rate phenomenon for the first time
- To elucidate the experimental measurements and characterize the corresponding atomic structure
- To propose novel synthetic processes which exploit the "on-water" concept, such as catalysis at the organic/metal oxide interface
- To investigate the possibility of "on-water" catalysis using two water-insoluble solid reactants

Project End Date: **31-DEC-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716265	**TSuNAMI**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. JANA KALBACOVA VEJPRAVOVA**
Host Institution: Univerzita Karlova V Praze, CZ

Trans-Spin NanoArchitectures: from birth to functionalities in magnetic field

Control over electrons in molecules and periodic solids can be reached via manipulation of their internal quantum degrees of freedom. The most prominent and exploited case is the electronic spin accommodated in standalone spin units composed of 1 – 10^5 of spins. A challenging alternative to the spin is the binary quantum degree of freedom, termed pseudospin existing e.g. in two-dimensional semiconductors. The aim of the proposed research is to build prototypes of trans-spin nano-architectures composed of at least two divergent spin entities, the TSuNAMIes. The spin entities of interest correspond to single atomic spin embedded in spin crossover complexes (SCO), molecular spin of molecular magnets (SMM), superspins of single-domain magnetic nanoparticles (SuperS) and pseudospins in two-dimensional transition metal dichalcogenides (PseudoS). Ultimate goal of the project is to identify a profit from trans-spin cooperation between the different spin entities coexisting in a single TSuNAMI. Influence of external static and alternating magnetic fields on the elementary spin state, unit cell magnetic structure, long-range magnetic order, mesoscopic spin order, spin relaxations and pseudospin state mirrored in essential fingerprints of the spin units and their ensembles will be explored using macroscopic and microscopic in situ and ex situ probes, including Raman and Mössbauer spectroscopies in magnetic field. Within the proposed high-risk/high-gain trans-spin strategy, we thus expect: 1. Enhancement of magnetic anisotropy in SMM-SuperS with enormous impact on cancer therapy using magnetic fluid hyperthermia, 2. Control over SCO via coupling to giant classical spin giving rise to miniature ‘on-particle’ sensors, 3. Mutual visualization of electronic states in SCO-PseudoS pushing frontiers of nowadays pseudospintronics, and 4. Control over electronic states with nanometer resolution in SuperS-PseudoS giving rise to novel functionalization strategies of graphene successor.

Project End Date: **31-JAN-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716539	**HybridSolarFuels**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. CSABA JANAKY**
Host Institution: Szegedi Tudomanyegyetem, HU

Efficient Photoelectrochemical Transformation of CO2 to Useful Fuels on Nanostructured Hybrid Electrodes

Given that CO2 is a greenhouse gas, using the energy of sunlight to convert CO2 to transportation fuels (such as methanol) represents a value-added approach to the simultaneous generation of alternative fuels and environmental remediation of carbon emissions. Photoelectrochemistry has been proven to be a useful avenue for solar water splitting. CO2 reduction, however, is multi-electron in nature (e.g., 6 e- to methanol) with considerable kinetic barriers to electron transfer. It therefore requires the use of carefully designed electrode surfaces to accelerate e- transfer rates to levels that make practical sense. In addition, novel flow-cell configurations have to be designed to overcome mass transport limitations of this reaction.

We are going to design and assemble nanostructured hybrid materials to be simultaneously applied as both adsorber and cathode-material to photoelectrochemically convert CO2 to valuable liquid fuels. The three main goals of this project are to (i) gain fundamental understanding of morphological-, size-, and surface functional group effects on the photoelectrochemical (PEC) behavior at the nanoscale (ii) design and synthesize new functional hybrid materials for PEC CO2 reduction, (iii) develop flow-reactors for PEC CO2 reduction. Rationally designed hybrid nanostructures of large surface area p-type semiconductors (e.g., SiC, CuMO2, or CuPbI3) and N-containing conducting polymers (e.g., polyaniline-based custom designed polymers) will be responsible for: (i) higher photocurrents due to facile charge transfer and better light absorption (ii) higher selectivity towards the formation of liquid fuels due to the adsorption of CO2 on the photocathode (iii) better stability of the photocathode. The challenges are great, but the possible rewards are enormous: performing CO2 adsorption and reduction on the same system may lead to PEC cells which can be deployed directly at the source point of CO2, which would go well beyond the state-of-the-art.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716792	**SOFT-PHOTOCONVERSION**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. MICHEAL SCANLON**
Host Institution: University Of Limerick, IE

Solar Energy Conversion without Solid State Architectures: Pushing the Boundaries of Photoconversion Efficiencies at Self-healing Photosensitiser Functionalised Soft Interfaces

Innovations in solar energy conversion are required to meet humanity's growing energy demand, while reducing reliance on fossil fuels. All solar energy conversion devices harvest light and then separate photoproducts, minimising recombination. Normally charge separation takes place at the surface of nanostructured electrodes, often covered with photosensitiser molecules such as in dye-sensitised solar cells; DSSCs. However, the use solid state architectures made from inorganic materials leads to high processing costs, occasionally the use of toxic materials and an inability to generate a large and significant source of energy due to manufacturing limitations. An alternative is to effect charge separation at electrically polarised soft (immiscible water-oil) interfaces capable of driving charge transfer reactions and easily "dye-sensitised". Photoproducts can be separated on either side of the soft interface based on their hydrophobicity or hydrophilicity, minimising recombination. SOFT-PHOTOCONVERSION will explore if photoconversion efficiencies at soft interfaces can be improved to become competitive with current photoelectrochemical systems, such as DSSCs. To achieve this goal innovative soft interface functionalisation strategies will be designed. To implement these strategies an integrated platform technology consisting of (photo)electrochemical, spectroscopic, microscopic and surface tension measurement techniques will be developed. This multi-disciplinary approach will allow precise monitoring of morphological changes in photoactive films that enhance activity in terms of optimal kinetics of photoinduced charge transfer. An unprecedented level of electrochemical control over photosensitiser assembly at soft interfaces will be attained, generating photoactive films with unique photophysical properties. Fundamental insights gained may potentially facilitate the emergence of new class of solar conversion devices non-reliant on solid state architectures.

Project End Date: **31-MAR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724424	**No-LIMIT**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. IVÁN MORA SERÓ**
Host Institution: Universitat Jaume I De Castellon, ES

Boosting Photovoltaic Performance by the Synergistic Interaction of Halide Perovskites and Semiconductor Quantum Dots

Photovoltaic conversion has the extraordinary property of transforming the solar energy directly into electric power. However, the available electrical power is known to be severely limited by the so-called Shockley-Queisser (SQ) photoconversion limit. The maximum efficiency for a single absorber is limited as photons with energy lower than the bandgap (BG) cannot be absorbed, and just an energy equivalent to the BG can be used for photons with higher energy than the BG, due to thermalization. Tandem cells have overcome this SQ limit upon exploiting complex and expensive configurations. Alternative approaches, even with higher potentiality, as Intermediate Bandgap Solar Cells (IBSCs) have not reached the expected performance mainly due to the limitations introduced by the monocrystalline matrix. The incorporation of quantum dots (QD) to create the IB produces layer strain and defects that limit the cell performance. No-LIMIT proposes to revamp IBSCs concept, using polycrystalline halide perovskites (HP) host matrix in order to take benefit from the strain relaxation at polycrystalline materials and from HP benign defect physics. HPs show an outstanding performance even when they are grown in a porous structure, indicating that their excellent transport and recombination properties are preserved with embedded materials. No-LIMIT will exploit this potentiality by using the states of embedded QD as IB in IBSC with HP matrix. The project will focus on the preparation of HPs-QD systems with enhanced light collection efficiency preserving charge transport, recombination and stability. No-LIMIT will study the properties and interactions of the HP and QD materials developed, as well as injection, recombination and transport properties in the coupled system. The combination of these strategies will build a ground-breaking synergistic system able to break the SQ limit. The achievements of IBSC, together with the intermediate steps, will have a colossal impact on photovoltaics

Project End Date: **31-AUG-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725291	**BeStMo**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. ALEXANDRE TKATCHENKO**
Host Institution: Universite Du Luxembourg, LU

Beyond Static Molecules: Modeling Quantum Fluctuations in Complex Molecular Environments

We propose focused theory developments and applications, which aim to substantially advance our ability to model and understand the behavior of molecules in complex environments. From a large repertoire of possible environments, we have chosen to concentrate on experimentally-relevant situations, including molecular fluctuations in electric and optical fields, disordered molecular crystals, solvated (bio)molecules, and molecular interactions at/through low-dimensional nanostructures. A challenging aspect of modeling such realistic environments is that both molecular electronic and nuclear fluctuations have to be treated efficiently at a robust quantum-mechanical level of theory for systems with 1000s of atoms. In contrast, the current state of the art in the modeling of complex molecular systems typically consists of Newtonian molecular dynamics employing classical force fields. We will develop radically new approaches for electronic and nuclear fluctuations that unify concepts and merge techniques from quantum-mechanical many-body Hamiltonians, statistical mechanics, density-functional theory, and machine learning. Our developments will be benchmarked using experimental measurements with terahertz (THz) spectroscopy, atomic-force and scanning tunneling microscopy (AFM/STM), time-of-flight (TOF) measurements, and molecular interferometry.

Our final goal is to bridge the accuracy of quantum mechanics with the efficiency of force fields, enabling large-scale predictive quantum molecular dynamics simulations for complex systems containing 1000s of atoms, and leading to novel conceptual insights into quantum-mechanical fluctuations in large molecular systems. The project goes well beyond the presently possible applications and once successful will pave the road towards having a suite of first-principles-based modeling tools for a wide range of realistic materials, such as biomolecules, nanostructures, disordered solids, and organic/inorganic interfaces.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
741251	**ELECTRA**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. ALEXANDER KUHN**
Host Institution: Institut Polytechnique De Bordeaux, FR

Electrochemically induced Asymmetry: from materials to molecules and back

Asymmetry is a very common feature of many systems, objects and molecules, that we use in our daily life. Actually, it is in a majority of cases the absolutely crucial ingredient for conferring a useful property to a system, a prominent example being the chiral nature of pharmaceutically active compounds. Chemists have developed various approaches to generate asymmetry, from the molecular to the macroscopic scale, but are still facing major challenges when exploring efficient alternative physico-chemical concepts for symmetry breaking. The global aim of ELECTRA is to propose so far unexplored and versatile strategies, based on the unconventional use of electrochemical phenomena, to generate asymmetry in chemical systems at different length scales.
Investigating simultaneously wired and wireless electrochemistry will open up unique possibilities for advancing the topic of asymmetry generation in an original and cross-disciplinary way. We will determine the utility of these strategies in the frame of two major challenges that are:
-unconventional detection, separation and synthesis of enantiomers, based on chiral encoded metal phases, very recently pioneered by us;
-design and characterization of Janus systems with complex structures and reactivity
Carefully designed experiments at the forefront of electrochemical science will first enable us to gain a better understanding of the different mechanisms involved in symmetry breaking. An optimization by exploring new concepts with respect to their efficiency, yield and selectivity is the next step. This will prepare for the choice of the most innovative approaches of symmetry breaking, in view of the numerous highly relevant applications, ranging from the analysis to catalysis and energy conversion. Furthermore, due to the interdisciplinary character of asymmetry, the findings of this project will not only have a major impact in various areas of chemistry, but will also be very interesting for physics and biology.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
741860	**CLUNATRA**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. IB CHORKENDORFF**
Host Institution: Danmarks Tekniske Universitet, DK

Discovering new Catalysts in the Cluster-Nanoparticle Transition Regime

The purpose of this proposal is to establish new fundamental insight of the reactivity and thereby the catalytic activity of oxides, nitrides, phosphides and sulfides (O-, N-, P-, S- ides) in the Cluster-Nanoparticle transition regime. We will use this insight to develop new catalysts through an interactive loop involving DFT simulations, synthesis, characterization and activity testing. The overarching objective is to make new catalysts that are efficient for production of solar fuels and chemicals to facilitate the implementation of sustainable energy, e.g. electrochemical hydrogen production and reduction of CO2 and N2 through both electrochemical and thermally activated processes.

Recent research has identified why there is a lack of significant progress in developing new more active catalysts. Chemical scaling-relations exist among the intermediates, making it difficult to find a reaction pathway, which provides a flat potential energy landscape - a necessity for making the reaction proceed without large losses. My hypothesis is that going away from the conventional size regime, > 2 nm, one may break such chemical scaling-relations. Non-scalable behavior means that adding an atom results in a completely different reactivity. This drastic change could be even further enhanced if the added atom is a different element than the recipient particle, providing new freedom to control the reaction pathway. The methodology will be based on setting up a specifically optimized instrument for synthesizing such mass-selected clusters/nanoparticles. Thus far, researchers have barely explored this size regime. Only a limited amount of studies has been devoted to inorganic entities of oxides and sulfides; nitrides and phosphides are completely unexplored. We will employ atomic level simulations, synthesis, characterization, and subsequently test for specific reactions. This interdisciplinary loop will result in new breakthroughs in the area of catalyst material discovery.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
742422	**HBEAM**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. ALEC WODTKE**
Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Probing chemical dynamics at surfaces with ultrafast atom pulses

Ultra-short light pulses have become invaluable in time-resolved studies in chemistry and physics. But many important processes are initiated by collisions. While lasers have revolutionized experiments using light pulses, experimentally proven concepts for producing ultra-short pulses of neutral matter are still in their infancy. Hence, our ability to control when a collision occurs is still extremely limited. Recently, we have reported bunch-compression photolysis, the first demonstrated method for producing ultra-short pulses of neutral matter. Here, photolysis of jet-cooled hydrogen iodide is carried out with femto-second laser pulses whose frequency bandwidth has been spatially ordered. Thus, fast H-atom photoproducts overtake slow ones, producing an ultra-short pulse.The central objective of this project is to develop bunch-compression photolysis as a tool for ultrafast timing experiments involving collisions of ultrashort pulses of H-atoms at synchronously photo-excited solid surfaces. Bunch-compression photolysis allows collisions at a surface to be synchronized with photoexcitation on the ps time scale, opening up new ways to study the dynamics of collisions at selectively photo-excited surfaces that have not yet relaxed. Studies on collision dynamics involving excitons produced in 2D semiconductors is one exciting direction for this work. Experiments on synchronized H atom collisions with vibrationally excited surfaces prepared by infrared photoexcitation is another - this enables kinetics experiments with surface site-specificity as well as the direct observation of reaction intermediates. The work and ideas presented here show how to overcome the most challenging barrier to a new class of time-resolved dynamics experiments, opening new frontiers in the study of surface chemistry, where we will begin to understand how selected degrees of freedom of the solid influence collision dynamics and reaction rates.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
743016	**CartiLube**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. JACOB KLEIN**
Host Institution: Weizmann Institute Of Science, IL

Lubricating Cartilage: exploring the relation between lubrication and gene-regulation to alleviate osteoarthritis

Can we exploit insights from the remarkably lubricated surfaces of articular cartilage, to create lubricants that may alleviate osteoarthritis (OA), the most widespread joint disease, affecting millions? These, succinctly, are the challenges of the present proposal. They are driven by our recent finding that lubrication of destabilised joints leads to changes in gene-regulation of the cartilage-embedded chondrocytes to protect against development of the disease. OA alleviation is known to arise through orthopedically suppressing shear-stresses on the cartilage, and a central premise of this project is that, by reducing friction at the articulating cartilage through suitable lubrication, we may achieve the same beneficial effect on the disease. The objectives of this project are to better understand the origins of cartilage boundary lubrication through examination of friction-reduction by its main molecular components, and exploit that understanding to create lubricants that, on intra-articular injection, will lubricate cartilage sufficiently well to achieve alleviation of OA via gene regulation. The project will examine, via both nanotribometric and macroscopic measurements, how the main molecular species implicated in cartilage lubrication, lipids, hyaluronan and lubricin, and their combinations, act together to form optimally lubricating boundary layers on model surfaces as well as on excised cartilage. Based on this, we shall develop suitable materials to lubricate cartilage in joints, using mouse models. Lubricants will further be optimized with respect to their retention in the joint and cartilage targeting, both in model studies and in vivo. The effect of the lubricants in regulating gene expression, in reducing pain and cartilage degradation, and in promoting stem-cell adhesion to the cartilage will be studied in a mouse model in which OA has been induced. Our results will have implications for treatment of a common, debilitating disease.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757850	**BioNet**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. EDINA ROSTA**
Host Institution: King'S College London, UK

Dynamical Redesign of Biomolecular Networks

Enzymes created by Nature are still more selective and can be orders of magnitude more efficient than man-made catalysts, in spite of recent advances in the design of de novo catalysts and in enzyme redesign. The optimal engineering of either small molecular or of complex biological catalysts requires both (i) accurate quantitative computational methods capable of a priori assessing catalytic efficiency, and (ii) molecular design principles and corresponding algorithms to achieve, understand and control biomolecular catalytic function and mechanisms. Presently, the computational design of biocatalysts is challenging due to the need for accurate yet computationally-intensive quantum mechanical calculations of bond formation and cleavage, as well as to the requirement for proper statistical sampling over very many degrees of freedom. Pioneering enhanced sampling and analysis methods have been developed to address crucial challenges bridging the gap between the available simulation length and the biologically relevant timescales. However, biased simulations do not generally permit the direct calculation of kinetic information. Recently, I and others pioneered simulation tools that can enable not only accurate calculations of free energies, but also of the intrinsic molecular kinetics and the underlying reaction mechanisms as well. I propose to develop more robust, automatic, and system-tailored sampling algorithms that are optimal in each case. I will use our kinetics-based methods to develop a novel theoretical framework to address catalytic efficiency and to establish molecular design principles to key design problems for new bio-inspired nanocatalysts, and to identify and characterize small molecule modulators of enzyme activity. This is a highly interdisciplinary project that will enable fundamental advances in molecular simulations and will unveil the physical principles that will lead to design and control of catalysis with Nature-like efficiency.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759721	**APES**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. JIRI KLIMES**
Host Institution: Univerzita Karlova V Praze, CZ

Accuracy and precision for molecular solids

The description of high pressure phases or polymorphism of molecular solids represents a significant scientific challenge both for experiment and theory. Theoretical methods that are currently used struggle to describe the tiny energy differences between different phases. It is the aim of this project to develop a scheme that would allow accurate and reliable predictions of the binding energies of molecular solids and of the energy differences between different phases.

To reach the required accuracy, we will combine the coupled cluster approach, widely used for reference quality calculations for molecules, with the random phase approximation (RPA) within periodic boundary conditions. As I have recently shown, RPA-based approaches are already some of the most accurate and practically usable methods for the description of extended systems. However, reliability is not only a question of accuracy. Reliable data need to be precise, that is, converged with the numerical parameters so that they are reproducible by other researchers.

Reproducibility is already a growing concern in the field. It is likely to become a considerable issue for highly accurate methods as the calculated energies have a stronger dependence on the simulation parameters such as the basis set size. Two main approaches will be explored to assure precision. First, we will develop the so-called asymptotic correction scheme to speed-up the convergence of the correlation energies with the basis set size. Second, we will directly compare the lattice energies from periodic and finite cluster based calculations. Both should yield identical answers, but if and how the agreement can be reached for general system is currently far from being understood for methods such as coupled cluster. Reliable data will allow us to answer some of the open questions regarding the stability of polymorphs and high pressure phases, such as the possibility of existence of high pressure ionic phases of water and ammonia.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
766555	**ELECNANO**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. DAVID ECIJA FERNANDEZ**
Host Institution: Fundacion Imdea Nanociencia, ES

Electrically Tunable Functional Lanthanide Nanoarchitectures on Surfaces

Lanthanide metals are ubiquitous nowadays, finding use in luminescent materials, optical amplifiers and waveguides, lasers, photovoltaics, rechargeable batteries, catalysts, alloys, magnets, bio-probes, and therapeutic agents. In addition, they bear potential for high temperature superconductivity, magnetic refrigeration, molecular magnetic storage, spintronics and quantum information.

Surprisingly, the study of lanthanide physico-chemical properties on surfaces is at its infancy, particularly at the nanoscale. To address this extraordinary scientific opportunity, I will research the foundations and prospects of lanthanide elements to design functional nanoarchitectures on surfaces and I will study their inherent physico-chemical phenomena in distinct coordination environments, targeting novel approaches for sensing, nanomagnetism and electroluminescence. Importantly, our studies will encompass both metal substrates and decoupling surfaces including ultra-thin film insulators and graphene. Nurturing from these studies and in parallel, we will focus on graphene voltage back-gated supports, thus surpassing the seminal knowledge on electrically-inert substrates and enhancing the scope of our research to address the overarching objective of the proposal, i.e., the design of electrically tunable functional lanthanide nanomaterials.

The culmination of ELECNANO project will provide strategies for:
1.-Design of functional nanomaterials on high-technological supports.
2.-Development of advanced coordination chemistry on surfaces.
3.-Rationale of the physico-chemical properties of lanthanide-coordination environments.
4.-Engineering of lanthanide nanoarchitectures for ultimate sensing, nanomagnetism and electroluminescence.
5.-In-situ atomistic views of electrically tunable materials and unprecedented fundamental studies of charge-molecule/metal physics on devices.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771294	**AMPERE**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. MATHIEU SALANNE**
Host Institution: Sorbonne Universite, FR

Accounting for Metallicity, Polarization of the Electrolyte, and Redox reactions in computational Electrochemistry

Applied electrochemistry plays a key role in many technologies, such as batteries, fuel cells, supercapacitors or solar cells. It is therefore at the core of many research programs all over the world. Yet, fundamental electrochemical investigations remain scarce. In particular, electrochemistry is among the fields for which the gap between theory and experiment is the largest. From the computational point of view, there is no molecular dynamics (MD) software devoted to the simulation of electrochemical systems while other fields such as biochemistry (GROMACS) or material science (LAMMPS) have dedicated tools. This is due to the difficulty of accounting for complex effects arising from (i) the degree of metallicity of the electrode (i.e. from semimetals to perfect conductors), (ii) the mutual polarization occurring at the electrode/electrolyte interface and (iii) the redox reactivity through explicit electron transfers. Current understanding therefore relies on standard theories that derive from an inaccurate molecular-scale picture. My objective is to fill this gap by introducing a whole set of new methods for simulating electrochemical systems. They will be provided to the computational electrochemistry community as a cutting-edge MD software adapted to supercomputers. First applications will aim at the discovery of new electrolytes for energy storage. Here I will focus on (1) ‘‘water-in-salts’’ to understand why these revolutionary liquids enable much higher voltage than conventional solutions (2) redox reactions inside a nanoporous electrode to support the development of future capacitive energy storage devices. These selected applications are timely and rely on collaborations with leading experimental partners. The results are expected to shed an unprecedented light on the importance of polarization effects on the structure and the reactivity of electrode/electrolyte interfaces, establishing MD as a prominent tool for solving complex electrochemistry problems.

Project End Date: **31-MAR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772259	**topDFT**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. ANDREW TEALE**
Host Institution: The University Of Nottingham, UK

A topological approach to electron correlation in density-functional theories

Density-functional theory (DFT) is the most widely used method to study the electronic structure of complex molecules, solids, and materials. Its use across chemistry, solid-state physics and materials science is a testament to its black-box nature and low cost. However, many important areas remain inaccessible to DFT simulations, including applications to strongly correlated materials and systems in electromagnetic fields. The topDFT project will deliver new conceptual approaches to design the next generation of density-functional methods. This will be achieved by pursuing three parallel strategies: i) Developing new strategies for the design of functionals ii) Implementing topological DFT, a new computational framework iii) Developing extended density-functional theories.

A new approach to the exchange–correlation problem, based on a perspective from the kinetic energy of the electrons, will be developed – leading to new practical density-functional approximations (DFAs). A new framework for computation will be developed by combining techniques from topological electronic structure methods with DFT, allowing for the identification of correlation 'hotspots'. This idea is chemically intuitive; electrons close together interact in a fundamentally different way to those far apart. Recognising these hotspots, and adapting dynamically to them, will lead to new DFAs with substantially greater accuracy.

Extended-DFTs will open the way to study strongly correlated systems (e.g. high-Tc superconductors, transition metal oxides, Mott insulators) of importance in chemistry and materials science and magnetic systems (e.g. molecular magnets, spin glasses, spin frustrated systems) of importance in nano-science, advanced materials and spintronics applications. The topDFT project will have wide impact on areas including chemical synthesis, materials design and nano-science that underpin key areas such as manufacturing and medicine of benefit to all sections of society.

Project End Date: **30-APR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772579	**EIIonT**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. FABIO LA MANTIA**
Host Institution: Universitaet Bremen, DE

Electron- and Ion Transfer at the Interface: a Hyphenated Dynamic Multi-Frequency Approach

It is undisputed that electrochemistry has a central role in our contemporary society. This is demonstrated by its profound involvement in many aspects of everyday life: from powering portable electronic devices to personal electro-mobility, passing through recycling, waste water treatment, clean energy production, water desalination, personal care, and others. It appears that we have reached the limits of the technological development and no further revolutionary progresses can be achieved without a deeper understanding of the electron- and ion-transfer process at the interface. The objective of this proposal is to achieve a phenomenological modeling of the electron- and ion-transfer processes, by extending the Marcus-Hush theory of the electron transfer to a general kinetic equation based on experimental data. The extended kinetic equation should include and clarify the role of the excess free Gibbs energy on the kinetics of electron- and ion-transfer, as well as the role of the double layer charge (Frumkin effect). A unified theory of charge transfer and transport will be proposed in the frame of the phenomenological theory of transport and of classic and extended irreversible thermodynamics. Since the investigated phenomena are complex and inter-linked, the investigation techniques must seize snapshots of the system during its evolution; this will be done by hyphenating the electrochemical techniques with quartz crystal microbalance, able to measure in real time nanogram mass changes. In order to cover the time-scales necessary to develop the phenomenological theory, we will measure dynamic impedance and differential immitance spectra with a dynamic multi-frequency approach. This is based on perturbing the system with a multi-sine signal and extracting the linear and non-linear current response and mass change. The evaluation of the phenomenological parameters will rely on novel analysis algorithms and on precise modeling of the interface.

Project End Date: **30-APR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772752	**SMART-DNA**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. ILKO BALD**
Host Institution: Universitaet Potsdam, DE

Single Molecule Analytical Raman Tools based on DNA nanostructures

The monitoring of single molecule reactions promises unrivalled insight into chemical reaction mechanisms, but represents one of the most challenging tasks in chemistry. Surface-enhanced Raman scattering (SERS) is a particularly attractive single molecule (SM) technique due to its high chemical specificity, which allows to directly detect relevant intermediates and molecular subpopulations. However, SM-SERS is still at a premature state due to the highly challenging task to place single molecules precisely in nanoscale gaps of plasmonic nanostructures. These are required to provide sufficiently high electromagnetic field enhancement to reach SM sensitivity. The aim of SMART-DNA is to exploit artificial DNA nanostructures to provide sufficient structural control to assemble both, nanoparticles and target molecules, with nanometer precision. By means of novel DNA origami nanostructures the distance between two nanoparticles will be controlled, and at the same time target molecules will be placed at the positions of highest Raman enhancement through DNA aptamers.

Apart from Raman enhancement the excitation of the localized surface plasmon resonance of the metallic nanostructures results in other plasmonic effects such as heating and possibly the transfer of hot electrons. This can lead to diffusion, conformational changes or even dissociation of the target molecules. These issues do not only concern SM-SERS, but also make quantitative SERS and the SERS analysis of complex (bio)molecules very challenging. By the improved structural control achieved by SMART-DNA, nanoscale heating and hot electron transfer and their effect on SERS spectra will be studied on an ensemble and a SM level. Finally, reactions induced by plasmonically generated electrons in DNA and DNA modified with electrophilic molecules will be studied by SERS with the aim to develop novel strategies to improve cancer radiation therapies such as the photothermal therapy.

Project End Date: **31-MAR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772834	**QML**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. ANATOLE VON LILIENFELD**
Host Institution: Universitaet Basel, CH

Quantum Machine Learning: Chemical Reactions with Unprecedented Speed and Accuracy

Large and diverse property data sets of relaxed molecules and crystals, resulting from computationally demanding quantum calculations, have recently been used to train machine learning models of various energetic and electronic properties. We propose to advance these techniques to a level where they can also describe reaction profiles, i.e. reactive non-equilibrium processes which traditionally would require quantum chemistry treatment. The resulting quantum machine learning (QML) models will provide reaction profiles for new reactants in real-time and with quantum accuracy. The overall goal is to develop a predictive computational tool which allows chemists to easily optimize reaction conditions, develop new catalysts, or even plan new synthetic pathways.

Project End Date: **31-MAY-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
786707	**FunMagResBeacons**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator:	**Dr. MALCOLM LEVITT**
Host Institution:	University Of Southampton, UK

Functionalized Magnetic Resonance Beacons for Enhanced Spectroscopy and Imaging

This project will develop and demonstrate molecular agents called functional magnetic resonance beacons (fMRBs). These will provide a new set of versatile spectroscopic tools for the spatially resolved study of chemistry, biochemistry, diffusion, flow and percolation inside opaque objects. The fMRB agents support hyperpolarized nuclear spin order, which generates enormously enhanced nuclear magnetic resonance (NMR) signals. The agents are designed to maintain such order for long times (between 5 minutes and several hours) in ambient temperature solution, enabling their transport deep inside opaque objects. The molecules are functionalized, so that they “light up" in an NMR or magnetic resonance imaging (MRI) experiment, upon triggering by specific chemical signals or physical conditions (sensory functionality), and may also to bind to selected molecular targets (binding functionality). One set of proposed realisations possesses “lock-and-key” functionality, meaning that the hyperpolarized nuclear spin order is “locked” into a form which is invisible in the NMR spectrometer, but which may be “unlocked” at any chosen time by applying a suitable radiofrequency pulse sequence. The following molecular moieties are proposed as storage modules: (1) molecular cages, such as functionalized C60 fullerenes, encapsulating noble gas atoms such as 3He; (2) spin clusters supporting long-lived states, such as pairs of 13C or 15N nuclei, in shielded molecular environments. The sensory moieties include tailored peptide sequences, which may be activated by the presence of particular proteases, while binding modules include moieties such as biotin. The agents are designed to be conveniently transportable in a hyperpolarized state. Potential long-term applications include in vivo molecular imaging by MRI.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787534	**NanoBioNext**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. ANDREW EWING**
Host Institution: Goeteborgs Universitet, SE

Nanoscale Biomeasurements of Nerve Cells and Vesicles: Molecular Substructure and the Nature of Exocytosis

I propose to develop and apply state of the art analytical methods to investigate cell membrane and vesicle substructure to elucidate the chemistry of the closing regulatory phase of individual exocytosis events. The general goal of this proposal is to develop a new brand of analytical nanoelectrochemistry (nanogap and nanopore electrochemical cytometry), combined with chemical nanoscopy imaging methods with STED and nanoscale mass spectrometry imaging. I propose to apply this to the questions of the nature of exocytosis and the chemistry that initiates the process of a short-term memory. We have recently discovered that most neurotransmitter release is partial via an open and closed vesicle release process and this allows new mechanisms of plasticity and synaptic strength to be hypothesized. I propose to (i) test if partial release is ubiquitous phenomenon, (ii) develop new nanoscale analytical methods to measure exocytotic release from pancreatic beta cells and a neuron in Drosophila, and to elucidate the substructure of nanometer vesicles, (iii) use these analytical methods in model cells and neurons to test the hypothesis that lipid membrane changes are involved in the initiation of the chemical events leading to short-term memory, and (iv) test the effects of drugs and zinc on plasticity of vesicles and exocytosis. This work combines new method development with a revolutionary application of chemical analysis to test the hypothesis that lipids play a previously unanticipated role in synaptic plasticity and the chemical structures involved in the initiation of short-term memory. As long-term impact, this will provide sensitive analytical tools to understand how changes in these chemical species might be affected in relation to diseases involving short-term memory loss.

Project End Date: **31-JUL-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788218	**TRANSFORMER**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. JENS BIEGERT**
Host Institution: Fundacio Institut De Ciencies Fotoniques, ES

Structural transformations and phase transitions in real-time

Chemical and material sciences are key drivers of our modern economy with transformative impact at all levels of society. In particular, the ability to synthesize and to tailor substances and materials with specific function is all-pervading into modern society. Vital is a firm understanding of structural transformations of molecules and phase transitions of solids as they are omnipresent, e.g. as formation and breakage of molecular bonds, proton motion and isomerization, and as collective phenomena in phase transitions. Gaining insight into the ultrafast correlated dynamics is highly challenging and requires revolutionary methodologies and innovative approaches to capture the dynamics from its onset.

TRANSFORMER will provide unprecedented insight into the real-time electronic and nuclear dynamics of molecular transformations and phase transitions with advanced new methodologies and a multi-faceted approach to the investigation. The project exploits our pioneering achievements in attosecond soft X-ray spectroscopy (XAFS) and laser-induced electron diffraction (LIED) to pinpoint in real-time which electronic states participate at which nuclear configuration. The proposal consists of three objectives:

O1: We will establish the methodical boundaries of LIED for space-time imaging of isolated molecules.

O2: We will extract simultaneous and real-time electronic and nuclear information, thus gain insight into the underlying many-body quantum correlations.

O3: We will use our methodology to realize resolving both, molecular isomerization and a solid's metal-to-insulator phase transition, in its electronic and nuclear degrees of freedom and in real time.

If successful, TRANSFORMER would undoubtedly provide an unprecedented view into electronic and nuclear dynamics, thereby reaching far beyond the state of the art with clear potential to surpass current limits in molecular and material sciences.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802862	**HY-NANO**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. GIULIA GRANCINI**
Host Institution: Universita Degli Studi Di Pavia, IT

HYbrid NANOstructured multi-functional interfaces for stable, efficient and eco-friendly photovoltaic devices

HY-NANO focuses on one of the current major challenges in Europe: a global transition to a low-carbon society and green economy by 2050. Solar energy can lead a “paradigm shift” in the energy sector with a new low-cost, efficient, and stable technology (3-pillars strategy). Nowadays, low-cost three dimensional (3D) Hybrid Perovskites (HP) solar cells are revolutionizing the photovoltaic scene, with stunning power conversion efficiency beyond 22%. However, poor device stability (due to degradation in contact with water) and dependence on toxic components (lead) substantially hamper their commercialization.

HY-NANO aims to realize a new low-cost and efficient hybrid solar technology combining long-term stability with a reduced environmental impact. Design and engineering innovative multi-dimensional hybrid interfaces is the core idea. This will be achieved by: 1. design and characterization of new stable and eco-friendly perovskites structures, with tunable composition and dimensionality ranging from 3D to 2D; 2. exploiting new synergistic functions by combining 3D and 2D perovskites together into novel stable and efficient multi-dimensional interfaces while addressing the interface physics therein; 3. integrating the hybrid interfaces into high efficient and stable device architectures engineered “ad hoc”. In addition, I propose the development of new solar cell encapsulant using metal-organic frameworks (MOFs) functionalized as selective lead receptors to minimize the environmental risks associated with the potential release of lead.

My multidisciplinary expertise in advanced material design, cutting-edge photophysical experimental investigations, and solar cell engineering will enable me to successfully target the ambitious goals. HY-NANO is timely and it will generate the new fundamental knowledge that is urgently needed for a scientific and technological breakthrough in materials and devices for near future photovoltaics.

Project End Date: **30-JUN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818064	**GEMS**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. CHIARA CAPPELLI**
Host Institution: Scuola Normale Superiore, IT

General Embedding Models for Spectroscopy

Recently, there has been a paradigmatic shift in experimental molecular spectroscopy, with new methods focusing on the study of molecules embedded within complex supramolecular/nanostructured aggregates. In the past, molecular spectroscopy has benefitted from the synergistic developments of accurate and cost-effective computational protocols for the simulation of a wide variety of spectroscopies. These methods, however, have been limited to isolated molecules or systems in solution, therefore are inadequate to describe the spectroscopy of complex nanostructured systems. The aim of GEMS is to bridge this gap, and to provide a coherent theoretical description and cost-effective computational tools for the simulation of spectra of molecules interacting with metal nano-particles, metal nanoaggregates and graphene sheets.
To this end, I will develop a novel frequency-dependent multilayer Quantum Mechanical (QM)/Molecular Mechanics (MM) embedding approach, general enough to be extendable to spectroscopic signals by using the machinery of quantum chemistry and able to treat any kind of plasmonic external environment by resorting to the same theoretical framework, but introducing its specificities through an accurate modelling and parametrization of the classical portion. The model will be interfaced with widely used computational chemistry software packages, so to maximize its use by the scientific community, and especially by non-specialists.
As pilot applications, GEMS will study the Surface-Enhanced Raman (SERS) spectra of systems that have found applications in the biosensor field, SERS of organic molecules in subnanometre junctions, enhanced infrared (IR) spectra of oligopeptides adsorbed on graphene, Graphene Enhanced Raman Scattering (GERS) of organic dyes, and the transmission of stereochemical response from a chiral analyte to an achiral molecule in the vicinity of a plasmon resonance of an achiral metallic nanostructure, as measured by Raman Optical Activity-ROA

Project End Date: **31-MAY-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818266	**LactaDiff**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. JULIEN VALETTE**
Host Institution: Commissariat A L Energie Atomique Et Aux Energies Alternatives, FR

Assessing cellular compartmentation of brain lactate using diffusion MR spectroscopy in vivo

The idea has emerged that compartmentation of brain lactate, i.e. its distribution between different cell types and the extracellular space, plays a critical role in neurotransmission and brain plasticity. Dysregulations of lactate metabolism have also been reported in neurodegenerative diseases such as Alzheimer's disease. However, these notions remain challenged, and even fundamental mechanisms such as the astrocyte-to-neuron lactate shuttle, whereby astrocytes are supposed to export lactate to neurons to sustain neuronal energy needs, are still fiercely debated. This is largely due the lack of tools to evaluate cell-specific compartmentation of lactate in the living brain, in particular in Humans. In this project, we will develop new nuclear magnetic resonance spectroscopy techniques to non-invasively measure lactate diffusion, including in cortical regions. We will then take advantage of the unique ability of these methods to differentiate between metabolites diffusing in different environments, based on diffusion properties imposed by the microstructure, to quantify lactate in the extracellular space and, most importantly, in neurons and astrocytes. After validation in rodent models, these methods will be transposed on a clinical MRI system at ultra-high magnetic field, to gain unprecedented access to lactate compartmentation in the Human brain and its modifications during brain activity, plasticity, and in Alzheimer's disease. This will open a new research field for magnetic resonance spectroscopy in vivo.

Project End Date: **30-APR-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819039	**F-BioIce**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. TOBIAS WEIDNER**
Host Institution: Aarhus Universitet, DK

Fundamentals of Biological Ice Nucleation

Ice active bacteria can promote the growth of ice more effectively than any other material known. Using specialized ice nucleating proteins (INPs), they attack plants by frost damage and, when airborne in the atmosphere, they drive ice nucleation within clouds and control global precipitation patterns. The control INPs exert over water phase transitions has relevance for disciplines as diverse as climatology, plant pathology, biomedicine and material science. Despite the apparent importance, the molecular mechanisms behind INP freezing have remained largely elusive. This lack of our knowledge can be traced back to the challenges in studying protein and water structure and dynamics at the very interface between monolayers of proteins and water.

With F-BioIce my team and I want to reveal the molecular details of INP function. We ask the questions: What is the structural basis for protein control of freezing? What structural motifs do proteins use to interact with water, and what is the configuration of water molecules that INPs imprint into interfacial water layers? What is the role of structural dynamics and for surface freezing? We will develop new methods based on sum frequency generation (SFG) spectroscopy to determine mode of action by which INPs interact with and manipulate water. The INPs and water structure will be obtained by combining three rising methods in the field: SFG techniques that I have been spearheading, computer simulations and cryo-electron microscopy. We will study model water surfaces and, for the first time, realistic water aerosols interacting with INPs. These new strategies could lead to a paradigm shift in the entire field of ice nucleation and a search for similar processes in ice active fungi and pollen and abiotic ice nucleators – feldspar, silica and soot. The obtained information will provide critical input for climate models and revolutionary new freezing technologies for food preservation, cryomedicine and cloud seeding.

Project End Date: **31-MAR-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
832697	**BALANCE**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. PETER CHEN**
Host Institution: Eidgenoessische Technische Hochschule Zurich, CH

Mapping Dispersion Spectroscopically in Large Gas-Phase Molecular Ions

We use IR spectroscopy of trapped ions in a cryogenic FT-ICR spectrometer to probe non-covalent, "dispersion" interactions in large, gas-phase molecular ions. We will measure conformational equilibria by N-H frequency shifts, and correlate gas-phase IR frequency to the N-H-N bond angle in an ionic H-bond. Substituents on "onium" cations can adopt various conformations, whose energies map interaction potentials. Substituents on their proton-bound dimers interact non-covalently through dispersion forces, whose quantitative evaluation in large molecules has remained difficult despite dispersion becoming increasingly cited as a design principle in the construction of catalysts and materials. The non-covalent interactions bend the N-H-N bond, leading to large shifts in the IR frequency. The proton-bound dimer acts like a molecular balance where the non-covalent interaction, is set against the bending potential in an ionic hydrogen bond. Despite encouragingly accurate calculations for small molecules, experimental benchmarks for large molecules in the gas phase remain scarce, and there is evidence that the good results for small molecules may not extrapolate reliably to large molecules. The present proposal introduces a new experimental probe of non-covalent interactions, providing a sensitive test of the diverging results coming from various computational methods and other experiments. The experiment must be done on isolated molecules in the gas phase, as previous work has shown that solvation substantially cancels out the attractive potential. Accordingly, the proposed experimental design, which involves a custom-built spectrometer, newly available tunable IR sources, chemical synthesis of custom substrates, and quantum calculations up to coupled-cluster levels of theory, showcases how an interdisciplinary approach combining physical and organic chemistry can solve a fundamental problem that impacts how we understand steric effects in organic chemistry.

Project End Date: **30-APR-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
832703	**CONTROL**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. KLAAS WYNNE**
Host Institution: University Of Glasgow, UK

Laser control over crystal nucleation

The CONTROL programme I propose here is a five-year programme of frontier research to develop a novel platform for the manipulation of phase transitions, crystal nucleation, and polymorph control based on a novel optical-tweezing technique and plasmonics. About 20 years ago, it was shown that lasers can nucleate crystals in super-saturated solution and might even be able to select the polymorph that crystallises. However, no theoretical model was found explaining the results and little progress was made.

In a recent publication (Nat. Chem. 10, 506 (2018)), we showed that laser-induced nucleation can be understood in terms of the harnessing of concentration fluctuations near a liquid–liquid critical point using optical tweezing. This breakthrough opens the way to a research programme with risky, ambitious, and ground-breaking long-term aims: full control over crystal nucleation including chirality and polymorphism.

New optical and microscopic techniques will be developed to allow laser manipulation on a massively parallel scale and chiral nucleation using twisted light. Systematically characterising and manipulating the phase behaviour of mixtures, will allow the use of the optical-tweezing effect to effectively control the crystallisation of small molecules, peptides, proteins, and polymers. Exploiting nanostructures will allow parallelisation on a vast scale and fine control over chirality and polymorph selection through plasmonic tweezing. Even partial success in the five years of the programme will lead to fundamental new insights and technological breakthroughs. These breakthroughs will be exploited for future commercial applications towards the end of the project.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833404	**KIDS**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. THEOFANIS KITSOPOULOS**
Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Kinetics and Dynamics at Surfaces

This proposal implements slice imaging to measure catalytic rates for site-specific elementary reactions thus offering remarkable opportunities to advance our fundamental understanding of heterogeneous catalysis.

As evidence for global climate change continues to grow, catalysis has moved to the front line of the struggle to obtain new, sustainable technologies for the future. Catalysis and catalytic processes account, directly or indirectly, for 20-30 % of world Gross Domestic Product. Knowledge of elementary chemical reaction mechanisms in heterogeneous catalysis underlies our ability to construct comprehensive kinetic models for many such important chemical processes, in order to optimise them.

Our proposed strategy makes the formidable task of describing site-specific chemical reaction mechanisms and elementary rates in heterogeneous catalysis facile, while its necessity we justified (Nature 2018) on the prototypical CO oxidation reaction on Pt by demonstrating that 40 years of traditional experimentation led to false interpretation of the reaction mechanism.

The aim of this proposal is characterize the important factors that influence the kinetics of elementary reactions at surfaces, e.g. the chemical nature of the catalyst and the geometry of the active site (stereodynamics). We chose elementary reactions involving C, H, O, N, as these are important in many key industries, such as the methane reforming, syngas, fuel cells, Fischer-Tropsch synthesis and the Haber-Bosch process. Our strategy is that of a “bottoms up” approach to catalysis, i.e., building and understanding complex heterogeneous chemical catalysis, from the site-specific kinetics of the elementary building block reactions. Our measurements, will serve for benchmarking first principles calculations of reaction rates in surface chemistry. Our methodology measures the kinetics in the □s regime with temperatures in the 200 to 1000 K range, i.e, more relevant to industrial conditions.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
848668	**RadSpec**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. JOSHUA BARABAN**
Host Institution: Ben-Gurion University Of The Negev, IL

A New Strategy for Vibronic Spectroscopy of Radicals

This proposal aims to develop a novel strategy for high resolution vibronic spectroscopy of radicals, with unprecedented sensitivity, specificity, and applicability. The proposed scheme will provide answers to longstanding quantum mechanical questions about non-adiabatic dynamics, and, in combination with a unique, recently developed transparent microreactor source of reactive molecules, enable the pursuit of unknown reactive intermediates. Radicals and transient reactive intermediates are centrally important to chemistry but notoriously difficult to study. The proposer has recently led several successful experimental and theoretical efforts directed at molecules and transition states thought to be extremely difficult if not impossible to characterize. Here we propose to launch a revolutionary approach to spectroscopy of these important species, exploiting a key insight into dissociation dynamics on top of elements of state of the art laser spectroscopy techniques in the infrared, ultraviolet, and vacuum ultraviolet to forge a new universal method. It possesses the high sensitivity and mass selectivity of ion detection, while simultaneously being multidimensional and fully rovibronic in scope to extract the maximum possible information about coupled nuclear and electronic dynamics.

We anticipate that this advance will also be of great interest and utility to a broad swath of researchers in related fields, such as combustion, atmospheric chemistry, and surface science, who require the ability to track rare but reactive species. The nitrate and cyclopentadienyl radicals will initially be targeted as particularly important examples, and we also plan to hunt for as yet unobserved reactive intermediates using our new spectroscopic scheme alongside the flexibility of our molecular source to rationally explore chemical phase space.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850041	**ANHARMONIC**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. OMER YAFFE**
Host Institution: Weizmann Institute Of Science, IL

Anharmonic Semiconductors

Recent studies of halide perovskite semiconductors (SCs) showed that they exhibit a unique combination of very-low defect density, self-healing properties and low exciton binding energies that result in excellent photovoltaic activity.
I hypothesize that the fundamental property that sets the halide perovskites apart from conventional SCs and gives rise to their beneficial properties is strongly anharmonic lattice dynamics.
Large amplitude, local polar fluctuations that result from lattice anharmonicity localize the electronic states and enhance the screening of electric charges within the material.
In other words, in some aspects, halide perovskites behave more like a liquid than a crystalline solid.

Stimulated by the recent discoveries on halide perovskites, I aim to generalize our understanding of the relationship between lattice anharmonicity and the electronic properties of SCs.
The potential outcome of this investigation will be a novel scheme to design SCs with desirable properties where lattice anharmonicity is used as a new material-engineering tool.
My strategy is to perform comparative studies in both inorganic ionic crystals and small-molecule organic crystals.
We will use low-frequency Raman spectroscopy to quantify anharmonic lattice dynamics and compare between different crystals to identify the factors that induce anharmonicity in solids.
Photoluminescence, reflectance, time-resolved terahertz and impedance spectroscopies will be used to probe the SCs optical properties, carrier mobilities and lifetimes, and their dielectric response. I expect to find that as anharmonicity increases, the dielectric response and carrier lifetimes increase while carrier mobility decreases.
Finally, we will develop a modulated Raman spectroscopic methodology that will identify specific lattice motions that are coupled to band-edge carriers, thus elucidating the microscopic mechanism of carrier-lattice interactions.

Project End Date: **31-OCT-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850764	**TACCAMA**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. BARBARA LECHNER**
Host Institution: Technische Universitaet Muenchen, DE

Atomic-Scale Motion Picture: Taming Cluster Catalysts at the Abyss of Meta-Stability

From fine chemical synthesis over combustion control to electrode design – the majority of chemical reactions rely on catalysts to improve energy and material efficiency. Yet, the atomic-scale processes underlying a catalytic reaction at elevated pressures are far less well-understood than one might expect. Indeed, the successful optimization of industrial catalysts is typically achieved by 'trial and error'. If we precisely understood the correlation between catalyst dynamics and activity, we could instead design stable, yet intrinsically dynamic (i.e. structurally fluxional) catalysts, drastically reduce our waste of noble metals by using only the most active particles and replace rare and toxic materials.

This project constitutes a fundamental and systematic investigation of heterogeneous catalysis in action. My aim is to map the pressure and temperature range in which supported particle catalysts are stable, and correlate particle size and support morphology with dynamics and stability. To do so, I will combine my experience with surface dynamics studies, video-rate scanning tunneling microscopy (STM), ambient pressure (AP) surface science and cluster research. State-of-the-art video-rate APSTM will enable me to observe catalyst dynamics such as sintering, adsorbate spillover onto the support, dynamic structural fluxionality of clusters and support roughening as a function of reactant partial pressure and temperature. The novelty of this project lies in the direct observation of catalyst particles, defined to the exact number of atoms, under realistic reaction conditions in order to tune reactivity by controlling their dynamics and stability on structurally and electronically optimized oxide supports. AP X-ray photoelectron spectroscopy (APXPS) will supply complementary information about chemical changes occurring in cluster and support. The knowledge gained will contribute to the targeted design of more active and efficient catalysts for specific applications.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850818	**MULTIVIsion**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. DAAN BRINKS**
Host Institution: Technische Universiteit Delft, NL

Multiphoton Voltage Imaging

Understanding the brain is one of the great scientific challenges of our time. This pursuit fundamentally depends on advances in physical sciences and engineering to provide novel tools and methods to perturb, record and interpret brain activity.
Information in the brain is encoded in changes in the voltage across the membrane of brain cells. Voltage imaging with genetically encoded voltage indicators (GEVIs) is a revolutionary method that allows faithful recording of the fast electrical dynamics of many genetically targeted cells in parallel. This provides an unprecedented means to record how patterns of change in this membrane voltage, called action potentials, manifest in subcellular compartments, cells, and networks across the brain, which is the only way to arrive at a fundamental understanding of brain functions like learning and memory, and of neurogenerative diseases. For this promise to be fulfilled, we need voltage imaging deep in the living brain of awake and behaving organisms. To achieve this, I will evolve a GEVI optimized for three-photon (3P) imaging, by screening mutant libraries of GEVIs directly for brightness and photostability under 3P-excitation, voltage sensitivity, and membrane trafficking in neurons. I will optimize the photocycle dynamics of GEVIs with temporally structured light, using a NOPA with tunable repetition rate, pockels cell and multiple optical delay lines, to create optimal 3P excitation protocols. Crucially, this optimization will not depend on spectral phase and is therefore compatible with high speed multiphoton imaging, aberration correction, and deep tissue imaging. Finally, I will investigate memory formation in a proof-of-principle experiment. I will use a custom microscope I developed, for 3P voltage imaging of cells in the cerebellum of mice trained in an eyeblink task. Memory formation in this paradigm is hypothesized to look like subtle changes in the exact shape and timing of action potentials, which I will resolve.

Project End Date: **30-NOV-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850850	**HEIST**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. SØREN BREDMOSE SIMONSEN**
Host Institution: Danmarks Tekniske Universitet, DK

High-temperature Electrochemical Impedance Spectroscopy Transmission electron microscopy on energy materials

The great challenge for humankind is to mitigate climate changes by replacing fossil fuels with renewables. We will have to store excess energy produced by solar and wind power for usage in dark and calm weather. Excess energy can be stored electrochemically by high-temperature electrolysis cells as they have the potential to store vast amounts of electrical energy by conversion to chemical fuels. Solid oxide electrolysis cell (SOEC) technology is well known and proven, but not price competitive with storage of fossil fuels.

To drive the SOEC research towards a breakthrough, it is critical to determine relations between electrochemical activity and structure/composition in the cells. Electrochemical impedance spectroscopy (EIS) is a very powerful method for determining the contribution from processes in the cell to the overall activity. EIS cannot show structure/composition which is offered by transmission electron microscopy (TEM). Conventional TEM, however, does not offer insight into active cells, but only post mortem analysis.

High-temperature electrochemical TEM is extremely challenging because this requires a) that hard and brittle ceramic cells are thinned to electron transparency (ca. 100 nm), b) that the cells are carefully designed to allow for characterization of the layer interfaces, and c) that the cells are characterized during exposure of i) reactive gasses, ii) electrical potentials and iii) temperatures up to ca. 800 °C.

The aim of HEIST is to cover step a) to c), i.e. to transform TEM into an electrochemical lab for high-temperature electrochemical experiments including EIS. HEIST will give us “live” images of nanostructures and composition during operation of the electrochemical cells and thus disclose structure-activity relations. This is important, because the structures of nanomaterials will transform depending on the electrochemical environment, and post mortem analysis does not offer a correct representation of the active nanostructures.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851421	**POLYQUANT**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. EDIT MATYUS**
Host Institution: Eötvös Loránd Tudományegyetem, HU

Theoretical developments for precision spectroscopy of polyatomic and polyelectronic molecules

I propose research for an increasingly accurate quantum mechanical computation of small molecular systems including non-adiabatic, relativistic, and radiative effects. The computed rovibronic energy intervals will be directly comparable with high-resolution and precision spectroscopy measurements. The accuracy goal for theory (and experiment) is more than six-orders of magnitude tighter than the usual chemical accuracy defined to be on the order of 1 kcal/mol. The rovibronic eigenstates obtained from effective non-adiabatic, relativistic-radiative Hamiltonians to be developed will provide the most fundamental and most detailed quantum dynamical fingerprint of the molecular system, and as a complete database they are necessary for the simulation of a variety of molecular phenomena including ultrafast laser-molecule interactions.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851676	**OptEIon**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. WOLFGANG TRESS**
Host Institution: Zurcher Hochschule Fur Angewandte Wissenschaften, CH

Defect Engineering, Advanced Modelling and Characterization for Next Generation Opto-Electronic-Ionic Devices

Defects in semiconductor materials commonly deteriorate the performance of optoelectronic devices such as solar cells and light-emitting diodes. In the recently emerged and highly successful hybrid metal halide perovskite, some lattice defects are even mobile leading to mixed ionic-electronic conductivity. This and other outstanding properties (tunable bandgap, lower dimensional embodiments, solution processability) make the perovskite a very interesting material for research and application. At the same time, it suffers from various degradation processes, linked to these poorly understood ionic defects. The major questions are: Where and what are these defects? How are they formed and how can we control their movement?
OptEIon will provide answers to these questions.
Based on my expertise in the device physics and experience in perovskites I will proceed as follows: First, I will characterize the transient response of devices with different perovskite materials, different stoichiometry, partial pressure of constituents, temperature, etc. to find clear evidence for the nature of the mobile defects and their diffusion constant. Second, I will employ nano-scale characterization on cross sections of working devices to measure location and time evolution of defects causing recombination losses in solar cells. In addition to established measurement techniques, I will use tip-enhanced (near field) spectroscopic techniques, which can provide super-resolution imaging. Third, I will apply device simulation to examine the measurement results. I will furthermore evaluate how machine learning in combination with our physical model could be implemented to help analyse device data. Fourth, I will exploit the results by fabricating demonstrator memristor arrays that can be controlled by light.
The outcome will be more efficient and stable solar cells and novel optoelectronic devices such as memristors, which are supposed to herald a new era of neuromorphic computing.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851766	**T-CUBE**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. THOMAS JAGAU**
Host Institution: Katholieke Universiteit Leuven, BE

Theoretical Chemistry of Unbound Electrons

T-CUBE aims at the theoretical modeling of chemistry involving the continuum. Traditionally, chemistry has been concerned with electrons that remain bound to the nuclei during a reaction. However, in many settings that deal with X rays or plasma, electrons can enter and leave the system; they are unbound.

Most theoretical approaches for unbound electrons are not applicable to extended systems in complex environments. As a consequence, pathways and product distributions of processes such as dissociative electron attachment and Coulomb explosion are poorly understood. This hinders progress in laboratory and technology: The electron is a simple and versatile catalyst, but corresponding applications are
still in an infant stadium.

T-CUBE seeks to overcome these limitations. Often, unbound electrons can be described by resonances, electronic states with complex-valued energy. In recent years, I contributed to advancing this approach significantly. Small molecules in gas phase can now be described with an accuracy that allows for quantitative comparison to experiment.

Here, I propose to investigate the chemistry of unbound electrons in larger molecules and condensed phase, for example, in solutions, polymeric networks, and biomolecules. Aspects that we will address include: energetics and character of resonances in different environments, resulting changes in chemical reactivity, and the interplay of nuclear motion and electron loss.

To achieve these goals, quantum chemistry for electronic resonances needs to be advanced substantially. We will develop electronic-structure methods suitable for over a hundred of atoms, a quantum embedding scheme for describing different environments, and molecular dynamics simulations that take into account electron loss. In addition, we will advance the theory of electronic resonances itself. In exemplary applications, we will investigate phenomena involving dissociative electron attachment, electron transfer, and Coulomb explosion.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852208	**123STABLE**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. NEJC HODNIK**
Host Institution: Kemijski Institut, SI

Towards Nanostructured Electrocatalysts with Superior Stability

In the last decades, significant progress has been made on understanding and controlling solid/liquid electrochemical interfaces at atomic levels. As the principles guiding the activity of electrochemical reactions are quite well established (structure-activity relationships), the fundamentals of stability are still poorly understood (structure-stability relationships). 123STABLE proposes to employ (1) identical location, (2) online monitoring and (3) modeling of noble metals based nanoparticles changes with the state-of-the-art electron microscopy equipment and online dissolution and evolution analytics using electrochemical flow cell coupled to online mass spectrometers. Projects unique methodology approach with picogram sensitivity levels, in combination with sub-atomic scale microscopy insights and simulations, promises novel atomistic insights into the corrosion and reconstruction of noble metals in electrochemical environments. This unique approach is based on observations of the same nanoparticles before and after electrochemical treatment where weak and stable atomic features and events can be recognized, followed, understood and finally utilized. Upon (1) doping, (2) decoration and/or (3) other synthetic modification of nanoparticles like a change in size and shape further stabilization is envisioned. For instance, blockage of nanoparticle vulnerable defected sites like steps or kinks by more noble metal could stop or significantly slow down their degradation.

The 123STABLE project will feature platinum- and iridium-based nanostructures as a model system to introduce a unique “123” approach, as they still possess the best electrocatalytic properties for the future electrification of society through the Hydrogen economy. However, their electrochemical stability is still not sufficient. Coupled with the fact that their supply is hindered by extremely scarce, rare and uneven geological distribution, the increase in their stability is of immense importance.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864246	**PP-MAGIC**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. HENNING JESSEN**
Host Institution: Albert-Ludwigs-Universitaet Freiburg, DE

(Photo-)Control of Persisters: Targeting the Magic Spot

The abusive use of antibiotics has led to multidrug-resistant bacteria and the acute threat of a post-antibiotic era. However, apart from resisters, there is a subgroup of bacteria called persisters that surviveby recalcitrance to antibiotic treatment. Persisters are not resistant to antibiotics but simply survive by metabolic shutdown. Upon withdrawal of antibiotics, these persisters resuscitate and regenerate the colony. They are heavily involved in failure of antibiotic treatment and the development of chronic infections. Bacterial persistence is controlled by the stringent response, which itself is mediated by hyperphosphorylated nucleotides, known as the magic spot (MS) nucleotides or (p)ppGpp. The importance of the stringent response, its omnipresence in the domain of bacteria, its connection to persister formation and tolerance to (antibiotic) stress, and its absence in mammals has led to significant research in microbiology. However, until recently these activities have not been paralleled by the development of chemical biology approaches. The current proposal aims to fill this gap by research into

(1) synthetic methodology targeting the magic spot nucleotides and their analogs,
(2) tools to identify target proteins of (p)ppGpp, and more generally (p)ppNpp
(3) analytical approaches to extract, resolve, and quantify (p)ppGpp,
(4) strategies to control the stringent response and persister formation with light
(5) inhibitors of the stringent response.

These new tools will enable a detailed understanding of the stringent response and thus ultimately help in the design of new antibiotics effective against persisters. The goal is to develop methods to force bacteria into the persistent state or inversely wake them up by using light and small molecules. Forcing bacteria out of persistence and blocking their entry into this state in combination with antibiotic treatment is a highly promising strategy to avoid the development of chronic bacterial infections.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864625	**ConTROL**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. KOEN VANDEWAL**
Host Institution: Universiteit Hasselt, BE

Charge-TRansfer states for high-performance Organic eLectronics

Thin films comprising a blend of electron donating (D) and electron accepting (A) molecules are ubiquitous in organic electronic devices. At the D-A interfaces, intermolecular charge-transfer (CT) states form, in which an electron is transferred from D to A. Electrical doping (p- and n-type) involves ground-state CT from dopant to host and results in increased conductivities of the host organic semiconductor. Furthermore, the performances of organic solar cells, photodetectors and light emitting diodes depend crucially on D-A interfaces where the CT state is an excited state, mediating between photons and free charge carriers. New applications of intermolecular CT states, such as transparent conductors, artificial synapses, biosensors, organic persistent luminescent materials and low cost narrowband near-infrared sensors have emerged in the past years, and there is clearly potential for additional innovation. However, current progress is hampered by a lack of understanding of the fundamental properties of intermolecular CT states and their decay and dissociation mechanisms. ConTROL aims to fill this knowledge gap and link device performance to molecular parameters of D-A interfaces. Electro-optical properties will be tuned by molecular design and appropriate D-A selection, as well as by weak and strong interactions with the opto-electronic device's optical cavity. The knowledge generated will not merely result in improved performance of existing organic electronic devices, but new avenues and novel exciting applications of intermolecular CT states will be demonstrated.

Project End Date: **30-JUN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864628	**E-SAC**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. GARETH PARKINSON**
Host Institution: Technische Universitaet Wien, AT

Evolving Single-Atom Catalysis: Fundamental Insights for Rational Design

Rare and expensive metals tend to be the best catalysts, and minimising or replacing them is a major research target as we strive to develop an economy based on more environmentally-friendly, energy-efficient technologies. “Single-atom” catalysis (SAC) represents the ultimate in efficiency, and the chemical bonds formed between the metal atom and the support mean these systems strongly resemble the organometallic complexes utilized in homogeneous catalysis. If all active sites were identical, single-atom catalysts (SACs) could achieve similar levels of selectivity, and even be used to “heterogenize” difficult reactions that must be currently performed in solution. There is a problem however: homogeneous catalysts are designed based on well-understood structure-function relationships. In SAC, the structure of the active site is unknown, thus rational design is impossible.

My group in Vienna has pioneered the use of the model supports to understand fundamental mechanisms in SAC. Our work with Fe3O4(001) proves that we can precisely determine and even selectively modify the active site, and unravel the role of structure in catalytic activity. Real progress, however, requires realistic active sites, realistic supports, and realistic environments. In this project, I describe how we will determine the sites that robustly anchor metal atoms on five of the most important supports in ultrahigh vacuum (UHV), and test their performance in newly-developed high-pressure and electrochemical cells. The origins of selectivity for PROX, hydrogenation, hydroformylation, methane conversion, and the oxygen reduction reaction (ORR) will be elucidated, and the best atom/support combinations for each reaction identified. Robust XANES and IRAS spectra will allow us to bridge the complexity gap and recreate the optimal active sites on real SACs and lead the way into a new era in which heterogeneous catalysts are designed for purpose, based on a fundamental understanding of how they work.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865590	**Programmable Matter**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. ARTEM MISHCHENKO**
Host Institution: The University Of Manchester, UK

New materials enabled by programmable two-dimensional chemical reactions across van der Waals gap

Chemical reactions between solids are fundamental in areas as diverse as catalysis, information storage, pharmaceuticals, electronics manufacturing, advanced ceramics, and solar energy, to name just a few. Controlling the spatial extent of solid-state reactions at the nanoscale will enable development of materials, programmed on an atomic level, which will facilitate many emerging applications like bioinspired smart batteries and artificial synapses for future neuromorphic electronics. However, currently, there are no chemistry methods which allow precise spatial control at the nanoscale, limiting progress towards the programmable matter. Here I propose a completely new way to create novel materials using two-dimensional (2D) chemical reactions at the atomically-defined interfaces between crystalline solids. Usually, reactions between macroscopic solids are hindered as their large dimensions prevent placing them close enough to each other to support chemical transformations. Thus, just a few years ago, the task of placing two atomically flat crystals within angstrom proximity of each other, to initiate chemical interactions between them, was impossible to realise. This situation has changed dramatically with the advent of van der Waals technology - disassembly of various layered crystals into individual atom- or molecule-thick layers followed by a highly-controlled reassembly of these layers into artificial heterostructures. Building on our recent progress in van der Waals technology, I aim to realise interplanar chemical reactions between highly-crystalline solids in precisely controllable conditions using temperature, electric and magnetic fields, light, sound, pressure, and mechanical forces as means of control. Using digital control of 2D chemistry, mechanics, and electronics at the nanoscale, I and my team will develop programmable matter that actively responds to external and internal stimuli by adjusting their properties on an atomic level.

Project End Date: **30-APR-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865870	**QLIMIT**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. GEMMA SOLOMON**
Host Institution: Kobenhavns Universitet, DK

Challenging The Limits Of Molecular Quantum Interference Effects

Over the last ten years, there has been a growing interest in quantum interference effects observed in molecules. Remarkably, given their fragility in mesoscopic physics, molecular quantum interference effects can be readily observed at room temperature in solution. This robustness comes from the extremely small size of the molecular components (1-2nm) and thereby the small dimensions over which phase coherence is required. The aim of this project is to challenge the limits of molecular quantum interference effects delivering clear predictions of how to realise these effects in three challenge areas. 1. Beyond single molecules: intermolecular interference effects. This work package will investigate interference effects between molecules and in monolayers to find systems where intermolecular interference effects emerge with a long-term view to materials. 2. Beyond classical electronics: Quantum gates Given that interference effects are an indication of phase coherence being maintained across the molecule, we should be able to exploit the quantum nature of the system for more than simply suppressing current. Proposals exist in the literature for realising a quantum computer through scattering, so this work package will investigate use the interference effects in molecules to suggest candidate systems for this type of quantum computer. 3. Beyond electron transport: Controlling vibrational energy redistribution This work package will focus on how to use interference effects to control vibrational energy redistribution within single molecules with an aim of using this to modulate product ratios in organic reactions. This project takes ideas that have come out of molecular electronics and tests the scope of their application in three neighbouring areas: supramolecular chemistry, quantum computing and organic chemistry. This project takes a first step in these directions, and success in any work package has the possibility to open a whole new field of research.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866559	**NANOVR**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. DAVID GLOWACKI**
Host Institution: University Of Bristol, UK

Nanoscale Design using Virtual Reality

As molecular scientists have made progress in their ability to engineer and design the structure of mo-lecular systems at the nano-scale, a new fundamental challenge has emerged: namely, our ability to un-derstand and engineer molecular dynamics (MD) and flexibility. This limits our ability to carry out effi-cient molecular engineering in a range of important areas, including enzymatic catalysis, ligand-protein kinetics, and molecular signalling. In principle, MD simulations offer an excellent tool for furnishing microscopic insight into the fundamental dynamical and kinetic processes driving important molecular processes. However, the potential energy surfaces which characterize complex nano architectures have an extremely high dimensionality, making the exploration of structural dynamics a challenge; simula-tions tend to get trapped in metastable states, making it difficult to explore important transition path-ways. Drawing on the state-of-the-art in high performance computing [HPC] and virtual reality [VR], NanoVR will develop a new paradigm for undertaking nano-scale design, engineering, and analysis, through a synergistic combination of human design insight on the one hand and computational automation on the other. We will develop an intuitive open-source framework which enables molecular scientists to use VR-enabled interactive MD for guiding the automatic calculation of free energies along dynamical pathways in complex systems. We will highlight the power of this approach by applying it to under-stand enzyme-catalysed peptide macrocyclization, as well as the key protein-ligand interactions re-sponsible for emerging drug resistant strains of influenza. In so doing, we will advance fundamental new microscopic insight into molecular conformational dynamics, and grow a thriving user & develop-er community across both academia and industry committed to accelerating molecular design across important domains spanning biochemistry, materials chemistry, & catalysis.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
883395	**WatFun**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. ULRIKE DIEBOLD**
Host Institution: Technische Universitaet Wien, AT

Water at Oxide Surfaces: A Fundamental Approach

The water/oxide interface, and the molecular processes that happen there, regulate everything from environmental chemistry and the sequestration of CO2 to the cohesion of man-made structures. The properties of individual surface sites govern reactivity, so probing chemistry at this level is necessary to better understand natural processes, and to ultimately improve technologies where this interface plays a central role. In this project, we take a radically new approach to investigate the water/oxide interface at the most fundamental, the atomic, scale: we have found a way to integrate bulk liquid water into ultrahigh vacuum (UHV) setups, where an arsenal of highly-developed techniques is available to investigate surfaces. This provides the opportunity to accurately determine fundamental quantities that were hitherto inaccessible, and to obtain clear-cut experimental results for interpreting and predicting molecular-scale processes. In this project, we seize this opportunity to develop novel measurement concepts, and apply them to minerals. Following a broad work plan we will: measure the surface tension of neat water and the surface free energies of solids with unprecedented purity; devise a method to determine, site-by-site, the intrinsic proton affinity, the fundamental property that determines the point of zero charge of oxides in solutions, and their Brønsted acidity in gas-phase reactions; investigate, at the atomic scale, how liquid water affects surface structure, and how oxides become hydroxylated, dissolve, and 'age'; discover how ice nucleates on the mineral aerosol surfaces that are crucial in cloud formation; study how dissolved CO2 reacts with natural minerals, which affects the global carbon cycle; address the hydrated oxides that form the basis of cements in concrete. While this project focuses on providing a fresh view on environmentally-relevant chemistry, we also show how our approach can make an impact in a much wider range of areas.

Project End Date: **31-DEC-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
885180	**MOLBEC**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. EDVARDAS NAREVICIUS**
Host Institution: Weizmann Institute Of Science, IL

Molecular Bose Einstein Condensate

Generating a Bose Einstein Condensate (BEC) or Fermi gas of molecules is a long-standing goal of modern molecular science. Molecular BEC is a macroscopic millimeter-size quantum object with a large number of molecules occupying the lowest center-of-mass quantum state. In stark contrast to atoms, molecules possess internal degrees of freedom and stronger interactions that lead to the emergence of new phenomena. Strong dipole-dipole interactions give rise to new ordered states of matter, quantum crystals. Many-body effects start dominating collision dynamics where even molecular rotational excitations are dissipated as angular-momenta-carrying quasiparticles within the condensate.

Despite intense experimental efforts, these fascinating ideas remain in the realm of theory. The main difficulty in turning theory into reality has been the absence of general molecular cooling methods. Recently, we have demonstrated the first experiment where collisions between cold molecules trapped in a 1 K deep superconducting magnetic trap are achieved without laser cooling [Segev et al. Nature, 572 (2019)], opening a clear path to molecular evaporation.

We here propose to cool molecules by removing the fastest ones from the trap and letting the rest thermalize to lower temperatures via collisions. This method has been used to produce atomic BECs and we are the first group reaching identical initial conditions that are necessary for the successful application of the evaporative cooling. Generality of our approach is the key to successful search for a suitable molecular candidate. As an alternative to evaporation we suggest applying direct laser cooling on magnetically stopped NH radicals. We are confident that one of our approaches will lead to the long-sought generation of molecular quantum degenerate gas.

Our proposal opens new fields and will find applications in areas ranging from quantum chemistry to quantum information science.

Project End Date: **31-JUL-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677786	**DYNAP**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. JAVIER MONTENEGRO**
Host Institution: Universidad De Santiago De Compostela, ES

Dynamic Penetrating Peptide Adaptamers

The aim of this proposal is to identify, at the molecular level, the minimal topological and structural motifs that govern the membrane translocation of short peptides. A covalent reversible bond strategy will be developed for the synthesis of self-adaptive penetrating peptides (adaptamers) for targeted delivery.

It is known that the recently developed therapeutic technologies (i.e. gene therapy, chemotherapy, hyperthermia, etc.) cannot reach their expected potential due to limitations in the current delivery strategies, which hinder the efficient targeting of the appropriate tissues, cells and organelles. Despite the enormous therapeutic potential of short penetrating peptides, these molecules suffer from drawbacks such as toxicity, instability to protease digestion and lack of specificity.

Dynamic covalent chemistry has significant synthetic advantages. In the proposed research, peptide scaffolds with clickable reversible groups (e.g. hydrazide) will be conjugated with collections of aldehydes to afford self-adaptive biomimetic transporters, whose secondary structure and penetrating properties will be systematically characterized by biophysical, cell-biology and pattern recognition techniques.

The versatility of dynamic supramolecular “peptide adaptamers” with precisely positioned protein ligands will be explored for multivalent specific recognition, protein transport, cell targeting of drugs and probes and membrane epitoping.

Additionally, we propose to synthesise dynamic and environmentally sensitive fluorescent probes for biocompatible membrane labelling and uptake signalling.

The resulting discoveries of this research will allow the formulation of novel transfecting reagents for gene therapy, selective platforms for drug-delivery and the development of dynamic fluorescent membrane probes. The potential results of this proposal will shake the fields of drug-delivery and non-viral gene transfection and will resolve the limitations of the current approaches.

Project End Date: **31-JAN-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681895	**MOFcat**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. SASCHA OTT**
Host Institution: Uppsala Universitet, SE

Fundamental and Applied Science on Molecular Redox-Catalysts of Energy Relevance in Metal-Organic Frameworks

Organometallic redox-catalysts of energy relevance, i.e. water and hydrogen oxidation, and proton and carbon dioxide reduction catalysts, will be incorporated into metal-organic frameworks (MOFs). Immobilization and spatial organization of the molecular catalysts will stabilize their molecular integrity and ensure longevity and recyclability of the resulting MOFcats. The organized environment provided by the MOF will enable the control of conformational flexibility, diffusion, charge transport, and higher coordination sphere effects that play crucial roles in enzymes, but cannot be addressed in homogenous solution and are thus largely unexplored. The effect that the MOF environment has on catalysis will be directly probed electrochemically in MOFcats that are immobilized or grown on electrode surfaces. In combination with spectroscopic techniques in spectroelectrochemical cells, intermediates in the catalytic cycles will be detected and characterized. Kinetic information of the individual steps in the catalytic cycles will be obtained in MOFs that contain both a molecular photosensitizer (PS) and a molecular catalyst (PS-MOFcats). The envisaged systems will allow light-induced electron transfer processes to generate reduced or oxidized catalyst states the reactivity of which will be studied with high time resolution by transient UV/Vis and IR spectroscopy. The acquired fundamental mechanistic knowledge is far beyond the current state-of-the-art in MOF chemistry and catalysis, and will be used to prepare MOFcat-based electrodes that function at highest possible rates and lowest overpotentials. PS-MOFcats will be grown on flat semiconductor surfaces, and explored as a novel concept to photoanode and -cathode designs for dye-sensitized solar fuel devices (DSSFDs). The design is particularly appealing as it accommodates high PS concentrations for efficient light-harvesting, while providing potent catalysts close to the solvent interface.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
692981	**LEAPS**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. ALBERTO CREDI**
Host Institution: Alma Mater Studiorum - Universita Di Bologna, IT

Light effected autonomous molecular pumps: Towards active transporters and actuating materials

The crucial role played by molecular motors in major biological processes gives a clue on the potential of these nanoscale devices for technology. Their exploitation depends on our ability to build working and robust artificial systems, and to interface them with their environment or other molecular constructs for using the motion to carry out tasks.

The goal of this project is to develop the first synthetic photochemical supramolecular pumps and to apply them for performing nanoscale transport functions and macroscopic actuation. The motor modules, which rely on a functioning and affordable minimalist design based on first principles and threaded topologies, operate autonomously away from equilibrium by using light as a clean energy source, can be switched on/off chemically, and are easy to make and functionalize. Appropriately designed motors will be embedded in the bilayer of vesicles to pump molecules across physically separated places, thereby photogenerating concentration gradients. In parallel we plan to arrange the pump modules in oligomeric tracks and investigate the autonomous, directional and processive displacement of a molecule over a few nm. These linear motors will be equipped with a cargo that can be loaded/unloaded with control, yielding the first man-made molecular transporters. Finally, we will integrate the pump components in polymeric scaffolds such that the photoinduced operation of the motors produces a non-equilibrium entanglement of the polymer chains, that can be eventually unravelled by chemical stimulation. Such materials may be used to convert, store, and reuse the energy of (sun)light upon demand.

All the above functionalities are unprecedented for wholly synthetic chemical structures. Their demonstration would be a landmark result in supramolecular chemistry and nanoscience, and open up radically new directions for nanotechnology, nanomedicine, and energy conversion.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714122	**chem-fs-MOF**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. CARLOS MARTI-GASTALDO**
Host Institution: Universitat De Valencia, ES

Chemical Engineering of Functional Stable Metal-Organic Frameworks: Porous Crystals and Thin Film Devices

Metal-Organic-Frameworks (MOFs) offer appealing advantages over classical solids from combination of high surface areas with the crystallinity of inorganic materials and the synthetic versatility (unlimited combination of metals and linkers for fine tuning of properties) and processability of organic materials. Provided chemical stability, I expect combination of porosity with manipulable electrical and optical properties to open a new world of possibilities, with MOFs playing an emerging role in fields of key environmental value like photovoltaics, photocatalysis or electrocatalysis. The conventional insulating character of MOFs and their poor chemical stability (only a minimum fraction are hydrolytically stable) are arguably the two key limitations hindering further development in this context.

With chem-fs-MOF I expect to deliver:

1. New synthetic routes specifically designed for producing new, hydrolytically stable Fe(III) and Ti(IV)-MOFs (new synthetic platforms for new materials).
2. More advanced crystalline materials to feature tunable function by chemical manipulation of MOF's optical/electrical properties and pore activity (function-led chemical engineering).
3. High-quality ultrathin films, reliant on the transfer of single-layers, alongside establishing the techniques required for evaluating their electric properties (key to device integration). Recent works on graphene and layered dichalcogenides anticipate the benefits of nanostructuration for more efficient optoelectronic devices. Notwithstanding great potential, this possibility remains still unexplored for MOFs.

Overall, I seek to exploit MOFs' unparalleled chemical/structural flexibility to produce advanced crystalline materials that combine hydrolytical stability and tunable performance to be used in environmentally relevant applications like visible light photocatalysis. This is an emerging research front that holds great potential for influencing future R&D in Chemistry and Materials Science.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715060	**CALCEAM**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. MARC-ETIENNE MORET**
Host Institution: Universiteit Utrecht, NL

Cooperative Acceptor Ligands for Catalysis with Earth-Abundant Metals

Homogeneous catalysis is of prime importance for the selective synthesis of high added value chemicals. Many of the currently available catalysts rely on noble metals (Ru, Os, Rh, Ir, Pd, Pt), which suffer from a high toxicity and environmental impact in addition to their high cost, calling for the development of new systems based on first-row transition metals (Mn, Fe, Co, Ni, Cu). The historical paradigm for catalyst design, i.e. one or more donor ligands giving electron density to stabilize a metal center and tune its reactivity, is currently being challenged by the development of acceptor ligands that mostly withdraw electron density from the metal center upon binding. In the last decade, such ligands – mostly based on boron and heavier main-group elements – have evolved from a structural curiosity to a powerful tool in designing new reactive units for homogeneous catalysis.

I will develop a novel class of ligands that use C=E (E=O, S, NR) multiple bonds anchored in close proximity to the metal by phosphine tethers. The electrophilic C=E multiple bond is designed to act as an acceptor moiety that adapts its binding mode to the electronic structure of reactive intermediates with the unique additional possibility of involving the lone pairs on heteroelement E in cooperative reactivity. Building on preliminary results showing that a C=O bond can function as a hemilabile ligand in a catalytic cycle, I will undertake a systematic, experimental and theoretical investigation of the structure and reactivity of M–C–E three membered rings formed by side-on coordination of C=E bonds to a first-row metal. Their ability to facilitate multi-electron transformations (oxidative addition, atom/group transfer reactions) will be investigated. In particular, hemilability of the C=E bond is expected to facilitate challenging C–C bond forming reactions mediated by Fe and Ni. This approach will demonstrate a new conceptual tool for the design of efficient base-metal catalysts.

Project End Date: **31-JUL-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715923	**SUPRACOP**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. GUSTAVO FERNANDEZ**
Host Institution: Westfaelische Wilhelms-Universitaet Muenster, DE

Systems Chemistry Approach towards Semiconductive Supramolecular Copolymers with Homo- and Heterometallophilic Interactions

Infinite one-dimensional structures with a metallic main chain of short metal-metal contacts have attracted considerable attention in the field of materials science for many decades due to their excellent optical properties and remarkable dichroism and electrical (semi)conductivity. These materials suffer, however, from decomposition prior to melting and low solubility and processability. The strategy of introducing alkyl side chains of different nature in the past two decades proved to be particularly successful towards better soluble materials or gels with implications in optoelectronics. However, this comes at the price of reduced bulk conductivities leading in some cases to electrical insulators due to the perturbation of the metal-metal contacts.

In this proposal, a Systems Chemistry approach will be introduced to create unprecedented supramolecular copolymers that are anticipated to exhibit: a) high solubility, reversibility and stability in organic solvents and water and, b) short metal contacts involving either positively and negatively charged metal ions of the same nature (Pt2+/Pt2-) or dissimilar metal centres (Pd(II)/Pt(II) and Ag(I)/Au(I)) with equivalent coordination geometry. To achieve this goal, ligands with an extended aromatic surface for pi-stacking supported by complementary non-covalent interactions have been selected to bring suitable metal ions in close proximity. This can be summarized in three approaches. 1) Optimization of the geometrical complementarity between the interacting ligands; 2) Introduction of hydrogen bonding and electrostatic complementarity between side groups, and 3) Exploiting weak interactions between geometrically equivalent electron rich and electron poor units. The extent of metal-metal interactions can be ultimately controlled by introducing suitable light switchable groups.

This concept is expected to provide access to novel, highly-ordered materials with rich photophysical and semiconductive properties.

Project End Date: **30-APR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716315	**AlCat**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. MICHAEL COWLEY**
Host Institution: The University Of Edinburgh, UK

Bond activation and catalysis with low-valent aluminium

This project will develop the principles required to enable bond-modifying redox catalysis based on aluminium by preparing and studying new Al(I) compounds capable of reversible oxidative addition.

Catalytic processes are involved in the synthesis of 75 % of all industrially produced chemicals, but most catalysts involved are based on precious metals such as rhodium, palladium or platinum. These metals are expensive and their supply limited and unstable; there is a significant need to develop the chemistry of non-precious metals as alternatives. On toxicity and abundance alone, aluminium is an attractive candidate. Furthermore, recent work, including in our group, has demonstrated that Al(I) compounds can perform a key step in catalytic cycles - the oxidative addition of E-H bonds.

In order to realise the significant potential of Al(I) for transition-metal style catalysis we urgently need to:
- establish the principles governing oxidative addition and reductive elimination reactivity in aluminium systems.
- know how the reactivity of Al(I) compounds can be controlled by varying properties of ligand frameworks.
- understand the onward reactivity of oxidative addition products of Al(I) to enable applications in catalysis.

In this project we will:

- Study mechanisms of oxidative addition and reductive elimination of a range of synthetically relevant bonds at Al(I) centres, establishing the principles governing this fundamental reactivity.
- Develop new ligand frameworks to support of Al(I) centres and evaluate the effect of the ligand on oxidative addition/reductive elimination at Al centres.
- Investigate methods for Al-mediated functionalisation of organic compounds by exploring the reactivity of E-H oxidative addition products with unsaturated organic compounds.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
717026	**SHINING**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. FENG GAO**
Host Institution: Linkopings Universitet, SE

Stable and High-Efficiency Perovskite Light-Emitting Diodes

Light-emitting diodes (LEDs), which emit light by a solid-state process called electroluminescence, are considered as the most promising energy-efficient technology for future lighting and display. It has been demonstrated that optimal use of LEDs could significantly reduce the world's electricity use for lighting from 20% to 4%. However, current LED technologies typically rely on expensive high-vacuum manufacturing processes, hampering their widespread applications. Therefore, it is highly desirable to develop low-cost LEDs based on solution-processed semiconductors.

A superstar in the family of solution-processed semiconductors is metal halide perovskites, which have shown great success in photovoltaic applications during the past few years. The same perovskites can also been applied in LEDs. Despite being at an early stage of development with associated challenges, metal halide perovskites provide great promise as a new generation of materials for low-cost LEDs.

This project aims to develop high-efficiency and stable perovskite LEDs based on solution-processed perovskites. Two different classes of low-dimensional perovskites will be investigated independently. These new perovskites materials will then be coupled with novel interface engineering to fabricate perovskite LEDs with the performance beyond the state of the art. At the core of the research is the synthesis of new perovskite nanostructures, combined with advanced spectroscopic characterization and device development. This project combines recent advances in perovskite optoelectronics and low-dimensional materials to create a new paradigm for perovskite LEDs. This research will also lead to the development of new perovskites materials which will serve future advances in photovoltaics, transistors, lasers, etc.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725523	**NO-ESKAPE**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. NATHANIEL MARTIN**
Host Institution: Universiteit Leiden, NL

Addressing Antibiotic Resistance: New Strategies for Overcoming the ESKAPE Pathogens

Antibiotic resistance poses an alarming threat to global health. Most worrisome are the so-called "ESKAPE" pathogens (E. faecium, S. aureus, K. pneumoniae, A. baumanii, P. aeruginosa, and Enterobacter species), a collection of organisms capable of escaping the effects of almost all conventional antibiotics. Key to combating drug-resistant bacteria is the identification of new antibacterial targets and the ability to exploit these targets with novel and unconventional antibiotics.

The microbial world produces a wealth of antibacterial compounds that, while not suitable for therapeutic use, operate by diverse and unique modes of action. This proposal describes innovative approaches aimed at the discovery and development of such compounds as leads towards novel antibiotics with entirely new modes of action. Using a multidisciplinary approach, firmly grounded in synthetic organic chemistry, I will prepare and validate new antibiotics that target the ESKAPE pathogens by exploiting mechanisms critical to their survival and/or resistance.

To tackle the Gram-positive ESKAPE pathogens a number of new approaches to interfering with bacterial cell wall biosynthesis will be examined. Specifically, novel (semi)synthetic compounds capable of binding to and sequestering various bacterial cell wall precursors will be prepared and their antibiotic activity assessed. To address the Gram-negative ESKAPE pathogens, inhibitors of the metallo-beta-lactamase enzymes responsible for much of their antibiotic resistance will be pursued. These inhibitors will be achieved via a combination of rational design strategies and innovative natural product screening approaches.

The 21st century threat of a post-antibiotic era makes clear the need for innovation in antibacterial drug discovery. The strategies outlined in this proposal address this threat head-on with the aim of delivering valuable lead compounds in pursuit of novel antibiotics.

Project End Date: **31-MAY-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725767	**hyControl**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. MIRKO CINCHETTI**
Host Institution: Technische Universitat Dortmund, DE

Coherent optical control of multi-functional nano-scale hybrid units

In the physics and chemistry of materials science, an intense focus of forefront research is the search for ever-smaller and ever-faster building blocks for information and communication technology (ICT) applications. The realization of next-generation devices, in ICT fields such as spintronics, spin-orbitronics and plasmonics, will depend decisively on our ability to generate new functionalities that can be actively controlled on the shortest length and time scales.

The groundbreaking idea of hyControl is to develop a conceptually new class of active ICT nano-scale materials by building functionality into the nano-scale object that naturally forms when an organic molecule is hybridized on a metallic surface: a nano-scale hybrid unit (NHyU). NHyUs will be realized by depositing selected organic molecules onto three classes of inorganic systems: transition metals; spin-textured materials such as Rashba systems and topological insulators; and magneto-plasmonic nano-structures. By tuning optical excitation to specific resonances, we will control the hybridization strength with ultrashort laser pulses, and thereby induce a coherent response in the spin, orbit, and/or electron degrees of freedom of the NHyU. Thereby we will achieve coherent control - at the molecular scale - of technologically important parameters, such as magnetization, plasmonic resonances, and spin texture. This hyControl concept will be implemented using a novel experimental method, spin- and phase-resolved orbital mapping, that is capable of resolving the transient spin-dependent electronic structure of precisely those valence band electrons which mediate the hybridization in a single NHyU.

While inspired by the latest achievements in molecular spintronics, hyControl will open the way to new technologies in various ICT applications, three of which - spintronics, spin-orbitronics, and plasmonics - have been selected to demonstrate the ability and versatility of optically controlled NHyUs.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
726470	**CAM-RIG**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. OREN SCHERMAN**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

ConfocAl Microscopy and real-time Rheology of dynamIc hyroGels

Hydrogels cross-linked through supramolecular interactions are highly dependant on the dynamic charac- teristics of the physical cross-links. Few fundamental studies have been undertaken to quantitatively de- scribe structure-property relationships for these types of systems. Hydrogels formed from CB[8]-mediated supramolecular physical cross-linking mechanisms have gained significant interest on account of their excel- lent physical and mechanical properties such as self-healing and shear-thinning. This supramolecular motif has been further exploited to introduce and compatibilise a wide variety of different materials into hydrogel networks without phase separation, forming hybrid composite hydrogels attributed with unique and emergent properties. This proposal aims to pioneer the combination of several state-of-the-art characterisation tech- niques into an unique experimental setup (CAM-RIG), which will combine super-resolution and confocal microscopy imaging modalities with simultaneous strain-controlled rheological measurements to investigate fundamental structure-property relationships of these systems. For the first time it will be possible to decon- volute the molecular-level dynamics of the supramolecular physical cross-links from chain entanglement of the polymeric networks and understand their relative contributions on the resultant properties of the hydrogels. Using the fundamental insight gained, a set of key parameters will be determined to maximise the potential of supramolecular biocompatible hydrogels, driving paradigm shifts in sustainable science and biomaterial applications through the precise tuning of physical properties.

Project End Date: **30-APR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
756277	**ATMEN**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. TOMA SUSI**
Host Institution: Universitaet Wien, AT

Atomic precision materials engineering

Despite more than fifty years of scientific progress since Richard Feynman's 1959 vision for nanotechnology, there is only one way to manipulate individual atoms in materials: scanning tunneling microscopy. Since the late 1980s, its atomically sharp tip has been used to move atoms over clean metal surfaces held at cryogenic temperatures. Scanning transmission electron microscopy, on the other hand, has been able to resolve atoms only more recently by focusing the electron beam with sub-atomic precision. This is especially useful in the two-dimensional form of hexagonally bonded carbon called graphene, which has superb electronic and mechanical properties. Several ways to further engineer those have been proposed, including by doping the structure with substitutional heteroatoms such as boron, nitrogen, phosphorus and silicon. My recent discovery that the scattering of the energetic imaging electrons can cause a silicon impurity to move through the graphene lattice has revealed a potential for atomically precise manipulation using the Ångström-sized electron probe. To develop this into a practical technique, improvements in the description of beam-induced displacements, advances in heteroatom implantation, and a concerted effort towards the automation of manipulations are required. My project tackles these in a multidisciplinary effort combining innovative computational techniques with pioneering experiments in an instrument where a low-energy ion implantation chamber is directly connected to an advanced electron microscope. To demonstrate the power of the method, I will prototype an atomic memory with an unprecedented memory density, and create heteroatom quantum corrals optimized for their plasmonic properties. The capability for atom-scale engineering of covalent materials opens a new vista for nanotechnology, pushing back the boundaries of the possible and allowing a plethora of materials science questions to be studied at the ultimate level of control.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
756575	**CoopCat**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. JESUS CAMPOS MANZANO**
Host Institution: Agencia Estatal Consejo Superior De Investigaciones Cientificas, ES

Cooperative Catalysis: Using Interdisciplinary Chemical Systems to Develop New Cooperative Catalysts

Catalysis, a multidisciplinary science at the heart of many industrial processes, is crucial to deliver future growth and minimize anthropogenic environmental impact, thus being critical to our quality of life. Thus, the development and fundamental understanding of innovative new catalyst systems has clear, direct and long-term benefits to the chemical manufacturing sector and to the broader knowledge-based economy.

In this ERC project I will develop novel innovative cooperative catalysts using interdisciplinary chemical systems based on main group elements, transition metals and molecular clusters to achieve better efficiency and improve chemical scope and sustainability of key chemical transformations.

This will be achieved through 3 complementary and original strategies based on catalytic cooperation: (i) Transition-Metal Frustrated Lewis Pairs (TM-FLPs); (ii) hybrid systems combining low-valent heavier main group elements with transition metals (Hybrid TM/MGs); and (iii) intercluster compounds (ICCs) as versatile heterogeneized materials for Green Catalysis.

These systems, of high synthetic feasibility, combine fundamental concepts from independent areas, e.g. FLPs and low-valent heavier main group elements with transition metal chemistry, and homogeneous with heterogeneous catalysis. The overall approach will be pivotal in discovering novel reactions that rely on the activation of otherwise unreactive substrates. The experience and knowledge gained from (i)-(iii) will be used to inform the design of a second generation of ICC materials in which at least one of the nanoscale bricks is based on polymetallic TM-FLPs or Hybrid TM/MG systems.

Delivering ground-breaking new fundamental science, this pioneering project will lay the foundation for future broad ranging benefits to a number of EU priority areas dependant on innovations in catalysis: innovative and sustainable future energy systems, solar technologies, sustainable chemistry, manufacturing, and healthcare.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
756962	**HYPERION**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. SAMUEL STRANKS**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

HYbrid PERovskites for Next GeneratION Solar Cells and Lighting

An emerging class of materials called hybrid perovskites is poised to revolutionise how power is both produced and consumed by enabling the production of highly-efficient, tunable solar photovoltaics (PV) and light-emitting diodes (LEDs) at exceptionally low cost. Although the efficiencies of perovskite devices are rising fast, both PV and LEDs fall short of out-performing current technology and reaching their theoretical performance limits. To achieve their full potential, parasitic non-radiative losses and bandgap instabilities from ionic segregation must be fundamentally understood and eliminated. HYPERION will address these issues by i) elucidating the origins of non-radiative decay and ion segregation in films and devices, ii) devising means to eliminate these processes, and iii) implementing optimised materials into boundary-pushing PV and LED devices. This will be achieved through a groundbreaking hierarchical analysis of the perovskite structures that not only characterises thin films and interfaces, but also the sub-units that comprise them, including grain-to-grain and sub-granular properties. The optoelectronic behaviour on these scales will be simultaneously correlated with local structural and chemical properties. HYPERION will use this fundamental understanding to eliminate non-radiative losses and ionic segregation on all scales through passivation treatments and compositional control. Addressing these knowledge gaps in the operation of perovskites will produce fundamental semiconductor science discoveries as well as illuminate routes to yield optimised and functional perovskites across the broad bandgap range 1.2–3.0 eV. These will be used to demonstrate all-perovskite tandem PV devices with efficiency exceeding crystalline silicon (26%), and white light LEDs with efficacies surpassing fluorescent light (50 lm/W). The work will realise the promise of perovskite technology as a versatile and scalable energy solution to secure a sustainable future.

Project End Date: **31-OCT-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757991	**enzC-Hem**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. ANTHONY GREEN**
Host Institution: The University Of Manchester, UK

Creating Versatile Metallo-Enzyme Environments for Selective C-H Activation Chemistry: Lignocellulose Deconstruction and Beyond

The availability of a versatile catalytic platform to precisely target and functionalize individual C-H bonds in complex organic molecules would revolutionize our synthetic strategies, leading to streamlined routes to high value chemicals and supporting the development of a 'greener' chemical industry. Although an impressive range of C-H functionalizations can be achieved with small transition metal complexes, site selectivity is often determined by features of the substrate, and not by the catalyst. A general approach to achieve the more aspirational 'catalyst controlled' transformations requires molecular recognition elements within the catalyst which: a) allow precise substrate orientation and b) can be tuned to alter selectivity. In principle, these requirements could be perfectly addressed by protein catalysts which can be readily adapted via laboratory evolution. However, enzyme engineering strategies are currently limited to Nature's twenty amino acid alphabet, severely limiting the range of metal co-ordination environments, and thus catalytic activities, that are accessible within proteins.

In enzC-Hem, I will exploit advanced protein engineering technology available in my laboratory to install 'chemically programmed' ligands and/or noble metal co-factors into selected enzyme scaffolds. I will show that the resulting C-H activation catalysts can be systematically optimized via directed evolution with an expanded genetic code using modern ultra-high throughput methods (>100 variants per second), yielding biocatalysts with augmented selectivity/activity profiles. Thus my approach merges the broad range of C-H functionalizations accessible with small molecule catalysts with precise control of selectivity provided by proteins. The biocatalysts developed will address major global challenges in biotechnology and synthetic chemistry, from enhancing lignocellulose derived biofuel production to revealing novel bioactive molecules via late-stage functionalizations.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759552	**SEC**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. ANDREW LAWRENCE**
Host Institution: The University Of Edinburgh, UK

Stereoretentive-Enantioconvergent Catalysis: A New Concept in Asymmetric Synthesis

This project will experimentally establish a new concept in asymmetric synthesis: stereoretentive-enantioconvergent catalysis. This will represent a completely new method for accessing enantiopure materials starting from racemic substrates and will therefore impact all areas of synthetic chemistry. The ability to synthesise chiral molecules in enantiopure form is vitally important, most recognisably for the pharmaceutical industry. This is because the molecules of life are chiral (e.g., D-sugars and L-amino acids) and enantiomers often interact very differently with living organisms. Classically, asymmetric synthesis utilising racemic substrates is limited to achieving a maximum yield of 50% (e.g., kinetic resolutions). Enantioconvergent catalysis avoids this limitation with both enantiomers of the starting material being converted into a single enantioenriched product, thanks to complex stereoablative or stereomutative de-racemisation processes. This project will establish a conceptually new stereoretentive-dimerisation approach that results in both enantiomers of the starting material being incorporated into the product with no de-racemisation required. This new concept will prove highly valuable for the synthesis of small enantiopure building blocks, which will be of high value in many areas of synthesis, and also for more complex late-stage transformations in complex molecule synthesis. Several approaches will be pursued to demonstrate proof-of-principle, and applications in the synthesis of complex natural and unnatural products will then be used to demonstrate the potential of stereoretentive-enantioconvergent catalysis in target-orientated synthesis.

Project End Date: **31-OCT-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759577	**EnBioN**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. CIRO CHIAPPINI**
Host Institution: King'S College London, UK

Engineering the Biointerface of Nanowires to Direct Stem Cell Differentiation

ENBION will engineer a platform to direct the differentiation of stem cells by developing principles for the rational design of the biointerface of nanowires.

It is increasingly evident that efficient tissue regeneration can only ensue from combining the regenerative potential of stem cells with regulatory stimuli from gene therapy and niche engineering. Yet, despite significant advances towards integrating these technologies, the necessary degree of control over cell fate remains elusive.

Vertical arrays of high aspect ratio nanostructures (nanowires) are rapidly emerging as promising tools to direct cell fate. Thanks to their unique biointerface, nanowires enable gene delivery, intracellular sensing, and direct stimulation of signalling pathways, achieving dynamic manipulation of cells and their environment.

This broad manipulation potential highlights the importance and timeliness of engineering nanowires for regenerative medicine. However, developing a nanowire platform to direct stem cell fate requires design principles based on the largely unknown biological processes governing their interaction with cells. Enabling localized, vector-free gene therapy through efficient transfection relies on understanding the still debated mechanisms by which nanowires induce membrane permeability. Directing cell reprogramming requires understanding the largely unexplored mechanosensory processes and the resulting epigenetic effects arising from the direct interaction of nanowires with multiple organelles within the cell. Engineering the cell microenvironment requires yet undeveloped strategies to localize signalling and transfection with a resolution comparable to the lengthscale of cells.

ENBION will develop this critical knowledge and integrate it into guidelines for dynamic manipulation of cells. Beyond the nanowire platform, the principles highlighted by this unique interface can guide the development of nanomaterials with improved control over cellular processes.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771834	**POPCRYSTAL**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. PAOLO FALCARO**
Host Institution: Technische Universitaet Graz, AT

Precisely Oriented Porous Crystalline Films and Patterns

Metal-Organic Frameworks (MOFs) are nanoporous crystalline solids with narrow pore distributions and high accessible surface areas. MOFs are typically prepared in a polycrystalline form via the self-assembly of inorganic (nodes) and organic (links) building units. This bottom-up approach allows for properties such as, pore size, topology and chemical functionality to be precisely tailored. Such synthetic control has identified MOFs as promising platform material for device fabrication in the areas of microelectronics, photonics, sensing. However, current methods for fabricating MOF films and patterns cannot generate precisely oriented crystals on commercially relevant scales (i.e. cm). Thus, limiting access to applications that require anisotropic functional properties (e.g. optics, electronics, separation).

POPCRYSTAL will enable the fabrication of films and patterns composed of precisely oriented MOF crystals by exploiting crystalline ceramics to guide the aligned growth of MOF crystals. Remarkably, the scale of these heteroepitaxially grown MOFs is solely determined by the ceramic precursor which can be easily synthesized on areas covering mm2 to cm2.
POPCRYSTAL will advance a proof of concept study by addressing the following important research aims: the basic understanding of the formation mechanism and rules governing the heteroepitaxial relationship (WP1), the extension to different ceramic-MOF systems (WP2), the control over crystalline porous film and pattern features (WP3) and the fabrication of a proof-of-concept that will highlight the importance of aligned pores for separation (WP4).

In summary, by exploiting the heteroepitaxial growth mechanism between ceramics and MOFs POPOCRYSTAL will fabricate unprecedented crystalline MOF films and patterns with precisely oriented nanopores and nanochannels. Thus POPCRYSTAL intercrosses and connects nanoscale chemistry, controlled self-assembly on a macroscale and nanoporous-based device fabrication.

Project End Date: **30-APR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771985	**Living Bionics**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. RYLIE GREEN**
Host Institution: Imperial College Of Science, Technology And Medicine, UK

Living bioelectronics: Bridging the interface between devices and tissues

When bionic devices such as cochlear implants, bionic eyes and brain-machine interfaces are implanted into the body they induce an inflammatory response that is difficult to control. Metals used historically for these types of devices are both stiff and inorganic, which makes them recognisable as foreign to the soft and organic human nervous system. Consequently, these implants are tolerated by the body rather than integrated and the device is walled off in a scar tissue capsule. As a result high powered and unsafe currents are required to activate tissues and produce a therapeutic response.

I have brought together concepts from tissue engineering for regenerative medicine and bionic device technologies to pioneer living bioelectronics – creating a functional neural cell component as part of the device to avert scar formation. My laboratory has established a range of novel conductive polymeric biomaterials which can be used to coat existing devices or fabricate new devices from conductive polymers, hydrogels, proteins and cells.

Living Bionics is based on a world-wide unique combination of technologies and proposes to combine electronic devices with cell laden polymers to generate devices that can bridge the implant interface and improve tissue integration. Pioneering and ground breaking research within Living Bionics includes:

• An engineered hydrogel that can support differentiation of stem cells into neural cell networks on devices

• 3D patterning of living polymer electrode arrays that contain cells

• Understanding of the combined effects of environmental, biological and electrical cues to guide cell fate and create connections to nerve tissues

• In vivo proof of principle in the murine model

Living Bionics will be a ground breaking step towards safer neural cell stimulation, which is more compatible with tissue survival and regeneration. This research will create a paradigm shift in biomedical electrode design with tremendous impact on healthcare worldwide.

Project End Date: **30-APR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772391	**Fields4CAT**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. ISMAEL DÍEZ**
Host Institution: King'S College London, UK

Force Fields in Redox Enzymatic Catalysis

Fields4CAT aims to identify the nature and directionality of the driving forces in a redox enzyme that govern the catalytic chemical process.

Industrial bio-manufacturing is one of the pillars of today's world economy making its way to a sustainable development. Redox enzymes catalyze the most demanding chemical reactions under mild conditions, such as the oxy-functionalization of non-activated hydrocarbons, which usually requires harsh reaction conditions. Enzyme Biotechnology has greatly progressed thanks to rational mutagenesis schemes that draw upon the static X-ray structural information. The high complexity of enzymatic catalysis has, however, hampered its development because a single point mutation near the active site can affect several relevant parameters at the same time, obscuring the interpretation and constraining the rational design of technological biocatalysts.

Fields4CAT proposes dissecting the relevant forces exerted over an individual catalytic active site in its wild-type state, and then using the resulting forces map to design enzyme/metal platforms with enhanced capabilities. To this aim, it develops in 3 blocks organized in a step-wise fashion: (i) block 1 sets up a electrochemical multi-stimuli single-protein toolbox (Ec-SPT) with capabilities to trap individual proteins in a nanoscale tunnelling junction and subject them to a variety of force stimuli, i.e. mechanical, electrostatic and magnetic. (ii) Block 2 designs the chemical electrical plugs that will specifically connect the enzyme to the junction electrodes with precise controlled orientation. (iii) Block 3 characterizes the single-protein electrical signatures of the enzyme activity and quantifies the catalytic effect of the different force stimuli along the vertical junction axis.

Fields4CAT will identify new guidelines to bioengineer a redox enzyme/metal platform with tuned catalytic activity, bringing about new breakthroughs in the future of Bio-Catalysis.

Project End Date: **29-FEB-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772462	**ProLiCell**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. JULIEN GAUTROT**
Host Institution: Queen Mary And Westfield College University Of London, UK

Engineered Protein Nanosheets at Liquid-Liquid Interfaces for Stem Cell Expansion, Sorting and Tissue Engineering

A long standing dogma in the field of cell-based technologies is that bulk mechanical properties of solid substrates are essential to enable cell spreading, proliferation and fate decision. The use of solid materials to culture adherent cells constitutes an important hurdle for the scale up, automation and speed up of cell culture and recovery. Our recent results show that bulk solid substrates are not necessary to promote cell adhesion, growth and fate regulation as adherent stem cells spread and proliferate readily at the surface of ultra-soft materials, even liquids. In such cases, cell adhesion is enabled by the formation of a mechanically strong layer (nanosheet) of proteins at the interface between the oil (liquid substrate) and aqueous medium. This key discovery opens the door to the engineering of protein nanosheets enabling the use of liquid, free-flowing substrates sustaining cell adhesion, expansion, isolation and recovery.

ProLiCell will design the biochemical and mechanical properties of extracellular matrix (ECM) protein nanosheets that can sustain the formation of adhesion protein complexes and support cell proliferation and culture on materials with very weak bulk mechanical properties (liquids). The engineered ECM nanosheets will be applied to: 1. the design of 3D bioreactors based on emulsions, for the culture of stem cells; 2. the formation of stem cell sheets at oil-water interfaces for tissue engineering; 3. the isolation and purification of stem cells using emulsions presenting antibody-adsorbed interfaces. ProLiCell will provide fundamental insights into ECM nanosheet design and advance our understanding of the mechanisms via which cells adhering to such interfaces sense and respond to nanoscale cues. Such fundamental understanding will enable liquid-liquid platforms to transform stem cell technologies by borrowing a wider range of processing and manufacturing concepts to the field of Chemical Engineering.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772564	**Morpheus**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. NATHALIE KATSONIS**
Host Institution: Universiteit Twente, NL

Morphogenesis of photo-mechanized molecular materials

The sophistication reached by organic chemistry has enabled the design and synthesis of a wide range of dynamic molecules that display controlled shape changes with an ever-increasing refinement. However, amplifying these molecular-scale dynamics to support shape-transformation in a broad range of macroscopic functions remains a key challenge.

To address this challenge, I draw inspiration from living materials where molecular machines maintain out of equilibrium states by ingenious coupling with their anisotropic supramolecular environment, and ultimately promote the appearance of emergent properties on higher levels of organization.

The aim of Morpheus is to develop shape-shifting materials and shape-generating photochemical systems by amplifying the motion of molecular machines over increasing length scales, towards the emergence of cohesive shape transformation in artificial tissue-like materials.

We will (i) develop motorized materials by coupling light-driven molecular motors to liquid crystals and pre-program photoreaction-diffusion processes to achieve continuous motion; (ii) combine microfluidics with the anisotropic response of liquid crystal elastomers to create a library of shape-shifting bubbles and shells that undergo pre-programmed shape modification under irradiation with light; (iii) promote adhesion between units of mechanized matter, while preserving their original shape-shifting and shape-generating properties; and (iv) assemble tissue-like morphing materials from large cohesive networks of shape-shifting micro-spheres.

This project will lay the scientific foundation for a new and multidisciplinary approach towards shape-generating molecular materials. It will yield unprecedented examples of emergent dynamics, provide simple models to untangle the underpinnings of mechanical transduction in nature, and contribute to developing new paradigms for the design of active matter.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
773048	**MMGNRs**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. LAPO BOGANI**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Molecular Magnetic Graphene Nanoribbons

Intense research efforts are currently aimed at establishing a fundamental link between spintronics, molecular electronics and quantum computation. Novel materials could usher a true revolution in this area, and magnetic graphene nanoribbons, in particular, have attracted impressive theoretical attention. However, creating them with the necessary level of precision has, until now, proved elusive, so that the extensive theoretical work remains fundamentally untested, and the applicative potential untapped.

MMGNRs will investigate these uncharted waters, by developing a radically new approach: instead of the usual methods of cutting out graphene nanoribbons from large sheets, or randomly placing magnetic molecules on graphene surfaces, we will create graphene nanoribbons from a molecular bottom-up synthetic procedure, and attach molecular magnetic centres to their sides, at well-defined periodic intervals. In this way, a spin density is injected into the graphene backbone, and the homogeneity of the sample allows studying edge spin with unprecedented accuracy.

MMGNRs will test the chemical possibilities offered by this approach, and will then use low-temperature transport and pulsed electron-paramagnetic-resonance spectroscopy to reveal the classical and quantum magnetic properties of graphene spin states.

The success of MMGNRs will answer three fundamental questions: are our extensive theories of graphene magnetic states, for which there is no clean experimental counterpart, right? Can we use graphene magnetic states to perform quantum logic operations? Is it possible to push the quantum effects to high temperatures, and include them into electronic nanodevices? While answering these questions, MMGNRs will open a totally new area of chemical synthesis, redefine our experimental and theoretical knowledge of spins in graphene, and assess the limits and applicative potential of graphene and molecular spintronic devices.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
773264	**LACOPAROM**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. SYUZANNA HARUTYUNYAN**
Host Institution: Rijksuniversiteit Groningen, NL

Lewis acid promoted copper catalysis to functionalise and dearomatise arenes

Aromatic compounds are cheap and readily available, making them ideal starting materials for the synthesis of chiral alicyclic compounds, important synthetic building blocks for both natural product synthesis and drug discovery. However, general strategies for efficient, catalytic dearomatisation of aromatics are lacking.

This proposal aims to fill this gap by developing general asymmetric methods for dearomatisation reactions of both electron-rich and electron-deficient aromatics. It relies on an innovative approach based on LA activation of the arenes, followed by copper catalyzed carbon-carbon bond forming reactions, with a special focus on environmentally benign and cost-effective processes.

To achieve the overall aim of the proposed project, the research program is composed of four distinct but complementary research lines aiming at catalytic asymmetric dearomatisation/carbon-carbon bond forming reactions using:

- Electron-deficient carbonyl substituted arenes
- Pyridines and other N-containing heteroarenes
- Phenols and anilines and fused analogues
- Benzylic aromatic systems

The remarkable and novel feature of this strategy is that it enables for the first time selective catalytic asymmetric dearomatisations of various classes of aromatic substrates following a general, unified concept. Furthermore, since sequential bond constructions take place in a single synthetic operation, a rapid increase of molecular complexity can be achieved at greatly reduced cost and increased atom-efficiency, thereby contributing to a more sustainable future. Consequently, there is huge potential for this strategy to become an invaluable instrument to access a wide variety of chiral carbocyclic compounds and I anticipate it will have a significant impact in the field of organic synthesis.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
786976	**BioMet**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. ILAN MAREK**
Host Institution: Technion - Israel Institute Of Technology, IL

Selective Functionalization of Saturated Hydrocarbons

Despite that C–H functionalization represents a paradigm shift from the standard logic of organic synthesis, the selective activation of non-functionalized alkanes has puzzled chemists for centuries and is always referred to one of the remaining major challenges in chemical sciences. Alkanes are inert compounds representing the major constituents of natural gas and petroleum. Converting these cheap and widely available hydrocarbon feedstocks into added-value intermediates would tremendously affect the field of chemistry. For long saturated hydrocarbons, one must distinguish between non-equivalent but chemically very similar alkane substrate C−H bonds, and for functionalization at the terminus position, one must favor activation of the stronger, primary C−H bonds at the expense of weaker and numerous secondary C-H bonds. The goal of this work is to develop a general principle in organic synthesis for the preparation of a wide variety of more complex molecular architectures from saturated hydrocarbons. In our approach, the alkane will first be transformed into an alkene that will subsequently be engaged in a metal-catalyzed hydrometalation/migration sequence. The first step of the sequence, ideally represented by the removal of two hydrogen atoms, will be performed by the use of a mutated strain of Rhodococcus. The position and geometry of the formed double bond has no effect on the second step of the reaction as the metal-catalyzed hydrometalation/migration will isomerize the double bond along the carbon skeleton to selectively produce the primary organometallic species. Trapping the resulting organometallic derivatives with a large variety of electrophiles will provide the desired functionalized alkane. This work will lead to the invention of new, selective and efficient processes for the utilization of simple hydrocarbons and valorize the synthetic potential of raw hydrocarbon feedstock for the environmentally benign production of new compounds and new materials.

Project End Date: **31-OCT-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787073	**ADOR**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. RUSSELL MORRIS**
Host Institution: The University Court Of The University Of St Andrews, UK

Assembly-disassembly-organisation-reassembly of microporous materials

Microporous materials are an important class of solid; the two main members of this family are zeolites and metal-organic frameworks (MOFs). Zeolites are industrial solids whose applications range from catalysis, through ion exchange and adsorption technologies to medicine. MOFs are some of the most exciting new materials to have been developed over the last two decades, and they are just beginning to be applied commercially.

Over recent years the applicant's group has developed new synthetic strategies to prepare microporous materials, called the Assembly-Disassembly-Organisation-Reassembly (ADOR) process. In significant preliminary work the ADOR process has shown to be an extremely important new synthetic methodology that differs fundamentally from traditional solvothermal methods.

In this project I will look to overturn the conventional thinking in materials science by developing methodologies that can target both zeolites and MOF materials that are difficult to prepare using traditional methods – the so-called 'unfeasible' materials. The importance of such a new methodology is that it will open up routes to materials that have different properties (both chemical and topological) to those we currently have. Since zeolites and MOFs have so many actual and potential uses, the preparation of materials with different properties has a high chance of leading to new technologies in the medium/long term. To complete the major objective I will look to complete four closely linked activities covering the development of design strategies for zeolites and MOFs (activities 1 & 2), mechanistic studies to understand the process at the molecular level using in situ characterisation techniques (activity 3) and an exploration of potential applied science for the prepared materials (activity 4).

Project End Date: **30-SEP-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788143	**RECGLYCANMR**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. JESÚS JIMÉNEZ-BARBERO**
Host Institution: Asociacion Centro De Investigacion Cooperativa En Biociencias, ES

Breaking the limits in glycan recognition by NMR

Carbohydrates (glycans, sugars) play key roles in virtually all biological events. Given their chemical complexity, understanding their roles in nature requires a multidisciplinary approach. Research in the field is growing, since advances in the area could be part of the solution to many health issues. However, we lack full knowledge on the role of most glycan-mediated events especially at the resolution required from a chemical perspective to manipulate them and create new probes and eventually drugs. Understanding sugar recognition remains a major challenge in science. Although X-ray diffraction has been employed to study sugar/protein complexes, a recent report has highlighted that most sugar conformers deposited in the Protein Data Bank are incorrect. Flexible glycans are handled poorly in X-ray: errors reflect incorrect refinement of sugars, with huge implications when interpreted in the biocontext.I propose to address glycan recognition by using a multidisciplinary approach, combining synthesis, molecular biology and biophysics, with a prominent role for NMR. In RECGLYCANMR I will develop new NMR protocols to decipher key glycan recognition aspects beyond current knowledge: the role of presentation and dynamics and understanding the mechanisms behind the exquisite receptor and ligand selectivity. Importantly, till now, sugar recognition NMR studies have been exclusively limited to in vitro. RECGLYCANMR will break the limits of NMR, studying the interactions in-cell, a crowded ambient where viscosity is doubled respect to water. I am in a unique position to approach this project due to my wide expertise in NMR and the network of collaborators I have established for years, enabling me to access a large variety of synthetic sugars. Discovering the molecular bases of in-cell interactions will provide groundbreaking information on sugar chemical biology and will open unexplored avenues for approaching sugar-associated diseases, as inflammation and viral infections

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788222	**Mol-2D**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. EUGENIO CORONADO**
Host Institution: Universitat De Valencia, ES

Molecule-induced control over 2D Materials

We propose to create heterostructures based on functional molecules and 2D materials. As molecular systems we focus on bistable magnetic molecules able to switch between two spin states upon the application of an external stimulus (temperature, light, pressure, electric field etc.). As 2D materials we concentrate on those exhibiting in particular superconductivity or magnetism. The driving idea is to tune/improve the properties of the "all surface" 2D material via an active control of the hybrid interface. This concept, which goes much beyond the conventional chemical functionalization of a 2D material, will provide an entire new class of smart molecular/2D heterostructures, which may be at the origin of a novel generation of hybrid materials and devices of direct application in highly topical fields like electronics, spintronics, molecular sensing and energy storage. Through this molecular approach, we will address major challenges in different areas of the 2D research: i) in 2D physics, we investigate the new properties that should appear in heterostructures involving 2D superconductors and 2D magnets or magnetic molecules; ii) in 2D electronics, we explore the possibility of tuning the superconducting/magnetic properties of a 2D material by applying an external stimulus (light for example), or to design smart electronic/spintronic devices able to respond to physical (light, magnetic field, etc.) or chemical stimuli (trapping of molecules); iii) in 2D composite materials, a general goal is to design hybrid molecular/2D materials with improved properties with respect to the pure 2D material to be used in the fabrication of energy storage devices. To reach these challenging goals an integrative and multidisciplinary approach is proposed in which various facets of chemistry – coordination, solid-state and supramolecular chemistry – are coupled with physics, materials science and nanotechnology.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802929	**ChemLife**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. LARISA FLOREA**
Host Institution: The Provost, Fellows, Foundation Scholars & The Other Members Of Board Of The College Of The Holy & Undivided Trinity Of Queen Elizabeth Near Dublin, IE

Artificial micro-vehicles with life-like behaviour

One of the most interesting properties of living organisms is the way in which they can sense and respond to changes by moving. Movement has been essential to the survival of all life; even units as small as cells can react to different chemicals through movement. This is a phenomenon known as chemotaxis. Bacteria use chemotaxis to find sources of food, while white blood cells use chemotaxis to follow a chemical trail left by a virus, then find it and destroy it. Throughout areas of science, from robotics to drug delivery, if we could mimic a fraction of this fascinating complexity, the possibilities would be endless.

Imagine micro-structured vehicles, which could 'navigate' through complex fluidic environments, and could effectively 'recognise', 'sense', 'diagnose' and 'treat' a variety of conditions. This is exactly what this proposed project, ChemLife, will explore. I will make smart droplets which travel through complicated mazes by chemotaxis, communicate with each other, and move to find their partners or locate and neutralise a 'droplet intruder'. Other biological systems have much more complicated means of movement, such as swimming, crawling or gliding along surfaces. In an attempt to replicate this, I will fabricate 'swimmers' and 'crawlers', from soft materials which will move independently and travel through liquids or at the bottom of fluidic channels. Not only will these micro-vehicles be able to travel inside fluids, but they will also be able to detect molecules, signal to other vehicles, and repair problems which they encounter. They underpin a key ambition of ChemLife: the realisation of a Biomimetic Toolbox, a library of adaptable vehicles, which can be demonstrated in a wide range of scenarios. The assembly of these micro-vehicles in to 'smart' societies which can perform complicated tasks would be a really exciting achievement, with the potential to become a disruptive foundational breakthrough for movement and transport at the micro-scale.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802940	**inClTe**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. KIM BONGER**
Host Institution: Stichting Katholieke Universiteit, NL

Seeing Citrulline: A Molecular Toolbox for Peptidyl Arginine Deiminases

Roughly 1% of the world's population is affected by rheumatoid arthritis (RA); a devastating autoimmune disease causing cartilage destruction and bone erosion. Recent evidences suggest that dysregulation of Peptidyl Arginine Deiminase (PAD) levels are associated with the onset of the disease, leading to the production of antibodies targeting the citrullinated neoepitopes. The exact role of each of the PAD isotypes in these pathological processes is unknown and fundamental questions on the intracellular activation mechanism and substrate specificity remain unanswered. Moreover, isoform specific and high affinity enzyme inhibitors are lacking thereby not only hampering fundamental research towards each PAD isotype, but also excluding PAD as a potential therapeutic target for these diseases.

This proposal is aimed at developing innovative chemical biology- and molecular tools to study PAD functioning and protein citrullination in health and disease. The work reflects my interdisciplinary experiences as well as my interest I have obtained over the last years in chemical immunology as well as my ambition to improve patients wellbeing. More detailed, I aim to 1) find unknown PAD modulators, 2) find PAD substrates, 3) find selective and high affinity PAD inhibitors using enzyme-templated inhibitor evolution as novel lead discovery strategy, 4) explore multifunctional targeted PAD 'nanosponges' as advanced avidity-based nanomedicine approach and 5) explore unprecedented citrulline 'eraser' enzymes by innovative chemical biology strategies.

The workpackages described in this ambitious and highly interdisciplinary proposal deliver high-end molecules and methods that can be used to answer fundamental (conflicting) questions on citrullination and PAD biology. Moreover, possible molecular leads and advanced therapeutic insights are provided thereby centring PAD as therapeutic target for citrulline-mediated autoimmune diseases such as RA.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803426	**ELDORADO**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. ALEXANDER BREDER**
Host Institution: Universitaet Regensburg, DE

Electrophilicity-Lifting Directed by Organochalcogen Redox-Auxiliaries and Diversiform Organocatalysis

The implementation of viable practices for the ecologically cognizant production and consumption of energy and renewable resources rank among the most pressing societal challenges of the 21st century. Against this background, the design and development of innovative concepts for the sustainable use of energy and energy-rich compounds from regenerative sources becomes a matter of profound technological and scientific pertinence. A promising approach that has been put forward in the context of chemical synthesis is the application of visible light as an inexpensive source of energy and air as an abundant and gratuitous oxidant for the derivatization of certain hydrocarbons. Despite the enormous economic and ecological benefits associated with the use of light and air as integral components of redox reactions, the realization of such processes is strikingly limited to very isolated applications. Consequently, this methodological deficit represents a momentous opportunity for modern chemical sciences to lastingly transform the routine lines of action for the oxidative manipulation of organic molecules. A key issue that needs to be taken into consideration for the design of efficient light-driven aerobic oxidation protocols is the identification of proper catalyst systems that allow for the site- and chemoselective activation of individual bonds within polyatomic frameworks. In this regard, the prime objective of the proposed research program is the rational design of non-metallic and in part cooperative catalysis regimes as enabling technologies for the electrophilic activation of non-aromatic carbon–carbon multiple- and carbon-chalcogen single bonds to facilitate a wide and diverse array of heretofore unprecedented oxidative coupling-, addition-, and rearrangement reactions. To demonstrate its utility in a superordinate context, this methodological concept will be applied in highly modular enantioselective syntheses of biologically relevant polyketide natural products.

Project End Date: **31-JUL-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803758	**3D-FNPWriting**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. ANNETTE ANDRIEU-BRUNSEN**
Host Institution: Technische Universitaet Darmstadt, DE

Unprecedented spatial control of porosity and functionality in nanoporous membranes through 3D printing and microscopy for polymer writing

Membranes are key materials in our life. Nature offers high performance membranes relying on a parallel local regulation of nanopore structure, functional placement, membrane composition and architecture. Existing technological membranes are key materials in separation, recycling, sensing, energy conversion, being essential components for a sustainable future. But their performance is far away from their natural counterparts. One reason for this performance gap is the lack of 3D nanolocal control in membrane design. This applies to each individual nanopore but as well to the membrane architecture. This proposal aims to implement 3D printing (additive manufacturing, top down) and complex near-field and total internal reflection (TIR) high resolution microscopy induced polymer writing (bottom up) to nanolocally control in hierarchical nanoporous membranes spatially and independent of each other: porosity, pore functionalization, membrane architecture, composition. This disruptive technology platform will make accessible to date unachieved, highly accurate asymmetric nanopores and multifunctional, hierarchical membrane architecture/ composition and thus highly selective, directed, transport with tuneable rates. 3D-FNPWriting will demonstrate this for the increasing class of metal nanoparticle/ salt pollutants aiming for tuneable, selective, directed transport based monitoring and recycling instead of size-based filtration, accumulation into sewerage and distribution into nature. Specifically, the potential of this disruptive technology with respect to transport design will be demonstrated for a) a 3D-printed in-situ functionalized nanoporous fiber architecture and b) a printed, nanolocally near-field and TIR-microscopy polymer functionalized membrane representing a thin separation layer. This will open systematic understanding of nanolocal functional control on transport and new perspectives in water/ energy management for future smart industry/ homes.

Project End Date: **31-MAR-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804106	**ReverseAndCat**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. PAWEL DYDIO**
Host Institution: Centre International De Recherche Aux Frontieres De La Chimie, FR

Reversible Creation of Non-Inherent Reactivity Patterns in Catalytic Organic Synthesis

Current methods in organic synthesis only enable reactions at the most reactive bonds or at bonds predisposed by specific directing groups. Consequently, many less reactive bonds, including numerous C-H and C-C bonds, cannot be functionalized, enormously limiting the scope of possible transformations. To overcome these limitations, I propose Reverse&Cat, a revolutionary strategy using a novel method to change the reactivity pattern of molecules. This strategy combines the dynamic equilibrium mediated by the first catalyst and a functionalization reaction catalyzed by the second catalyst. The originality of the transformation stems from exploiting three simultaneous processes: (i) the dynamic exchange of one functional group (FG) for another FG that modulates the reactivity of the substrate; (ii) the functionalization of the temporarily activated bond; and (iii) the restoration of the initial FG. In essence, the processes (i) and (iii) – the components of the dynamic equilibrium – realize the novel concept of the temporary creation of non-inherent reactivity of a substrate.

The program is divided in three phases, which will establish the full potential of the strategy. In phase A, I will develop a set of new reactions enabled by the bi-catalytic systems. I will exploit two types of reversible reactions: (1) reversible oxidation of alcohols, which delivers temporarily activated aldehydes/ketones, with the distinct reactivity of their C-H bonds; and (2) reversible retro-hydrofunctionalization of nitriles or their analogues, which delivers temporarily activated alkenes, containing allylic C-H and C=C bonds. In phase B, I will conduct detailed mechanistic studies to gain the mechanistic understanding and enable further rational development. In phase C, I will establish the utility of this new strategy in practical organic synthesis. Overall, the strategy will open a new dimension of reactivity, with prospective applications in production of fine-chemicals and materials.

Project End Date: **31-OCT-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804110	**2D-PnictoChem**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. GONZALO ABELLAN SAEZ**
Host Institution: Universitat De Valencia, ES

Chemistry and Interface Control of Novel 2D-Pnictogen Nanomaterials

2D-PnictoChem aims at exploring the Chemistry of a novel class of graphene-like 2D layered elemental materials of group 15, the pnictogens: P, As, Sb, and Bi. In the last few years, these materials have taken the field of Materials Science by storm since they can outperform and/or complement graphene properties. Their strongly layer-dependent unique properties range from semiconducting to metallic, including high carrier mobilities, tunable bandgaps, strong spin-orbit coupling or transparency. However, the Chemistry of pnictogens is still in its infancy, remaining largely unexplored. This is the niche that 2D-PnictoChem aims to fill. By mastering the interface chemistry, we will develop the assembly of 2Dpnictogens in complex hybrid heterostructures for the first time. Success will rely on a cross-disciplinary approach combining both Inorganic- and Organic Chemistry with Solid-state Physics, including: 1) Synthetizing and exfoliating high quality ultra-thin layer pnictogens, providing reliable access down to the monolayer limit. 2) Achieving their chemical functionalization via both non-covalent and covalent approaches in order to tailor at will their properties, decipher reactivity patterns and enable controlled doping avenues. 3) Developing hybrid architectures through a precise chemical control of the interface, in order to promote unprecedented access to novel heterostructures. 4) Exploring novel applications concepts achieving outstanding performances. These are all priorities in the European Union agenda aimed at securing an affordable, clean energy future by developing more efficient hybrid systems for batteries, electronic devices or applications in catalysis. The opportunity is unique to reduce Europe's dependence on external technology and the PI's background is ideally suited to tackle these objectives, counting as well on a multidisciplinary team of international collaborators.

Project End Date: **31-OCT-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
805021	**TESLA**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. SONIA CONESA BOJ**
Host Institution: Technische Universiteit Delft, NL

Living on the Edge: Tunable Electronics from Edge Structures in 1D Layered Materials

One of the driving forces of the ongoing nanotechnology revolution is the ever-improving ability to understand and control the properties of quantum matter even down to the atomic scale. Key drivers of this revolution are layered materials like transition metal dichalcogenides (TMD). The realisation of novel TMD-based electronic devices relies heavily on understanding the relation between structural and electrical properties at the nanoscale. Crucially, one-dimensional (1D) TMDs have been predicted to exhibit striking functionalities including metallic edge states, ferromagnetic behaviour, and mobilities that are not suppressed as compared to their 2D counterparts. Indeed, in the 1D nanoscale limit, the lateral edges of TMDs become dominant, opening novel opportunities to tune edge-induced electrical properties leading to i.e. enhanced charge carrier mobility.

However, these predictions for novel phenomena in 1D TMDs lack experimental verification, due to the challenge in accessing the relevant information at the nanoscale. I propose to unravel the interplay between structural and electrical edge-induced properties by exploiting recent breakthroughs in electron microscopy (EM) allowing simultaneous unprecedented spatial and spectral resolution. I will focus on MoS2 nanoribbons, and use electron-energy loss spectroscopy to map the electronic properties at the nanometer-scale. Beyond the optimization of EM for 1D TMD characterization, I will investigate semiconducting-to-metal and ferromagnetic transitions by realising controllable edge structures. I have an extensive track record in pushing the frontier of EM characterization and growing nanostructures. I recently demonstrated the feasibility of pinning down the interplay between structure and electronic properties at the edges of 2D MoS2. This proposal will provide input towards novel quantum technologies for developing low-energy-consumption tunable electronics, efficient signal processing and quantum computation.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
814804	**MOF-reactors**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. EMILIO PARDO**
Host Institution: Universitat De Valencia, ES

Metal-Organic Frameworks as Chemical Reactors for the Synthesis of Well-Defined Sub-Nanometer Metal Clusters

Humankind advancement is connected to the use and development of metal forms. Recent works have unveiled exceptional properties –such as luminescence, biocompatibility, antitumoral activity or a superlative catalytic activity– for small aggregations of metal atoms, so–called sub–nanometer metal clusters (SNMCs). Despite this importance, the gram-scale synthesis of structurally and electronically well–defined SNMCs is still far from being a reality.

The present proposal situates at the centre of such weakness and aims at making a breakthrough step-change on the use of metal-organic frameworks (MOFs) as chemical reactors for the in–situ synthesis of stable ligand-free SNMCs with such unique properties. This challenging synthetic strategy, which is assisted by striking published and inedited preliminary results, has solid foundations. Firstly, the design and large-scale preparation of cheap and novel families of highly robust and crystalline MOFs with tailor-made functional channels to be used as chemical reactors. Secondly, the application of solid-state post-synthetic methods to drive the multigram-scale preparation of unique ligand-free homo- and heterometallic SNMCs, which are, in the best-case scenario, very difficult to be obtained and stabilised outside the channels. Last but not least, single-crystal X-Ray diffraction will be used as the definitive tool for the characterisation, at the atomic level, of such ultrasmall species offering unprecedented snapshots about their real structures and formation mechanisms.

The ultimate goal will be upscaling this synthetic strategy aiming at the large-scale fabrication of SNMCs and their industrial application will be then evaluated. A successful achievement of all the aforementioned objectives of this ground-breaking project would open new routes for the use of MOFs as chemical reactors to manufacture, at competitive prices, MOF-driven, structurally and electronically well–defined, ligand–free SNMCs in a multigram-scale.

Project End Date: **29-FEB-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
816856	**InOutBioLight**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. RUBÉN COSTA**
Host Institution: Fundacion Imdea Materiales, ES

Advanced biohybrid lighting and photovoltaic devices

InOutBioLight aims to design multifunctional rubbers with enhanced mechanical, thermal, color-converting, and light-guiding features towards advanced biohybrid lighting and photovoltaic technologies. The latter are placed at the forefront of the EU efforts for low-cost production and efficient consumption of electricity, a critical issue for a sustainable development.

In this context, the use of biomolecules as functional components in lighting and photovoltaic devices is still a challenge, as they quickly denature under storage and device operation conditions. This paradigm has changed using an innovative rubber-like material, in which the biofunctionality is long preserved. As a proof-of-concept, color down-converting rubbers based on fluorescent proteins were used to design the first biohybrid white light-emitting diode (bio-HWLED). To develop a new generation of biohybrid devices, InOutBioLight will address the following critical issues, namely i) the nature of the protein-matrix stabilization, ii) how to enhance the thermal/mechanical features, iii) how to design multifunctional rubbers, iv) how to mimic natural patterns for light-guiding, and v) how to expand the technological use of the rubber approach.

To achieve these goals, InOutBioLight involves comprehensive spectroscopic, microscopic, and mechanical studies to investigate the protein-matrix interaction using new polymer matrices, additives, and protein-based nanoparticles. In addition, the mechanical, thermal, and light-coupling features will be enhanced using structural biocompounds and reproducing biomorphic patterns. As such, InOutBioLight offers three major advances: i) a thorough scientific basis for the rubber approach, ii) a significant thrust of the emerging bio-HWLEDs, and iii) innovative breakthroughs beyond state-of-the-art biohybrid solar cells.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818862	**HighPotOx**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. SEBASTIAN HASENSTAB-RIEDEL**
Host Institution: Freie Universitaet Berlin, DE

Exploring the Limits of High Potential Oxidizers
Prediction, Validation and Preparation of Unusual Molecules at the Edge of Stability

The very well-known concept of formal oxidation states, used e. g. for redox reactions is one of the most fundamental ones in general chemistry. However, in the area of very strong oxidizers even the familiar oxido(-II) ligand becomes redox-innocent and assigning oxidation states becomes ambiguous. Very strong (super-) oxidizers are compounds whose oxidizing strength exceeds that of elemental F2. Anyhow, not only molecular oxidizer but also their interaction with the environment in different media needs to be considered, as these dramatically affect their intrinsic oxidizing strength. Here we propose novel conjugate oxidizer/Lewis or Brønsted acid systems with extremely high ox. power. These new ox. media make use of the alliance of high ox. strength and Lewis /Brønsted super acidity. The investigation and development of oxidizers is of essential interest in all areas of chemistry and beyond. Unfortunately a detailed understanding of this fundamental chemistry is still lacking. Here we describe based on three work strands PV, MI, and BP, how we aim at a more fundamental understanding of such systems. The undertaken research, which includes qc investigations, molecular characterizations in matrices and synthetic fluorine chemistry as well as oxido complexes is summarized in five work packages describing different prototype areas (organigram). Based on the gained knowledge, the project will rank and specify such oxidizers and the mechanism leading to ox. media. By using the threefold work strand approach, our project will guide us in a systematic discovery of the systems with high application potential in terms of selectivity and disposability, and oxidizing systems with high to ultrahigh oxidation potentials, and into the chemical terra incognita of fragile molecules at the edge of stability. We envision to highlight that the outcome of the project will be extremely useful for scientists from almost all fields of chemistry and related disciplines.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819075	**MechanoTubes**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. TIBOR KUDERNAC**
Host Institution: Universiteit Twente, NL

Supramolecular machineries with life-like mechanical functions

Artificial molecular motors and switches have the potential to become a core part of nanotechnology. However, a wide gap in length scales still remains unaccounted for, between the operation of these molecules in solution, where their individual mechanical action is randomly dispersed in the Brownian storm, and on the other hand their action at the macroscopic level, e.g. in polymer networks and crystals.

This proposal is about bridging this gap, by developing chemo-mechanical transduction strategies that will allow dynamic molecules to perform a range of unprecedented tasks, e.g. by generating strong directional forces at the nanoscale, and through shape-shifting microscopic formations.

This project aims to harness the mechanically-purposeful motion of dynamic molecules as to generate measurable forces from the nanoscale, and ultimately establish operational principles for chemo-mechanical transduction in supramolecular systems.

In my wholly synthetic approach, I draw inspiration from the operational principles of microtubules. I will incorporate molecular photo-switches into supramolecular tubes, and enable the controlled growth and disassembly of the tubes by using light as the energy input. Thus, I will: (i) Synthesize stiff supramolecular tubes that grow actively under continuous illumination, and disassemble with a power stroke as soon as illumination stops; (ii) Measure, and harvest the forces generated by the tubes to manipulate individual nanoparticles with a sense of directionality; and (iii) Encapsulate the tubes into water droplets and vesicles, to yield shape-shifting, and eventually rudimentary splitting models for cells.

This project reaches beyond the state of the art in adaptive molecular nano-systems, by pioneering strategies to engineer and harness strain in supramolecular assemblies. It thus lays the foundations for machineries that are capable of manipulating matter at length scales that are also those at which the cytoskeleton operates.

Project End Date: **29-FEB-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819856	**SUPRAVACC**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. POL BESENIUS**
Host Institution: Johannes Gutenberg Universitaet Mainz, DE

Supramolecular engineering of glycan-decorated peptides as synthetic vaccines

The main and most important feature of vaccines is the induction of an immunological memory response, which is key to providing long-term protection against pathogens. The current strategies for potent antibacterial and antiviral vaccines employ conjugation of pathogen specific entities onto carrier proteins, and are limited to formulations that suffer from low stability and short shelf-lives, and are thus not viable in developing countries. Strategies for the development of new vaccinations against endogenous diseases like cancer further remain an unmet challenge, since current methodologies suffer from a lack of a modular and tailored vaccine-specific functionalisation. I therefore propose a radically new design approach in the development of fully synthetic molecular vaccines. My team will synthesise carbohydrate and glycopeptide appended epitopes that are grafted onto supramolecular building blocks. These units can be individually designed to attach disease specific antigens and immunostimulants. Due to their self-assembling properties into nanoscaled pathogen mimetic particles, they serve as a supramolecular subunit vaccine toolbox. By developing a universal supramolecular polymer platform, we will construct multipotent vaccines from glycan-decorated peptides, that combine the activity of protein conjugates with the facile handling, precise composition and increased stability of traditional small molecule pharmaceutical compounds.
SUPRAVACC will pioneer the design of minimalistic and broadly applicable vaccines, and will evaluate the supramolecular engineering approach for immunisations against antibacterial diseases, as well as for applications as antitumour vaccine candidates. The fundamental insights gained will drive a paradigm shift in the design and preparation of vaccine candidates in academic and industrial research laboratories.

Project End Date: **31-MAR-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
831783	**SynProAtCell**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. ASHRAF BRIK**
Host Institution: Technion - Israel Institute Of Technology, IL

Delivery and On-Demand Activation of Chemically Synthesized and Uniquely Modified Proteins in Living Cells

While advanced molecular biology approaches provide insight on the role of proteins in cellular processes, their ability to freely modify proteins and control their functions when desired is limited, hindering the achievement of a detailed understanding of the cellular functions of numerous proteins. At the same time, chemical synthesis of proteins allows for unlimited protein design, enabling the preparation of unique protein analogues that are otherwise difficult or impossible to obtain. However, effective methods to introduce these designed proteins into cells are for the most part limited to simple systems. To monitor proteins cellular functions and fates in real time, and in order to answer currently unanswerable fundamental questions about the cellular roles of proteins, the fields of protein synthesis and cellular protein manipulation must be bridged by significant advances in methods for protein delivery and real-time activation. Here, we propose to develop a general approach for enabling considerably more detailed in-cell study of uniquely modified proteins by preparing proteins having the following features: 1) traceless cell delivery unit(s), 2) an activation unit for on-demand activation of protein function in the cell, and 3) a fluorescence probe for monitoring the state and the fate of the protein.

We will adopt this approach to shed light on the processes of ubiquitination and deubiquitination, which are critical cellular signals for many biological processes. We will employ our approach to study 1) the effect of inhibition of deubiquitinases in cancer. 2) Examining effect of phosphorylation on proteasomal degradation and on ubiquitin chain elongation. 3) Examining effect of covalent attachment of a known ligase ligand to a target protein on its degradation Moreover, which could trigger the development of new methods to modify the desired protein in cell by selective chemistries and so rationally promote their degradation.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
832994	**HBPTC**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. VERONIQUE GOUVERNEUR**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Hydrogen Bonding Phase Transfer Catalysis

The objective of the research described in this proposal is to develop a new mode of activation for catalysis leading to more sustainable catalytic processes using abundant feedstock materials. By merging hydrogen bonding and phase transfer catalysis, we propose that hydrogen bonding of an insoluble unreactive anionic nucleophile with a hydrogen bond donor catalyst will form a soluble and reactive entity now capable of carbon-nucleophile bond formation with concomitant release of the hydrogen bond donor catalyst. This activation mode is applicable to nucleophiles as simple as feedstock inorganic salts enabling challenging asymmetric bond-forming reactions in a general and predictable fashion. Inexpensive lost nucleophiles currently unusable due to poor solubility and reactivity will be reclaimed as effective reagents for asymmetric catalysis. Common inorganic salts such as sodium chloride or potassium fluoride will be transformed into high-value products such as complex pharmaceutical and agrochemical products applying operationally simple and cost effective protocols. Synergistic catalysis whereby hydrogen bonding phase transfer catalysis will work in concert with an additional catalytic cycle will be implemented to introduce new chemical transformations with these feedstock reagents, improve efficiency, and create catalytic enantioselectivity where stereocontrol is absent or challenging. This research will require the development of high performance catalysts and the understanding of catalytic mechanisms applying structural, kinetics, and computational studies. HBPTC is expected to expand the field of catalysis, and rival the efficiency of some of the most active metal, organocatalyst and biocatalyst known to date.

Project End Date: **30-JUN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834134	**WATUSO**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. JOHAN MARTENS**
Host Institution: Katholieke Universiteit Leuven, BE

Water Forced in Hydrophobic Nano-Confinement: Tunable Solvent System

Water is the sustainable solvent of excellence but its high polarity limits the solubility of non-polar compounds. Confinement of water in hydrophobic pores alters its hydrogen bonding structure and related properties such as dielectric constant and solvation power. Whether this special state of confined water can be rendered useful in chemical processes is hitherto underexplored. The original idea of this project is to modulate water solvent properties through hydrophobic nano-confinement. Pressure is applied to force a heterogeneous mixture of poorly soluble molecules and water into hydrophobic nanopores of host material where the lowered polarity of water enhances dissolution. Decompression after reaction causes expulsion of the solution from the pores and spontaneous demixing of reaction products as water returns to its normal polar state.

Temporary dissolution enhancement during confinement is expected to be advantageous to chemical reaction and molecular storage. Development of dedicated hydrophobic nanoporous materials and research methodologies providing in situ characterization of confined water, solutes and host material using NMR, EIS, DRS, X-ray and neutron scattering under static and dynamic conditions are key aspects of this project. Nano-confined water offers a potential alternative to compression for storing CH4 and H2 gas, and opens new opportunities for green chemistry such as aqueous phase hydrogenation reactions which benefit from enhanced hydrogen solubility.

Unprecedented control in time and space over H2O solvation properties in a WATUSO system will enable new technologies with major scientific and societal impact. WATUSO will lead to new insights in water research and deliver new multi-diagnostic characterization tools. WATUSO could revolutionize chemical manufacturing and gas storage and the concept could spill over to many more solvent-based processes. WATUSO will contribute significantly to a greener, more sustainable chemical industry.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834290	**TOCINA**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. ERIK BAKKERS**
Host Institution: Technische Universiteit Eindhoven, NL

Topological Crystalline Insulator Nanowires

The key challenge in quantum computation is decoherence - the collapse of a quantum state due to local perturbations. In this proposal we address this challenge by developing a new nanomaterials system, which forms the core of a future topological quantum computer. In a topological quantum bit, information is encoded in Majorana modes, which are topologically protected by a local symmetry and therefore have long coherence times.

In this project we develop a new state of matter -topological crystalline insulator nanowires- in which the topology is defined by the band inversion and the crystal symmetry of the material. Therefore, these topological states should be exceptionally robust. Further, we integrate strong superconductors on these nanowires. These two features together should increase the energy scales of the system compared to current state-of-the-art devices, and therefore lead to stable and electrically-isolated Majorana states.

In this project we develop new crystal growth strategies, which enable to grow out-of-thermodynamic equilibrium structures. We will be the first to employ Molecular Beam Epitaxy (MBE) to precisely tune the SnTe nanowire growth conditions. We use the directionality offered by MBE to shadow-grow superconductors on one nanowire facet. The in-situ ultra-high-vacuum growth of hybrid semiconductor/superconductor devices will result in unprecedented device quality.

Due to the increased energy scales, experiments, which have been unattainable so far, come within reach. We use this new materials platform to demonstrate entanglement of two Majorana modes at the ends of a nanowire. This quantum teleportation is a groundbreaking experiment and is the key of a topological quantum computer.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
835080	**Foldmetcat**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. ANTONIO M ECHAVARREN**
Host Institution: Fundacio Privada Institut Catala D'Investigacio Quimica, ES

Bioinspired Catalytic Metallofoldamers

Inspired by mimicking the characteristics of terpenoid cyclase enzymes, the goal of this proposal is to design new types of catalysts containing electrophilic transition metal centers that could simultaneously fold and activate polyunsaturated substrates promoting non-inherent cyclization modes. Our goal is unprecedented, although it is rooted on fundamental organometallic chemistry, in particular, on the known activation of polyunsaturated substrates by highly electrophilic transition metals. These unconventional cyclizations cascades challenge the paradigm that the intrinsic reactivity of the substrate is the relevant factor in carbocation-initiated processes and would provide access to large carbocyclic skeletons such as those present in taxol and ophiobolin enantioselectively in a single step under catalytic conditions. Although the initial work will be carried out with gold catalysts, a major goal of this research is to develop other general-purpose efficient chiral electrophilic catalysts based on zinc. To attain our goal, we will study more simple catalysts to delineate the factors that control the folding of polyenynes and polyenes. Thus, we will prepare new series of C2-chiral catalysts in which the stereogenic elements are close to the reaction site. Related C2-chiral systems will be generated by supramolecular hydrogen-bond pairing. A similar chiral arrangement could also be achieved by an intramolecular chiral anion translocation from the metal to a distant hydrogen-bond donor site. In addition, we will explore larger systems based on structurally well-defined metallic clusters to generate highly electrophilic chiral reactive sites. The folding and activation of polyunsaturated substrates will be studied first with a series of catalytic prototypes based on digold or heterobimetallic complexes with N-heterocyclic carbenes, diphosphines, mixed ligands of these types, as well as resorcinarene-phosphonite cavitant ligands.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
848339	**BioSilica**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. ASSAF GAL**
Host Institution: Weizmann Institute Of Science, IL

Materials synthesis in vivo – intracellular formation of nanostructured silica by microalgae

Organisms evolved the ability to form a magnificent array of functional materials, which surpass any man-made product. A prominent example is diatoms, marine microalgae that form an intricate cell-wall made of meso-porous silica. Diatom silica is a tough, hierarchically built, and biocompatible material that is environmentally friendly and cheap, making it an exciting target for nanotechnology. Nevertheless, the principles of this regulated formation mechanism remain elusive.

A persistent obstacle for elucidating biomineralization processes is the inaccessibility of the cellular environment for structural and chemical investigations. Recently, far-reaching developments in electron microscopy have revolutionized our abilities to investigate chemical processes inside living organisms. It is now becoming feasible to image and analyze, with nanometer-scale resolution, an intracellular mineralization process.

This proposal aims to elucidate the intracellular mechanism of silica formation by diatoms. We will study cells undergoing the silicification process in situ, using a suite of state-of-the-art electron and X-ray imaging and spectroscopy tools. The combination of structural and chemical data will enable us to elucidate:

1) The concentration and stabilization mechanism of transient Si phases in the cell.
2) The nanoscale environment in which silica condensation takes place.
3) Genetic and environmental strategies to engineer the silicification process for designed outcomes.

Diatom silica is a promising material for applications such as photonics, pharmaceuticals, and catalysis, which require hierarchical, high-surface area, nano-materials. The achievements of this project will inspire synthetic methodologies to produce and design nano-patterned silica, and genetically-engineer the biological silicification process to produce custom-made materials.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850875	**Light-DYNAMO**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. ILKA KRIEGEL**
Host Institution: Fondazione Istituto Italiano Di Tecnologia, IT

Light driven hybrid nanocrystal TMDC capacitors

Sunlight is an intermittent energy source coupled to the availability of the sun. Light-DYNAMO aims for an innovative solution to directly store the solar energy. The challenge is to implement solution-processable light-driven nanocrystal capacitors (NCCs), such as doped metal oxides. They show high charge-storage capacity accumulating multiple delocalized electrons after light absorption. This was to date shown in solution only with the additional drawback of reducing the hole with a sacrificial hole scavenger. The innovative aspect of Light-DYNAMO is to use 2D transition metal dichalcogenides (2D TMDCs), such as MoS2 or WS2, as efficient hole acceptors in a solid state structure. The sensitivity of the TMDCs' spatial electronic landscape to the local environment (i.e. strain, defects or doping) serves as driving force for energetically driven hole relocation within the TMDC. The electrons instead remain in the NCCs. This results in long-lasting and efficient charge separation and opens novel design principles. In optimized device structures, such stored carriers are extracted. The working principle of the suggested NC/TMDC hybrid device is based on several challenges: first, the absorption and charge storage capacity of the NCCs will be enhanced by exploring novel materials. Second, the TMDC's sensitivity to the surrounding will be extracted to a high level of control over the 2D energy level distribution. Third, the intentional design of the energy landscape (e.g. through strain manipulation) in the optimized hybrid geometry will be introduced to control carrier redistribution after charge transfer within the TMDC. Finally, appropriate devices for carrier extraction will be structured. The proposal embarks on a pioneering study by the PI on optical control over carrier density in NCC/TMDC hybrids, advancing such novel systems to a level in which the incoming sunlight is harnessed, converted, stored as charges and released on demand to power an electric circuit.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851448	**RibiTool**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. LIANNE WILLEMS**
Host Institution: University Of York, UK

Ribitol-phosphate: chemical tools to probe the biology of a unique mammalian carbohydrate

Cell-surface proteins are decorated with a variety of different carbohydrate structures that play central roles in mammalian biology. The complex nature of glycan structures and the pathways by which they are assembled make it a challenging task to decipher their exact function in cells, knowledge that is essential if we are to understand how malfunctioning leads to disease. This proposal aims to deliver innovative approaches to probe a distinct pathway of glycosylation essential to mammalian biology and to use these strategies to provide novel insights into the mechanisms underlying normal cellular functioning and disease pathology. The work programme is built around a specific type of O-linked cell-surface glycan that carries two critical ribitol-phosphate (RboP) residues, unique carbohydrates that so far have not been identified in other mammalian glycoconjugates. Failure to correctly assemble this glycan causes a range of congenital muscular dystrophies known as α-dystroglycanopathies. Despite its importance in disease pathology, many aspects of RboP utilisation and functioning in mammalian cells are poorly understood. The proposed programme offers a powerful and original approach to address these key issues in cell biology by creating a set of novel chemical tools. These tools will enable the probing and manipulation of both RboP-carrying glycoconjugates as well as the enzymes responsible for installing RboP onto the glycans in a cellular context. Integration of these tools with fundamental 3-D structural information and studies in cellular models of α-dystroglycanopathy will offer the unprecedented opportunity to directly link genetic defects to molecular and cellular aspects of enzyme function and through to observed changes in glycosylation status. These pioneering strategies will impact our fundamental understanding of key processes in mammalian cells and will also enable the exploitation of this unique pathway for the design of therapeutic strategies.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852084	**TWIST**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. FELIX DESCHLER**
Host Institution: Technische Universitaet Muenchen, DE

Twisted Perovskites - Control of Spin and Chirality in Highly-luminescent Metal-halide Perovskites

The translation of chirality from molecular to bulk inorganic systems opens many possibilities for new phenomena. The properties of chiral electronic states are interesting scientifically and attractive for applications. While optoelectronic properties of semiconductors are controlled by charge, magnetic materials function by spin. If a material can combine these functionalities, powerful novel applications and large gains in performance are possible in opto-spintronics. Yet, existing magnetic semiconductors often show lower optoelectronic quality or work at low temperature. Development of new systems is a scientific challenge due to the required coordination of spins and control of physical properties of excited states, while minimizing defects.

TWIST will demonstrate novel highly-luminescent semiconductors for spin-control and chiral emission that show combined properties of ferromagnets and excellent semiconductors for efficient spin-LEDs at room temperature. To achieve this, TWIST will develop new approaches to control spin and chirality in doped metal-halide perovskites (MHPs) with magnetic elements and molecules, also in chiral superstructures.

In 2014, I reported that MHPs are exceptionally bright emitters, which underpins their tolerance to defects and chemical variation, and which recently enabled remarkable doping with transition-metals. Optical spin-control and chiral emission are possible from spin-orbit coupling and Rashba effects, which will enhance spin-order for Curie temperatures towards room temperature. These exceptional properties of MHPs, which have already produced efficient solar cells and LEDs, provide now a unique opportunity for my project.

TWIST will use state-of-the art optical and electronic techniques to unravel the fundamental mechanisms how magnetic moments, light and chiral states order and interact in MHPs. The results of TWIST will instigate opto-spintronic applications with novel functionality and lower energy consumption.

Project End Date: **31-MAR-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852909	**FC2DMOF**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. RENHAO DONG**
Host Institution: Technische Universitaet Dresden, DE

Development of Functional Conjugated Two-Dimensional Metal-Organic Frameworks

Metal-organic frameworks (MOFs) have been highlighted for catalysis, gas storage and separation. However, due to low conductivity (<1E-8 S/cm), weak magnetic interaction as well as difficult device integration, the application of bulk 3D MOFs in (spin-)electronics is challenging. Recent advances disclose that the designs of conjugated 2D MOFs (C2DMOFs) have led to improved intrinsic conductivity (up to 1000 S/cm). However, the related research remains immature due to lack of high-quality film samples, very limited structural types and elusive transport mechanism. In this project, we will develop unprecedented magnetic (semi-)conductive C2DMOFs and accomplish electronic/magnetic structure engineering for functions in electronics and spintronics. Here, we will synthesize novel conjugated monomers to tune geometries and pore sizes of C2DMOFs, thus achieving in-plane engineering on charge and spin distribution. We will develop versatile synthesis strategies towards highly crystalline C2DMOF films/nanosheets: (1) develop solvothermal synthesis and subsequent electrochemical exfoliation of layer-stacked bulk samples into 2D nanosheets; (2) develop air/liquid and liquid/liquid interfacial synthesis of large-area single-/few-layer films; (3) particularly establish a ground-breaking chemical vapor deposition (CVD) synthesis route for “clean” single-crystalline films. We will further establish unprecedented C2DMOF-based 2D-2D van der Waals heterostructures (vdWHs) with other inorganic 2D crystals to realize out-of-plane engineering on band gaps and unique interfacial transport characteristics. By employing the developed C2DMOFs and vdWHs, we will explore magnetism and temperature-/magnetic field-depended charge transport properties. As the key achievements, we expect to establish novel electronic/magnetic structures and general synthesis strategies, delineation of reliable structure-transport relationships and superior device performance of C2DMOFs.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
853064	**HEINE**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. VICTOR MOUGEL**
Host Institution: Eidgenoessische Technische Hochschule Zurich, CH

Hybrid Electrocatalysts Inspired by the Nitrogenase Enzyme

Artificial nitrogen reduction to ammonia using the Haber-Bosch process directly supports half of the global food production and accounts for 2% of the global energy consumption. This large consumption of energy originates mostly from the use of H2 (derived from fossil fuels) as a reductant and from the high pressure and temperature required to undertake the Haber-Bosch process.

Electrochemical synthesis of ammonia, using a proton and electron source combined with an electrocatalyst at room temperature to reduce N2, thus presents an appealing, energy-efficient alternative. However, despite years of research, the few currently available catalysts have very limited efficiency in N2 electroreduction.

Drawing inspiration from biochemistry and using the tools of coordination chemistry, catalysis and surface chemistry, this project will explore an original strategy to develop catalysts for the reduction of N2 inspired by the nitrogenase enzyme.

Motivated by the recent discovery of two unique moieties in the nitrogenase cofactor – the presence of a μ6-carbide moiety and a Mo(III) center – and of the increased understanding of substrate pathways in the nitrogenase protein structure, the goal of HEINE is to design new hybrid catalysts based on the immobilisation of accurate mimics of the nitrogenase active sites onto heterogeneous supports used to generate properties analogous of the protein scaffold (hydrophobicity, proton relays, etc.). This will provide us with novel ways to develop functional electrocatalysts for N2 reduction in ambient conditions, combining the activity of traditional solid-state systems, with the selectivity of molecular catalysts.

By identifying and reproducing the parameters responsible for the unique activity of nitrogenase enzymes, HEINE will yield invaluable information on nature's routes to N2 reduction and will pave the way towards a new generation of electrocatalysts able to promote this reaction.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864982	**CoaExMatter**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. MARLEEN KAMPERMAN**
Host Institution: Rijksuniversiteit Groningen, NL

Bio-inspired Coacervate Extruded Materials

The threads produced by velvet worms are remarkably sticky and stiff; the beak of a jumbo squid is extremely hard; and spider silk is incredibly tough. The extraordinary material properties found in these natural systems have been of interest to researchers for a long time. However, only recently, biologists discovered that a crucial element in the processing of many of these materials are coacervates, which are concentrated macromolecular phases that form upon liquid liquid phase separation from the initial solution. An understanding is emerging that the liquid coacervate phases enable extrusion of the material and allow for conformational changes within the material before solidification. Thus, the coacervate nature is crucial for obtaining extraordinary property profiles in these natural materials.

Here I propose to mimic this environmentally benign processing of coacervate extrusion for the development of completely new synthetic materials. Previous work in my group has led to the development of bio-inspired synthetic coacervates with well-controlled architecture and composition, and of various tools to study their mechanics. Here, I will take advantage of this expertise to develop unique material systems by extruding synthetic coacervates and by using the induced mechanical stress to obtain alignment and conformational changes.

Analogous to the wide variety of materials found in natural systems that commence as a coacervate, this processing principle may be applicable to a wide variety of synthetic material classes. In this research program coacervate extrusion will be used to produce fibers, rods or scaffolds composed of: polyelectrolyte complexes, liquid-crystal elastomers, peptide-polymers, protein-polymers and nanocomposites.
This bio-inspired processing principle of coacervate extrusion will lead to materials with unexplored property profiles and holds great promise for the development of novel high performance materials obtained by green processing.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865175	**KineTic**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. SANDER VAN KASTEREN**
Host Institution: Universiteit Leiden, NL

New Reagents for Quantifying the Routing and Kinetics of T-cell Activation

The activation of The activation of cytotoxic T-cells (CTLs) marks the key step in the adaptive immune response against cancer and viral infections. Vaccines that activate the CTL-response against tumours are currently hotly pursued, with those targeting tumour-specific mutations now reaching the clinic. However, the capacity of these vaccines to actually activate CTLs is low and rational design improvements are needed to broaden their application. For this, better in vivo knowledge on the processes leading to CTL-activation is needed.

CTLs are activated by dendritic cells. These cells take up the vaccine, and process it to 8-10-mer peptides for presentation to CTLs on MHC-I complexes. A process called cross-presentation. In this proposal, I aim to quantify key unknowns of this pathway, relating to its kinetics and the subcellular route a vaccine takes to reach the MHC-loading site. I will:

a) Quantify the kinetics of peptide-MHC appearance, persistence and disappearance, in vivo using vaccines carrying bioorthogonal protecting/blocking groups that allow me to chemically activate, and stop, the recognition by CTLs in time.

b) I will also study the sub-cellular route(s) the vaccine antigens take in vivo, by developing a second family deprotection and blocking reagents that are targeted to specific organelles.

This localised vaccine activation (or de-activation) will allow me to study the different proposed subcellular routes of the antigen in isolation and assess the importance of the many proposed subcellular routes in vivo to overall cross-presentation success.

The kinetic and routing information obtained from this new set of reagents, will allow me to shed light on some of the key unknowns relating to cross-presentation in vivo, and assess their importance to the success of CTL-activation. By using vaccine-models closely related to existing cancer vaccines, these data will in turn serve to support the rational design of better anti-tumour vaccines.

Project End Date: **31-JUL-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865437	**ThermoRise**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. NUNO SILVA**
Host Institution: Universidade De Aveiro, PT

Rise of the 3rd dimension in nanotemperature mapping

The last decades witnessed a quest for devices responding to temperature at a distance with unprecedented space resolution, approaching the nanoscale. Such devices are valuable in both fundamental and applied science, from overheat in micromachines to hyperthermia applied to cells. Despite great advances, the response is still collected in 2D. In real systems, heat flows in 3 dimensions such that 2D nanothermometers give just a plane view of a 3D reality. The restriction to 2D emerges because space resolution is bound to time and temperature resolutions, leading to a trilemma: scanning into the 3rd dimension is time consuming and cannot be achieve without losing temperature and time resolutions. While incremental improvements have been achieved in recent years, adding the 3rd dimension to nanothermometry is crucial for further impact and requires an innovative approach. Herein, I propose the development of nano local probes with tailored magnetic properties recording critical information about local temperature in 3D. These thermometric local probes avoid the resolution trilemma by recording the most relevant temperature information instead of reading the present temperature value. In many applications, including cellular hyperthermia, most part of the current temperature reading is of minor relevance and can be dropped. The key temperature information includes the maximum temperature achieved, the surpass of a given temperature threshold, and the time elapsed after this surpass. Once recorded, this key information can be read in 3D by standard devices (such as confocal microscopes and magnetic resonance imaging scanners) without time constrains and thus keeping a high space and temperature resolution. Moreover, the reading step can be performed in-situ and/or ex-situ, decoupling probes and reading devices if needed. This widens the range of applications of nanothermometers, allowing detection in confined environments and in non-transparent media.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865974	**NMR4CO2**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. LUÍS MAFRA**
Host Institution: Universidade De Aveiro, PT

Unveiling CO2 chemisorption mechanisms in solid adsorbents via surface-enhanced ex(in)-situ NMR

Reaching a historic high of 3Reaching a historic high of 32.5 gigatonnes in 2017, global carbon dioxide emissions from fossil fuels combustion continue to increase. CO2 removal technologies are part of the solution to tackle this crucial environmental challenge. Because of their lower regeneration cost, amine-modified porous silicas (AMPS) are the most promising CO2-adsorbents for replacing the decades-old liquid amine scrubbing technology. AMPS are “moisture-tolerant” and selectively chemisorb CO2 from low-concentration mixtures, important features for operating under large-point CO2 emission source conditions.

The nature of CO2 species formed on AMPS surfaces determines the gas adsorption capacity/kinetics, selectivity, stability, and regenerability. However, a molecular-scale understanding of the CO2-AMPS adsorption process remains elusive, hindering our ability to design improved sorbents. NMR4CO2 aims to fill in this gap, engaging for the first time state-of-the-art surface-enhanced ex- and in-situ solid-state NMR (SSNMR) to study the chemistry of acidic gases (mainly CO2) adsorbed on AMPS, and the gas-solid interfaces, using simulated industrial gas mixtures. The project combines the expertise of spectroscopists, chemists, and engineers to tackle these challenges.

NMR4CO2 encompasses the design of novel SSNMR methods to study the kinetically- and thermodynamically-driven CO2-AMPS adsorption process, comprising in-situ flow NMR, dynamic nuclear polarization NMR, and isotopically-labeled gas mixtures. Important outcomes include: i) identification of competing CO2 chemisorption pathways; ii) effect on CO2 speciation of textural properties, amine type, inter-amine spacing, and amine-support cooperative effects; iii) real-time monitoring of acid gas speciation in multiple adsorption/desorption cycles; iv) identification of sorbent deactivation species; v) effect of pressure on CO2 speciation and vi) improvement of AMPS sorbent properties by synthetic modification.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866345	**ExploDProteins**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. DENNIS GILLINGHAM**
Host Institution: Universitaet Basel, CH

Exploiting the DNA damage response to induce degradation of proteins

Here I propose to use small molecules to degrade proteins specifically around sites of DNA damage by using the damage itself as a homing signal. The approach will create new ways to study DNA damage, but will also offer translational possibilities in cancer. Cancer cells are often acutely sensitive to DNA damage because they have one or more faulty DNA damage response (DDR) pathways – a feature that makes them highly dependent on their remaining DNA repair systems. We will pioneer two novel and related chemical approaches for selectively killing cancer cells by modulating DDR pathways with bifunctional DNA damaging molecules. We will do this by reprogramming E3 ligases. E3 ligases are modular multi-protein complexes that destabilize cellular proteins by catalysing the formation of polyubiquitin chains on its substrates, which serve as a signal for proteasomal degradation. A recent revolutionary advance in chemical biology is to use small molecules to reprogram the protein degradation specificity of E3 ligases. By degrading proteins instead of inhibiting them, these small molecules achieve levels of functional modulation typically only possible with genetic techniques. We are inspired by this new protein degradation technology, but will take it in a new direction. Chemical damage of DNA recruits E3 ligases as well as critical DDR proteins in preparation for DNA repair. We will invent a new generation of small molecule protein degradation catalysts by repurposing these natural responses to DNA damage.
We will accomplish our goal with three aims:
Aim 1: Use DNA damage as a homing signal for induced protein degradation
Aim 2: Use direct repair of DNA damage by the repair protein MGMT to promote the degradation of other proteins
Aim 3: Promote pleiotropic protein degradation by recruiting broadly acting E3 ligases to sites of DNA damage
I propose an ambitious project that will create conceptually novel ways to study the DDR and potentially build new medicines.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
883922	**ECHO-GRACADE**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. MIQUEL COSTAS**
Host Institution: Universitat De Girona, ES

Enantioselective C-H Oxidation Guided by Rational Catalyst Design

Chemo- and enantioselective oxidation of aliphatic C-H bonds is a cornerstone reaction in metabolism. The ubiquitous presence of multiple and diverse C-H bonds in organic molecules is used by oxidative enzymes to deliver functionality and chirality to metabolite precursors, rapidly creating product diversity. Despite its huge potential in organic synthesis, non-enzymatic enantioselective C-H oxidation of aliphatic sites remains inaccessible and has never been incorporated in synthesis. Harnessing the power of this reaction will open straightforward, yet currently inaccessible, paths in synthetic planning. However, realization of this goal requires conceptual breakthroughs in order to chemo-, regio- and stereo-selectively create a C-O bond from a non-activated alkyl C-H bond, even in the presence of a priori more reactive groups. In this project, chemo-, and site-selective asymmetric aliphatic oxidation is targeted by taking advantage of; a) stereoretentive enzyme-like metal-based C-H oxidations performed by small molecule manganese catalysts, devised as minimalistic hydroxylases, and b) polarity reversal exerted by fluorinated alcohol solvents in electron-rich functional groups, which enable chemoselective C-H hydroxylation of densely functionalized molecules. Desymmetrization via enantioselective C-H oxidation is devised as a powerful type of reaction that will create multiple chiral centers in a single step. Building on the rich chemical diversity and modular architecture of aminopyridine manganese complexes, rapid elaboration of libraries of catalysts is targeted. Rational manipulation of steric, electronic, directing effects and supramolecular substrate recognition factors guided by multiple parametrization analyses will be employed for directing evolution in catalyst design. This project will provide the catalysts and their use in paradigmatic reactions in order to establish enantioselective C-H oxidation as a reliable tool in organic synthesis.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
670035	**Con Espressione**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. GERHARD WIDMER**
Host Institution: Universitaet Linz, AT

Getting at the Heart of Things: Towards Expressivity-aware Computer Systems in Music

What makes music so important, what can make a performance so special and stirring? It is the things the music expresses, the emotions it induces, the associations it evokes, the drama and characters it portrays. The sources of this expressivity are manifold: the music itself, its structure, orchestration, personal associations, social settings, but also – and very importantly – the act of performance, the interpretation and expressive intentions made explicit by the musicians through nuances in timing, dynamics etc.

Thanks to research in fields like Music Information Research (MIR), computers can do many useful things with music, from beat and rhythm detection to song identification and tracking. However, they are still far from grasping the essence of music: they cannot tell whether a performance expresses playfulness or ennui, solemnity or gaiety, determination or uncertainty; they cannot produce music with a desired expressive quality; they cannot interact with human musicians in a truly musical way, recognising and responding to the expressive intentions implied in their playing.

The project is about developing machines that are aware of certain dimensions of expressivity, specifically in the domain of (classical) music, where expressivity is both essential and – at least as far as it relates to the act of performance – can be traced back to well-defined and measurable parametric dimensions (such as timing, dynamics, articulation). We will develop systems that can recognise, characterise, search music by expressive aspects, generate, modify, and react to expressive qualities in music. To do so, we will (1) bring together the fields of AI, Machine Learning, MIR and Music Performance Research; (2) integrate theories from Musicology to build more well-founded models of music understanding; (3) support model learning and validation with massive musical corpora of a size and quality unprecedented in computational music research.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682315	**Skye**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. JAMES CHENEY**
Host Institution: The University Of Edinburgh, UK

A programming language bridging theory and practice for scientific data curation

Science is increasingly data-driven. Scientific research funders now routinely mandate open publication of publicly-funded research data. Safely reusing such data currently requires labour-intensive curation. Provenance recording the history and derivation of the data is critical to reaping the benefits and avoiding the pitfalls of data sharing. There are hundreds of curated scientific databases in biomedicine that need fine-grained provenance; one important example is GtoPdb, a pharmacological database developed by colleagues in Edinburgh.

Currently there are no reusable methodologies or practical tools that support provenance for curated databases, forcing each project to start from scratch. Research on provenance for scientific databases is still at an early stage, and prototypes have so far proven challenging to deploy or evaluate in the field. Also, most techniques to date focus on provenance within a single database, but this is only part of the problem: real solutions will have to integrate database provenance with the multiple tiers of web applications, and no-one has begun to address this challenge.

I propose research on how to build support for curation into the programming language itself, building on my recent research on the Links Web programming language and on data curation. Links is a strongly-typed language that provides state-of-the-art support for language-integrated query and Web programming. I propose to build on Links and other recent language designs for heterogeneous meta-programming to develop a new language, called Skye, that can express modular, reusable curation and provenance techniques. To keep focus on the real needs of scientific databases, Skye will be evaluated in the context of GtoPdb and other scientific database projects. Bridging the gap between curation research and the practices of scientific database curators will catalyse a virtuous cycle that will increase the pace of breakthrough results from data-driven science.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714034	**SMART**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. CEZARY KALISZYK**
Host Institution: Universitaet Innsbruck, AT

Strong Modular proof Assistance: Reasoning across Theories

Formal proof technology delivers an unparalleled level of certainty and security. Nevertheless, applying proof assistants to the verification of complex theories and designs is still extremely laborious. High profile certification projects, such as seL4, CompCert, and Flyspeck require tens of person-years. We recently demonstrated that this effort can be significantly reduced by combining reasoning and learning in so called hammer systems: 40% of the Flyspeck, HOL4, Isabelle/HOL, and Mizar top-level lemmas can be proved automatically.

Today's early generation of hammers consists of individual systems limited to very few proof assistants. The accessible knowledge repositories are isolated, and there is no reuse of hammer components.

It is possible to achieve a breakthrough in proof automation by developing new AI methods that combine reasoning knowledge and techniques into a smart hammer, that works over a very large part of today's formalized knowledge. The main goal of the project is to develop a strong and uniform learning-reasoning system available for multiple logical foundations. To achieve this, we will develop: (a) uniform learning methods, (b) reusable ATP encoding components for different foundational aspects, (c) integration of proof reconstruction, and (d) methods for knowledge extraction, reuse and content merging. The single proof advice system will be made available for multiple proof assistants and their vast heterogeneous libraries.

The ultimate outcome is an advice system able to automatically prove half of Coq, ACL2, and Isabelle/ZF top-level theorems. Additionally we will significantly improve success rates for HOL provers and Mizar. The combined smart advice method together with the vast accumulated knowledge will result in a novel kind of tool, which allows working mathematicians to automatically find proofs of many simple conjectures, paving the way for the widespread use of formal proof in mathematics and computer science.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715672	**DisDyn**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. DANUPON NANONGKAI**
Host Institution: Kungliga Tekniska Hoegskolan, SE

Distributed and Dynamic Graph Algorithms and Complexity

This project aims to (i) resolve challenging graph problems in distributed and dynamic settings, with a focus on connectivity problems (such as computing edge connectivity and distances), and (ii) on the way develop a systematic approach to attack problems in these settings, by thoroughly exploring relevant algorithmic and complexity-theoretic landscapes. Tasks include

- building a hierarchy of intermediate computational models so that designing algorithms and proving lower bounds can be done in several intermediate steps,

- explaining the limits of algorithms by proving conditional lower bounds based on old and new reasonable conjectures, and

- connecting techniques in the two settings to generate new insights that are unlikely to emerge from the isolated viewpoint of a single field.

The project will take advantage from and contribute to the developments in many young fields in theoretical computer science, such as fine-grained complexity and sublinear algorithms. Resolving one of the connectivity problems will already be a groundbreaking result. However, given the approach, it is likely that one breakthrough will lead to many others.

Project End Date: **31-JAN-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724464	**Mathador**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. ALEKSANDAR NANEVSKI**
Host Institution: Fundacion Imdea Software, ES

Type and Proof Structures for Concurrent Software Verification

Verification of concurrent software is a notoriously difficult subject, whose complexities stem from the inability of the existing verification methods to modularize, and thus divide-and-conquer, the verification problem.

Dependent types are a formal method well-known for its ability to modularize and scale complex mathematical proofs. But, when it comes to programming, dependent types are considered limited to the purely functional and terminating programming model.

The grand challenge of this project is to remove the limitation and scale dependent types to support implementation of stateful concurrent programs, and their correctness proofs, simultaneously. By applying the modularizing power of dependent types to both programs and proofs, the project will obtain novel and scalable foundations for the field of concurrent software verification.

Writing mechanized proofs of software, concurrent or otherwise, is generally considered infeasible. But if one chooses the right linguistic abstractions to express the proofs, we argue that it does not have to be so. This observation is supported by our encouraging preliminary results. The project will discover further novel linguistic abstraction that facilitate engineering of practically feasible formal proofs, and experimentally evaluate them by mechanically verifying extensive concurrent programs drawn from realistic applications, such as concurrent garbage collectors, OS kernels, and popular open-source concurrent libraries.

The project is high risk because it proposes novel foundations for concurrent software verification, whose development requires deep intertwining of logic and program semantics theory, with significant hands-on implementation and experimentation with formal proofs. But it is also high gain, as scaling concurrent software verification is the most significant open problem of present-day programming languages and semantics research.

Project End Date: **31-MAR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725253	**EyeCode**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. RAFAL MANTIUK**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

Perceptual encoding of high fidelity light fields

One of the grand challenges of computer graphics has been to generate images indistinguishable from photographs for a naïve observer. As this challenge is mostly completed and computer generated imagery starts to replace photographs (product catalogues, special effects in cinema), the next grand challenge is to produce imagery that is indistinguishable from the real-world.

Tremendous progress in capture, manipulation and display technologies opens the potential to achieve this new challenge (at the research stage) in the next 5-10 years. Electronic displays offer sufficient resolution, frame rate, dynamic range, colour gamut and, in some configurations, can produce binocular and focal depth cues. However, most of the work done in this area ignores or does not sufficiently address one of the key aspects of this problem - the performance and limitations of the human visual system.

The objective of this project is to characterise and model the performance and limitations of the human visual system when observing complex dynamic 3D scenes. The scene will span a high dynamic range (HDR) of luminance and provide binocular and focal depth cues. In technical terms, the project aims to create a visual model and difference metric for high dynamic range light fields (HDR-LFs). The visual metric will replace tedious subjective testing and provide the first automated method that can optimize encoding and processing of HDR-LF data.

Perceptually realistic video will impose enormous storage and processing requirements compared to traditional video. The bandwidth of such rich visual content will be the main bottleneck for new imaging and display technologies. Therefore, the final objective of this project is to use the new visual metric to derive an efficient and approximately perceptually uniform encoding of HDR-LFs. Such encoding will radically reduce storage and bandwidth requirements and will pave the way for future highly realistic image and video content.

Project End Date: **30-JUN-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
741097	**Load Slice Core**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. LIEVEN EECKHOUT**
Host Institution: Universiteit Gent, BE

Load Slice Core: A Power and Cost-Efficient Microarchitecture for the Future

The ideal processor building block is a power and cost-efficient core that can maximize the extraction of memory hierarchy parallelism, a combination that neither traditional in-order nor out-of-order cores provide. We propose the Load Slice Core microarchitecture, a restricted out-of-order engine aimed squarely at extracting memory hierarchy parallelism, which, according to preliminary results, delivers a nearly 8 times higher performance per Watt per euro compared to an out-of-order core.

The overarching objective of this project to fully determine the potential of the Load Slice Core as a key building block for a novel multi-core processor architecture needed in light of both current and future challenges in software and hardware, including variable thread-level parallelism, managed language workloads, the importance of sequential performance, and the quest for significantly improved power and cost efficiency.

We anticipate significant improvement in multi-core performance within the available power budget and cost by combining chip-level dynamism to cope with variable thread-level parallelism along with the inherent power- and cost-efficient Load Slice Core design. If we are able to demonstrate the true value and potential of the Load Slice Core to address future hardware and software challenges, this project will have a long-lasting impact on the microprocessor industry moving forward.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
742989	**MoTIVE**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. MEL SLATER**
Host Institution: Universitat De Barcelona, ES

Moments in Time in Immersive Virtual Environments

This project investigates how virtual reality (VR) can be used to live through an historical event so that participants perceive themselves to be there (Place Illusion) and take the events that are happening as real (Plausibility). To provide an application focus the research will be constructed around recreating a famous rock concert from the 1980s. The specific elements of the research involve an Agent Based Model (ABM) that populates the environment with thousands of virtual characters with their behaviour driven by the music. This ABM will run in VR embedding participants as a type of agent. Agents will have personality and emotional state that can influence one another, and the actions and state of participants will also influence the unfolding of the model. Based on the predictive coding model of brain functioning a theory of Place Illusion will be developed that results in a universal measurement. Similarly, the Plausibility Illusion will be modelled and corresponding universal measure derived. Participants in VR will be embodied, so that they will have a first person perspective life-sized virtual body that moves as they do. We will exploit the concept of body ownership and its consequences for attitudinal, behavioural, cognitive and agency changes to give people unique experiences of the virtual events, and carry out a series of experiments to assess the influence of being transported back in time in a younger body has on ageing. Our recent discovery that illusory agency can be realised through virtual embodiment will be used for research on improved motor learning. To allow people to move through the environment we will investigate paradigms for virtual walking, and in particular whether the multisensory principles involved in body ownership illusions can be used to lessen simulator sickness. The long term goal of the project is to understand how to capture treasured past moments lost in time, through their reproduction in ABM inspired virtual reality.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757360	**NoTape**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. SØREN HAUBERG**
Host Institution: Danmarks Tekniske Universitet, DK

Measuring with no tape

Society generates increasing amounts of data, which is both a resource and a challenge. The data reveal new insights that may potentially improve our livelihood, but their quantity renders such insights difficult to find. Machine learning techniques sift through the data looking for statistical patterns of interest to a given task. Due to an exponential growth in available data, these techniques enable us to automate difficult decisions, such as those needed for personalized medicine and self-driving cars.

NoTape note that machine learning techniques depend on a distance measure to determine which data points are similar and which are not. As this measure is difficult to choose, NoTape develop methods for estimating an optimal distance measure directly from data. Empirical evidence suggest that the optimal distance measure in one region of data space need not coincide with the optimal measure in another region, i.e.that the distance measure should locally adapt to the data. Local adaptability imply that the distance measure itself will be sensitive to noise in the data, and therefore should be described as a random variable. NoTape estimate distance measures as random Riemannian metrics and perform statistical data analysis accordingly. The notion of statistical computations with respect to an uncertain locally adaptive distance measure is uncharted territory, which need new algorithms for numerical integration and for solving differential equations.

As a guiding example, we estimate statistical models that reflect human perception. As perception processes are not fully understood, an optimal distance measure cannot be precisely estimated and the uncertainty of NoTape is needed.

The geometric nature of the developed methods ensure that attained models are interpretable by humans, which contrast current locally adaptive techniques. As society automate more decisions, interpretability is increasing important to ensure that the machine learning system can be trusted

Project End Date: **30-NOV-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757481	**ScaleOpt**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. LASZLO VEGH**
Host Institution: London School Of Economics And Political Science, UK

Scaling Methods for Discrete and Continuous Optimization

One of the most important open questions in optimization is to find a strongly polynomial algorithm for linear programming. The proposed project aims to tackle this problem by combining novel techniques from two different domains: discrete optimization and continuous optimization. We expect to contribute to exciting recent developments on the interface of these two fields.

We use and develop new variants of the classical scaling technique. From the discrete optimization side, recent work of the PI on generalized flows extends classical network flow theory and opens up new domains for strongly polynomial computability beyond integer constraint matrices. We will apply this novel scaling technique to obtain strongly polynomial algorithms for broad classes of linear programs.

From the continuous optimization side, we aim to build the theory of geometric rescaling algorithms for linear and convex optimization. This approach combines first-order methods with geometric rescaling techniques to obtain a new family of polynomial-time algorithms. We expect to devise variants efficient in theory and in practice, which we will use in a wide range of applications.

Our discrete and continuous techniques will have important applications in submodular function minimization. We will develop new, efficient algorithms for the general problem as well as for specific applications in areas such as machine learning and computer vision.

In summary, the project will develop novel approaches for some of the most fundamental optimization problems. It will change the landscape of strongly polynomial computability, and make substantial progress towards finding a strongly polynomial algorithm for linear programming.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757609	**CGinsideNP**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. WOLFGANG MULZER**
Host Institution: Freie Universitaet Berlin, DE

Complexity Inside NP - A Computational Geometry Perspective

Traditional complexity theory focuses on the dichotomy between P and NP-hard problems. Lately, it has become increasingly clear that this misses a major part of the picture. Results by the PI and others offer glimpses on a fascinating structure hiding inside NP: new computational problems that seem to lie between polynomial and NP-hard have been identified; new conditional lower bounds for problems with large polynomial running times have been found; long-held beliefs on the difficulty of problems in P have been overturned. Computational geometry plays a major role in these developments, providing some of the main questions and concepts. We propose to explore this fascinating landscape inside NP from the perspective of computational geometry, guided by three complementary questions: (A) What can we say about the complexity of search problems derived from existence theorems in discrete geometry? These problems offer a new perspective on complexity classes previously studied in algorithmic game theory (PPAD, PLS, CLS). Preliminary work indicates that they have the potential to answer long-standing open questions on these classes. (B) Can we provide meaningful conditional lower bounds on geometric problems for which we have only algorithms with large polynomial running time? Prompted by a question raised by the PI and collaborators, such lower bounds were developed for the Frechet distance. Are similar results possible for problems not related to distance measures? If so, this could dramatically extend the traditional theory based on 3SUM-hardness to a much more diverse and nuanced picture. (C) Can we find subquadratic decision trees and faster algorithms for 3SUM-hard problems? After recent results by Pettie and Gronlund on 3SUM and by the PI and collaborators on the Frechet distance, we have the potential to gain new insights on this large class of well-studied problems and to improve long-standing complexity bounds for them.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757672	**NeuroLang**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. DEMIAN WASSERMANN**
Host Institution: Institut National De Recherche En Informatique Et En Automatique, FR

Accelerating Neuroscience Research by Unifying Knowledge Representation and Analysis Through a Domain Specific Language

Neuroscience is at an inflection point. The 150-year old cortical specialization paradigm, in which cortical brain areas have a distinct set of functions, is experiencing an unprecedented momentum with over 1000 articles being published every year. However, this paradigm is reaching its limits. Recent studies show that current approaches to atlas brain areas, like relative location, cellular population type, or connectivity, are not enough on their own to characterize a cortical area and its function unequivocally. This hinders the reproducibility and advancement of neuroscience.

Neuroscience is thus in dire need of a universal standard to specify neuroanatomy and function: a novel formal language allowing neuroscientists to simultaneously specify tissue characteristics, relative location, known function and connectional topology for the unequivocal identification of a given brain region.

The vision of NeuroLang is that a unified formal language for neuroanatomy will boost our understanding of the brain. By defining brain regions, networks, and cognitive tasks through a set of formal criteria, researchers will be able to synthesize and integrate data within and across diverse studies. NeuroLang will accelerate the development of neuroscience by providing a way to evaluate anatomical specificity, test current theories, and develop new hypotheses.

NeuroLang will lead to a new generation of computational tools for neuroscience research. In doing so, we will be shedding a novel light onto neurological research and possibly disease treatment and palliative care. Our project complements current developments in large multimodal studies across different databases. This project will bring the power of Domain Specific Languages to neuroscience research, driving the field towards a new paradigm articulating classical neuroanatomy with current statistical and machine learning-based approaches.

Project End Date: **28-FEB-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758824	**INFLUENCE**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. FRANS OLIEHOEK**
Host Institution: Technische Universiteit Delft, NL

Influence-based Decision-making in Uncertain Environments

Decision-theoretic sequential decision making (SDM) is concerned with endowing an intelligent agent with the capability to choose actions that optimize task performance. SDM techniques have the potential to revolutionize many aspects of society and recent successes, e.g., agents that play Atari games and beat a world champion in the game of Go, have sparked renewed interest in this field.

However, despite these successes, fundamental problems of scalability prevents these methods from addressing other problems with hundreds or thousands of state variables. For instance, there is no principled way of computing an optimal or near-optimal traffic light control plan for an intersection that takes into account the current state of traffic in an entire city. I will develop one in this project.

To achieve this, I will develop a new class of influence-based SDM methods that overcome scalability issues for such problems by using novel ways of abstraction. Considered from a decentralized system perspective, the intersection's local problem is manageable, but the influence that the rest of the network exerts on it is complex. The key idea is that by using (deep) machine learning methods, we can learn sufficiently accurate representations of such influence to facilitate near-optimal decisions.

This project will construct a theoretical framework for such approximate influence representations and SDM methods that use them. Scalability of these methods will be demonstrated by rigorous empirical evaluation on two simulated challenge domains: traffic lights control in an entire city, and robotic order picking in a large-scale autonomous warehouse.

If successful, INFLUENCE will produce a range of influence-based SDM algorithms that can, in a principled manner, deal with a broad range of very large complex problems consisting of hundreds or thousands of variables, thus making an important step towards realizing the promise of autonomous agent technology.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759207	**P2PMODELS**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. SAMER HASSAN**
Host Institution: Universidad Complutense De Madrid, ES

Decentralized Blockchain-based Organizations for Bootstrapping the Collaborative Economy

The Collaborative Economy (CE) is rapidly expanding through new forms of Internet labor and commerce, from Wikipedia to Kickstarter and Airbnb. However, it suffers from 3 main challenges: (1) Infrastructure: centralized surveillance that the central hubs of information exercise over their users, (2) Governance: disempowered communities which do not have any decision-making influence over the platform, and (3) Economy: concentration of profits in a few major players who do not proportionally redistribute them to the contributors.

How can CE software platforms be implemented for solving these challenges? P2PMODELS explores a new way of building CE software platforms harnessing the blockchain, an emerging technology that enables autonomous agent-mediated organizations, in order to (1) provide a software framework to build decentralized infrastructure for Collaborative Economy organizations that do not depend on central authorities, (2) enable democratic-by-design models of governance for communities, by encoding rules directly into the software platform, and (3) enable fairer value distribution models, thus improving the economic sustainability of both CE contributors and organizations.

Together, these 3 objectives will bootstrap the emergence of a new generation of self-governed and more economically sustainable peer-to-peer CE communities. The interdisciplinary nature of P2PMODELS will open a new research field around agent-mediated organizations for collaborative communities and their self-enforcing rules for automatic governance and economic rewarding. Bringing this proposal to life requires a funding scheme compatible with a high-risk/high-gain vision to finance a fully dedicated and highly motivated research team with multidisciplinary skills.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759557	**ALGOCom**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. PARINYA CHALERMSOOK**
Host Institution: Aalto-Korkeakoulusaatio, FI

Novel Algorithmic Techniques through the Lens of Combinatorics

Real-world optimization problems pose major challenges to algorithmic research. For instance, (i) many important problems are believed to be intractable (i.e. NP-hard) and (ii) with the growth of data size, modern applications often require a decision making under {\em incomplete and dynamically changing input data}. After several decades of research, central problems in these domains have remained poorly understood (e.g. Is there an asymptotically most efficient binary search trees?) Existing algorithmic techniques either reach their limitation or are inherently tailored to special cases.

This project attempts to untangle this gap in the state of the art and seeks new interplay across multiple areas of algorithms, such as approximation algorithms, online algorithms, fixed-parameter tractable (FPT) algorithms, exponential time algorithms, and data structures. We propose new directions from the {\em structural perspectives} that connect the aforementioned algorithmic problems to basic questions in combinatorics.
Our approaches fall into one of the three broad schemes: (i) new structural theory, (ii) intermediate problems, and (iii) transfer of techniques. These directions partially build on the PI's successes in resolving more than ten classical problems in this context.

Resolving the proposed problems will likely revolutionize our understanding about algorithms and data structures and potentially unify techniques in multiple algorithmic regimes. Any progress is, in fact, already a significant contribution to the algorithms community. We suggest concrete intermediate goals that are of independent interest and have lower risks, so they are suitable for Ph.D students.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
770784	**4DRepLy**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. CHRISTIAN THEOBALT**
Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Closing the 4D Real World Reconstruction Loop

4D reconstruction, the camera-based dense dynamic scene reconstruction, is a grand challenge in computer graphics and computer vision. Despite great progress, 4D capturing the complex, diverse real world outside a studio is still far from feasible. 4DRepLy builds a new generation of high-fidelity 4D reconstruction (4DRecon) methods. They will be the first to efficiently capture all types of deformable objects (humans and other types) in crowded real world scenes with a single color or depth camera. They capture space-time coherent deforming geometry, motion, high-frequency reflectance and illumination at unprecedented detail, and will be the first to handle difficult occlusions, topology changes and large groups of interacting objects. They automatically adapt to new scene types, yet deliver models with meaningful, interpretable parameters. This requires far reaching contributions: First, we develop groundbreaking new plasticity-enhanced model-based 4D reconstruction methods that automatically adapt to new scenes. Second, we develop radically new machine learning-based dense 4D reconstruction methods. Third, these model- and learning-based methods are combined in two revolutionary new classes of 4DRecon methods: 1) advanced fusion-based methods and 2) methods with deep architectural integration. Both, 1) and 2), are automatically designed in the 4D Real World Reconstruction Loop, a revolutionary new design paradigm in which 4DRecon methods refine and adapt themselves while continuously processing unlabeled real world input. This overcomes the previously unbreakable scalability barrier to real world scene diversity, complexity and generality. This paradigm shift opens up a new research direction in graphics and vision and has far reaching relevance across many scientific fields. It enables new applications of profound social pervasion and significant economic impact, e.g., for visual media and virtual/augmented reality, and for future autonomous and robotic systems.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771005	**CoCoSym**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. LIBOR BARTO**
Host Institution: Univerzita Karlova V Praze, CZ

Symmetry in Computational Complexity

The last 20 years of rapid development in the computational-theoretic aspects of the fixed-language Constraint Satisfaction Problems (CSPs) has been fueled by a connection between the complexity and a certain concept capturing symmetry of computational problems in this class. My vision is that this connection will eventually evolve into the organizing principle of computational complexity and will lead to solutions of fundamental problems such as the Unique Games Conjecture or even the P-versus-NP problem. In order to break through the current limits of this algebraic approach, I will concentrate on specific goals designed to (A) discover suitable objects capturing symmetry that reflect the complexity in problem classes, where such an object is not known yet; (B) make the natural ordering of symmetries coarser so that it reflects the complexity more faithfully; (C) delineate the borderline between computationally hard and easy problems; (D) strengthen characterizations of existing borderlines to increase their usefulness as tools for proving hardness and designing efficient algorithm; and (E) design efficient algorithms based on direct and indirect uses of symmetries. The specific goals concern the fixed-language CSP over finite relational structures and its generalizations to infinite domains (iCSP) and weighted relations (vCSP), in which the algebraic theory is highly developed and the limitations are clearly visible.

The approach is based on joining the forces of the universal algebraic methods in finite domains, model-theoretical and topological methods in the iCSP, and analytical and probabilistic methods in the vCSP. The starting point is to generalize and improve the Absorption Theory from finite domains.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771113	**FoTran**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. JÖRG TIEDEMANN**
Host Institution: Helsingin Yliopisto, FI

Found in Translation – Natural Language Understanding with Cross-Lingual Grounding

Natural language understanding is the "holy grail" of computational linguistics and a long-term goal in research on artificial intelligence. Understanding human communication is difficult due to the various ambiguities in natural languages and the wide range of contextual dependencies required to resolve them. Discovering the semantics behind language input is necessary for proper interpretation in interactive tools, which requires an abstraction from language-specific forms to language-independent meaning representations. With this project, I propose a line of research that will focus on the development of novel data-driven models that can learn such meaning representations from indirect supervision provided by human translations covering a substantial proportion of the linguistic diversity in the world. A guiding principle is cross-lingual grounding, the effect of resolving ambiguities through translation. The beauty of that idea is the use of naturally occurring data instead of artificially created resources and costly manual annotations. The framework is based on deep learning and neural machine translation and my hypothesis is that training on increasing amounts of linguistically diverse data improves the abstractions found by the model. Eventually, this will lead to universal sentence-level meaning representations and we will test our ideas with multilingual machine translation and tasks that require semantic reasoning and inference.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771779	**DeciGUT**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. SEBASTIAN RUDOLPH**
Host Institution: Technische Universitaet Dresden, DE

A Grand Unified Theory of Decidability in Logic-Based Knowledge Representation

Logic-based knowledge representation (KR) constitutes a vital area of IT. The field inspires and guides scientific and technological developments enabling intelligent management of large and complex knowledge resources. Elaborate languages for specifying knowledge (so-called ontology languages) and querying it have been defined and standardized. Algorithms for automated reasoning and intelligent querying over knowledge resources are being developed, implemented and practically deployed on a wide scale.

Thereby, decidability investigations play a pivotal role to characterize what reasoning or querying tasks are at all computationally solvable.

Past decades have seen a proliferation of new decidable formalisms for KR, dominated by two major paradigms: description logics and rule-based approaches, most notably existential rules. Recently, these research lines have started to converge and first progress has been made toward identifying commonalities among the various formalisms. Still, the underlying principles for establishing their decidability remain disparate, ranging from proof-theoretic notions to model-theoretic ones.

DeciGUT will accomplish a major breakthrough in the field by establishing a "Grand Unified Theory" of decidability. We will provide a novel, powerful model-theoretic criterion inspired by advanced graph-theoretic notions. We will prove that the criterion indeed ensures decidability and that it subsumes most of (if not all) currently known decidable formalisms in the KR field.

We will exploit our results toward the definition of novel decidable KR languages of unprecedented expressivity. We will ultimately extend our framework to encompass more advanced KR features beyond standard first order logic such as counting and non-monotonic aspects.

Our research will draw from and significantly impact the scientific fields of AI, Database Theory and Logic, but also give rise to drastically improved practical information management technology.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772346	**TUgbOAT**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. PIOTR SANKOWSKI**
Host Institution: Uniwersytet Warszawski, PL

Towards Unification of Algorithmic Tools

Over last 50 years, extensive algorithmic research gave rise to a plethora of fundamental results. These results equipped us with increasingly better solutions to a number of core problems. However, many of these solutions are incomparable. The main reason for that is the fact that many cutting-edge algorithmic results are very specialized in their applicability. Often, they are limited to particular parameter range or require different assumptions.

A natural question arises: is it possible to get “one to rule them all” algorithm for some core problems such as matchings and maximum flow? In other words, can we unify our algorithms? That is, can we develop an algorithmic framework that enables us to combine a number of existing, only “conditionally” optimal, algorithms into a single all-around optimal solution? Such results would unify the landscape of algorithmic theory but would also greatly enhance the impact of these cutting-edge developments on the real world. After all, algorithms and data structures are the basic building blocks of every computer program. However, currently using cutting-edge algorithms in an optimal way requires extensive expertise and thorough understanding of both the underlying implementation and the characteristics of the input data.

Hence, the need for such unified solutions seems to be critical from both theoretical and practical perspective. However, obtaining such algorithmic unification poses serious theoretical challenges. We believe that some of the recent advances in algorithms provide us with an opportunity to make serious progress towards solving these challenges in the context of several fundamental algorithmic problems. This project should be seen as the start of such a systematic study of unification of algorithmic tools with the aim to remove the need to “under the hood” while still guaranteeing an optimal performance independently of the particular usage case.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772738	**TouchDesign**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. MIGUEL OTADUY**
Host Institution: Universidad Rey Juan Carlos, ES

A Computational Design Approach to Haptic Synthesis

We use touch permanently to explore, manipulate and interact with the world around us, but also to feel and transmit affection. Haptic synthesis, i.e., the ability to design and control what we feel, either on a computer application or with a consumer product, bears an immense scientific, industrial, and social impact. However, touch is still poorly understood and underexploited in today's digital era. The state of the art in computational haptic synthesis lags well behind the technological and scientific progress in additive manufacturing, computational design for fabrication, virtual reality displays, or cutaneous haptic interfaces.

TouchDesign will define a formal and comprehensive computational design methodology for haptic synthesis, applied to both tactile digital communication and to computational design and fabrication of objects with desired tactile properties. Haptic synthesis will be formulated as an optimization problem, with the objective function defined based on haptic perceptual metrics, and with the design space defined by the high-dimensional parameter space of a fabrication process or a haptic interface.

We will introduce multiple breakthroughs in four major scientific pillars.
(i) In contact biomechanics: develop measurement-based and data-driven models that enable interactive evaluation of the deformations undergone by skin mechanoreceptors.
(ii) In perceptual modeling: establish a connection between high-resolution biomechanics, mechanoreceptor activation fields, and psychophysics, through machine-learning analysis of exhaustive simulated and experimental data.
(iii) In numerical optimization: design methods that optimize perceptual metrics through robust and efficient search of the high-dimensional design space of haptic fabrication and haptic display problems.
(iv) In computational design: introduce methods and interfaces to visualize, explore, and define perceptual objective functions and haptic design spaces.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787413	**Interfaces**	**PE6** Computer Science and Informatics

Principal Investigator:	**Dr. SRIRAM SUBRAMANIAN**
Host Institution:	The University Of Sussex, UK

Manipulating Acoustic wavefronts using metamaterials for novel user interfaces

In this project we will leverage developments in acoustic meta-materials to build interactive systems that manipulate sound to create experiences with the same ease and fidelity as we are so accustomed to doing with light. This involves designing and evaluating new acoustic meta-materials AND building interactive systems that create novel interaction experiences that were hitherto impossible to achieve.

We will use acoustic metamaterials technology to build a Spatial Sound Modulator (SSM) that aims to be a software controlled device that transforms an input acoustic wave into a time-variable, user-defined acoustic field. SSM comprises of a surface made of electronically adjustable acoustic metamaterial bricks. Each brick in the surface can individually vary the phase of an incident acoustic field, to shape the complex output field.

Our objectives are:

1. Design, implement and evaluate dynamically reconfigurable metamaterial unit-cells and surfaces using transmissive modes of operation. We will explore narrow-band devices for air-borne operation at low ultrasonic frequencies (e.g. 40 kHz).
2. Design SSMs from a spatial distribution of metamaterial unit cells. Specifically, we will identify discretization strategies, digital control mechanisms and develop concepts that are efficient and reduce field reconstruction errors while at the same time constructing the SSM from a small set of reconfigurable metamaterial unit-cells.
3. Create multiple application-specific prototypes of the SUM and identify context specific design constraints and trade-offs.

Project End Date: **30-APR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787914	**FRAPPANT**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. JOOST-PIETER KATOEN**
Host Institution: Rheinisch-Westfaelische Technische Hochschule Aachen, DE

Formal Reasoning About Probabilistic Programs: Breaking New Ground for Automation

Probabilistic programs describe recipes on how to infer statistical conclusions about data from a complex mixture of uncertain data and real-world observations. They can represent probabilistic graphical models far beyond the capabilities of Bayesian networks and are expected to have a major impact on machine intelligence.

Probabilistic programs are ubiquitous. They steer autonomous robots and self-driving cars, are key to describe security mechanisms, naturally code up randomised algorithms for solving NP-hard problems, and are rapidly encroaching AI. Probabilistic programming aims to make probabilistic modeling and machine learning accessible to the programmer.

Probabilistic programs, though typically relatively small in size, are hard to grasp, let alone automatically checkable. Are they doing the right thing? What's their precision? These questions are notoriously hard — even the most elementary question "does a program halt with probability one?" is "more undecidable" than the halting problem — and can (if at all) be answered with statistical evidence only. Bugs thus easily occur. Hard guarantees are called for. The objective of this project is to enable predictable probabilistic programming. We do so by developing formal verification techniques.

Whereas program correctness is pivotal in computer science, the formal verification of probabilistic programs is in its infancy. The project aims to fill this barren landscape by developing program analysis techniques, leveraging model checking, deductive verification, and static analysis. Challenging problems such as checking program equivalence, loop-invariant and parameter synthesis, program repair, program robustness and exact inference using weakest precondition reasoning will be tackled. The techniques will be evaluated in the context of probabilistic graphical models, randomised algorithms, and autonomous robots.

FRAPPANT will spearhead formally verifiable probabilistic programming.

Project End Date: **31-OCT-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788506	**CALCULUS**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. MARIE-FRANCINE MOENS**
Host Institution: Katholieke Universiteit Leuven, BE

Commonsense and Anticipation enriched Learning of Continuous representations sUpporting Language UnderStanding

Natural language understanding (NLU) by the machine is of large scientific, economic and social value. Humans perform the NLU task in an efficient way by relying on their capability to imagine or anticipate situations. They engage commonsense and world knowledge that is often acquired through perceptual experiences to make explicit what is left implicit in language. Inspired by these characteristics CALCULUS will design, implement and evaluate innovative paradigms supporting NLU, where it will combine old but powerful ideas for language understanding from the early days of artificial intelligence with new approaches from machine learning. The project focuses on the effective learning of anticipatory, continuous, non-symbolic representations of event frames and narrative structures of events that are trained on language and visual data. The grammatical structure of language is grounded in the geometric structure of visual data while embodying aspects of commonsense and world knowledge. The reusable representations are evaluated in a selection of NLU tasks requiring efficient real-time retrieval of the representations and parsing of the targeted written texts. Finally, we will evaluate the inference potential of the anticipatory representations in situations not seen in the training data and when inferring spatial and temporal information in metric real world spaces that is not mentioned in the processed language. The machine learning methods focus on learning latent variable models relying on Bayesian probabilistic models and neural networks and focus on settings with limited training data that are manually annotated. The best models will be integrated in a demonstrator that translates the language of stories to events happening in a 3-D virtual world. The PI has interdisciplinary expertise in natural language processing, joint processing of language and visual data, information retrieval and machine learning needed for the successful realization of the project.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788893	**AMDROMA**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. STEFANO LEONARDI**
Host Institution: Universita Degli Studi Di Roma La Sapienza, IT

Algorithmic and Mechanism Design Research in Online MArkets

Online markets currently form an important share of the global economy. The Internet hosts classical markets (real-estate, stocks, e-commerce) as well allowing new markets with previously unknown features (web-based advertisement, viral marketing, digital goods, crowdsourcing, sharing economy). Algorithms play a central role in many decision processes involved in online markets. For example, algorithms run electronic auctions, trade stocks, adjusts prices dynamically, and harvest big data to provide economic information. Thus, it is of paramount importance to understand the algorithmic and mechanism design foundations of online markets.

The algorithmic research issues that we consider involve algorithmic mechanism design, online and approximation algorithms, modelling uncertainty in online market design, and large-scale data analysisonline and approximation algorithms, large-scale optimization and data mining. The aim of this research project is to combine these fields to consider research questions that are central for today's Internet economy. We plan to apply these techniques so as to solve fundamental algorithmic problems motivated by web-basedInternet advertisement, Internet market designsharing economy, and crowdsourcingonline labour marketplaces. While my planned research is focussedcentered on foundational work with rigorous design and analysis of in algorithms and mechanismsic design and analysis, it will also include as an important component empirical validation on large-scale real-life datasets.

Project End Date: **30-JUN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788980	**ESCADA**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. JOAN DAEMEN**
Host Institution: Stichting Katholieke Universiteit, NL

Energy-optimized Symmetric Cryptography by Algebraic Duality Analysis

The main scientific contribution of this project will be a breakthrough in the understanding of cryptanalytic and side channel attacks of symmetric cryptosystems. We will do this by a unification of attacks that will a stepping stone to the holy grail of symmetric cryptography: provable security of concrete cryptosystems. The main real-world impact is that we will build cryptosystems that are much more efficient than those used today while having the same strength. Depending on the platform, higher efficiency translates to lower energy/power (in-body sensors, contactless payment cards etc.), but also lower latency (authentication for e.g car brakes or airbags) and/or lower heat dissipation (on-the-fly encryption of high bandwidth data streams). In a software implementation it simply means less CPU cycles per byte.

We build our cryptosystems as modes, on top of block ciphers or permutations. For these primitives we adopt the classical technique of iterating a simple round function (more rounds means more security but less efficiency). We focus on round functions of algebraic degree 2. Their relative simplicity will allow a unification of all cryptanalytic attacks that exploit propagation of affine varieties and polynomial ideals (their dual) through the rounds and to precisely estimate their success rates. Moreover, we will design modes that strongly restrict the exposure of the primitive(s) to attackers and that permit security reductions to specific properties of the underlying primitive(s) in a formally verifiable way. In comparison to the classical pseudorandom and ideal permutation models, this will allow reducing the number of rounds while preserving security with high assurance. We will also study side channel attacks of our round functions and ways to defend against them. We will make ASIC prototypes and implement novel efficient countermeasures against side channel attacks and use this to evaluate their effectiveness in practice.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
801708	**ANTICIPATE**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. ANDREAS BULLING**
Host Institution: Universitaet Stuttgart, DE

Anticipatory Human-Computer Interaction

Even after three decades of research on human-computer interaction (HCI), current general-purpose user interfaces (UI) still lack the ability to attribute mental states to their users, i.e. they fail to understand users' intentions and needs and to anticipate their actions. This drastically restricts their interactive capabilities.

ANTICIPATE aims to establish the scientific foundations for a new generation of user interfaces that pro-actively adapt to users' future input actions by monitoring their attention and predicting their interaction intentions - thereby significantly improving the naturalness, efficiency, and user experience of the interactions. Realising this vision of anticipatory human-computer interaction requires groundbreaking advances in everyday sensing of user attention from eye and brain activity. We will further pioneer methods to predict entangled user intentions and forecast interactive behaviour with fine temporal granularity during interactions in everyday stationary and mobile settings. Finally, we will develop fundamental interaction paradigms that enable anticipatory UIs to pro-actively adapt to users' attention and intentions in a mindful way. The new capabilities will be demonstrated in four challenging cases: 1) mobile information retrieval, 2) intelligent notification management, 3) Autism diagnosis and monitoring, and 4) computer-based training.

Anticipatory human-computer interaction offers a strong complement to existing UI paradigms that only react to user input post-hoc. If successful, ANTICIPATE will deliver the first important building blocks for implementing Theory of Mind in general-purpose UIs. As such, the project has the potential to drastically improve the billions of interactions we perform with computers every day, to trigger a wide range of follow-up research in HCI as well as adjacent areas within and outside computer science, and to act as a key technical enabler for new applications, e.g. in healthcare and education.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802020	**HARMONIC**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. YUVAL FILMUS**
Host Institution: Technion - Israel Institute Of Technology, IL

Discrete harmonic analysis for computer science

Boolean function analysis is a topic of research at the heart of theoretical computer science. It studies functions on n input bits (for example, functions computed by Boolean circuits) from a spectral perspective, by treating them as real-valued functions on the group Z_2^n, and using techniques from Fourier and functional analysis. Boolean function analysis has been applied to a wide variety of areas within theoretical computer science, including hardness of approximation, learning theory, coding theory, and quantum complexity theory.

Despite its immense usefulness, Boolean function analysis has limited scope, since it is only appropriate for studying functions on {0,1}^n (a domain known as the Boolean hypercube). Discrete harmonic analysis is the study of functions on domains possessing richer algebraic structure such as the symmetric group (the group of all permutations), using techniques from representation theory and Sperner theory. The considerable success of Boolean function analysis suggests that discrete harmonic analysis could likewise play a central role in theoretical computer science.

The goal of this proposal is to systematically develop discrete harmonic analysis on a broad variety of domains, with an eye toward applications in several areas of theoretical computer science. We will generalize classical results of Boolean function analysis beyond the Boolean hypercube, to domains such as finite groups, association schemes (a generalization of finite groups), the quantum analog of the Boolean hypercube, and high-dimensional expanders (high-dimensional analogs of expander graphs). Potential applications include a quantum PCP theorem and two outstanding open questions in hardness of approximation: the Unique Games Conjecture and the Sliding Scale Conjecture. Beyond these concrete applications, we expect that the fundamental results we prove will have many other applications that are hard to predict in advance.

Project End Date: **29-FEB-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802800	**DELPHI**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. JONATHAN BERANT**
Host Institution: Tel Aviv University, IL

Computing Answers to Complex Questions in Broad Domains

The explosion of information around us has democratized knowledge and transformed its availability for people around the world. Still, since information is mediated through automated systems, access is bounded by their ability to understand language. Consider an economist asking “What fraction of the top-5 growing countries last year raised their co2 emission?”. While the required information is available, answering such complex questions automatically is not possible. Current question answering systems can answer simple questions in broad domains, or complex questions in narrow domains. However, broad and complex questions are beyond the reach of state-of-the-art. This is because systems are unable to decompose questions into their parts, and find the relevant information in multiple sources. Further, as answering such questions is hard for people, collecting large datasets to train such models is prohibitive. In this proposal I ask: Can computers answer broad and complex questions that require reasoning over multiple modalities? I argue that by synthesizing the advantages of symbolic and distributed representations the answer will be “yes”. My thesis is that symbolic representations are suitable for meaning composition, as they provide interpretability, coverage, and modularity. Complementarily, distributed representations (learned by neural nets) excel at capturing the fuzziness of language. propose a framework where complex questions are symbolically decomposed into sub-questions, each is answered with a neural network, and the final answer is computed from all gathered information. This research tackles foundational questions in language understanding. What is the right representation for reasoning in language? Can models learn to perform complex actions in the face of paucity of data? Moreover, my research, if successful, will transform how we interact with machines, and define a role for them as research assistants in science, education, and our daily life.

Project End Date: **31-MAR-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802823	**REWOCRYPT**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. TIBOR JAGER**
Host Institution: Bergische Universitaet Wuppertal, DE

Theoretically-Sound Real-World Cryptography

Novel technologies like Cloud Computing, Ubiquitous Computing, Big Data, Industry 4.0, and the Internet
of Things do not only come with a huge demand for practical and efficient cryptosystems, but also with many novel attack surfaces. The security properties required from cryptographic building blocks for these innovative applications go beyond classical security goals.

Modern theoretical cryptography has very successfully developed powerful techniques that enable the design and rigorous formal analysis of cryptosystems in theoretical security models. Now that these techniques are readily available, we have to take the next important step: the evolution of these techniques from idealized theoretical settings to the demands of real-world applications.

The REWOCRYPT project will tackle this main research challenge at the intersection of theoretical and real-world cryptography. It will provide a solid foundation for the design and mathematically rigorous security analysis of the next generation of cryptosystems that provably meet real-world security requirements and can safely be used to realize secure communication in trustworthy services and products for a modern interconnected society.

Project End Date: **31-MAR-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803111	**TOROS**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. BJÖRN BRANDENBURG**
Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

A Theory-Oriented Real-Time Operating System for Temporally Sound Cyber-Physical Systems

The TOROS project targets the challenge of implementing safety-critical cyber-physical systems (CPSs) on commodity multicore processors such that their temporal correctness can be certified in a formal, trustworthy manner.
While today it is in principle possible to construct a CPS in a temporally sound way, in practice this rarely happens because, with the current real-time foundations, the prerequisite investments in time, expertise, and resources are prohibitive.

This situation is caused in large parts by three fundamental shortcomings in the design of state-of-the-art real-time operating systems (RTOSs) and the applicable timing analyses: (i) current RTOSs expose primarily low-level mechanisms that suffer from accidental unpredictability, i.e., mechanisms that require too much expertise to be used and composed in a temporally sound way; (ii) most analyses rely on idealized worst-case execution-time assumptions that realistically cannot be satisfied on commodity multicore platforms; and (iii) the available real-time theory depends on often complex and tedious proofs, and cannot always be trusted to be sound.
As a result, formal timing analysis is rarely relied upon in the certification of CPSs in reality, and instead
the use of ad-hoc, unsound "safety margins" prevails.

The TOROS project seeks to close this gap by moving the RTOS closer to analysis, the analysis closer to reality, and by ensuring that the analysis can be trusted.
Specifically, the TOROS project will
1. introduce a radically new, theory-oriented RTOS that by design ensures that the temporal behavior of any workload can be analyzed (even if the application developer is unaware of the relevant theory),
2. develop a matching novel timing analysis that allows for below-worst-case provisioning with analytically sound safety margins that yields meaningful probabilistic response-time guarantees, and
3. mechanize and verify all supporting timing analysis with the Coq proof assistant.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804226	**PERDY**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. PIOTR DIDYK**
Host Institution: Universita Della Svizzera Italiana, CH

Perceptually-Driven Optimizations of Graphics Content for Novel Displays

Displays play a vital role in many professional and personal activities. They are a crucial interface between a user and the digital world in tasks involving visualization and interaction with digital data. The abilities of new display technologies regarding reproduction of important visual cues, such as binocular disparity, accommodation, or motion parallax, outperform the capabilities of methods for optimizing graphics content to match the requirements of particular hardware designs. This leads to a poor visual quality and massive computational overhead, which hamper the adoption of novel displays. I argue that there are significant gaps between hardware, computational techniques, and understanding of human perception, which prevents taking full advantage of these technologies.

To overcome these limitations, I and my team will combine hardware, computation, and perception into a unique platform where the capabilities of displays and quality requirements are represented in a shared space. The basis for our project will be in-depth understanding of human perception. Our experiments will focus on three aspects: (1) investigation of perceptual limits across a wide field of view, (2) involving all visual cues, and (3) establishing optimal trade-offs between different quality aspects. We will build efficient computational models that will predict perceived quality and enable perceptual optimizations to drive new content adaptation techniques.

This project will contribute display-specific perceptual optimizations of graphics content to match the requirements of human perception. It will address the key aspects of portable devices such as energy efficiency and visual quality. Our experiments and modeling of human perception will provide crucial insights into new hardware developments. The contributions will be necessary for development and standardization of new, high-quality display devices which will not only improve existing applications but also enable new ones.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804636	**DYMO**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. MILICA GASIC**
Host Institution: Heinrich-Heine-Universitaet Duesseldorf, DE

Dynamic dialogue modelling

With the prevalence of information technology in our daily lives, our ability to interact with machines in increasingly simplified and more human-like ways has become paramount. Information is becoming ever more abundant but our access to it is limited not least by technological restraints. Spoken dialogue systems address this issue by providing an intelligent speech interface that facilitates swift, human-like acquisition of information.

The advantages of speech interfaces are already evident from the rise of personal assistants such as Siri, Google Assistant, Cortana or Amazon Alexa. In these systems, however, the user is limited to a simple query, and the systems attempt to provide an answer within one or two turns of dialogue. To date, significant parts of these systems are rule-based and do not readily scale to changes in the domain of operation. Furthermore, rule-based systems can be brittle when speech recognition errors occur.

The vision of this project is to develop novel dialogue models that provide natural human-computer interaction beyond simple information-seeking dialogues and that continuously evolve as they are being used by exploiting both dialogue and non-dialogue data. Building such robust and intelligent spoken dialogue systems poses serious challenges in artificial intelligence and machine learning. The project will tackle four bottleneck areas that require fundamental research: automated knowledge acquisition, optimisation of complex behaviour, realistic user models and sentiment awareness. Taken together, the proposed solutions have the potential to transform the way we access information in areas as diverse as e-commerce, government, healthcare and education.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819141	**PASS**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. CRISTIAN CADAR**
Host Institution: Imperial College Of Science, Technology And Medicine, UK

Program Analysis for Safe and Secure Software Evolution

Constant evolution is an inherent property of modern software systems. Software evolves to implement new features, adapt to new hardware and platforms, fix bugs and security vulnerabilities, or improve non-functional properties such as performance and energy consumption.

While these changes have an overall positive impact, they are also responsible for a large number of critical bugs and security attacks. The reason is twofold: first, software changes are not vetted enough, due to the difficulty of reasoning about all possible new behaviours that they introduce. Second, even when critical errors in deployed changes are later discovered and fixed, users take a long time to update their software to the latest version, mostly because they are concerned about the potential negative impact of an update.

The PASS project aims to tackle both problems and help software evolve safely and securely. It takes a holistic approach to the challenges of safe and secure software evolution, by combining offline program analysis to verify or comprehensively test software changes, with runtime mechanisms for keeping the software updated and secure against potentially erroneous changes that make it into the deployed system.

This is an ambitious project, which requires fundamental advances at the intersection of program analysis, software engineering, and computer systems to develop practical cross-version specifications, scalable patch verification, in-production testing and analysis, and low-overhead reversible software updates.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819317	**CerQuS**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. DOMINIQUE UNRUH**
Host Institution: Tartu Ulikool, EE

Certified Quantum Security

Digital communication permeates all areas of today's daily life. Cryptographic protocols are used to secure that communication. Quantum communication and the advent of quantum computers both threaten existing cryptographic solutions, and create new opportunities for secure protocols. The security of cryptographic systems is normally ensured by mathematical proofs. Due to human error, however, these proofs often contain errors, limiting the usefulness of said proofs. This is especially true in the case of quantum protocols since human intuition is well-adapted to the classical world, but not to quantum mechanics. To resolve this problem, methods for verifying cryptographic security proofs using computers (i.e., for "certifying" the security) have been developed. Yet, all existing verification approaches handle classical cryptography only - for quantum protocols, no approaches exist. This project will lay the foundations for the verification of quantum cryptography. We will design logics and software tools for developing and verifying security proofs on the computer, both for classical protocols secure against quantum computer (post-quantum security) and for protocols that use quantum communication. Our main approach is the design of a logic (quantum relational Hoare logic, qRHL) for reasoning about the relationship between pairs of quantum programs, together with an ecosystem of manual and automated reasoning tools, culminating in fully certified security proofs for real-world quantum protocols. As a final result, the project will improve the security of protocols in the quantum age, by removing one possible source of human error. In addition, the project directly impacts the research community, by providing new foundations in program verification, and by providing cryptographers with new tools for the verification of their protocols.

Project End Date: **31-MAY-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819416	**LOPRE**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. SAKET SAURABH**
Host Institution: Universitetet I Bergen, NO

Lossy Preprocessing

A critical component of computational processing of data sets is the `preprocessing' or `compression' step which is the computation of a \emph{succinct, sufficiently accurate} representation
of the given data. Preprocessing is ubiquitous and a rigorous mathematical understanding of preprocessing algorithms is crucial in order to reason about and understand the limits of preprocessing.
Unfortunately, there is no mathematical framework to analyze and objectively compare two preprocessing routines while simultaneously taking into account `all three dimensions' --

-- the efficiency of computing the succinct representation,
-- the space required to store this representation, and
-- the accuracy with which the original data is captured in the succinct representation.

``The overarching goal of this proposal is the development of a mathematical framework for the rigorous analysis of preprocessing algorithms. ''
We will achieve the goal by designing new algorithmic techniques for preprocessing, developing a framework of analysis to make qualitative comparisons between various preprocessing routines based on the criteria above and by developing lower bound tools required
to understand the limitations of preprocessing for concrete problems.
This project will lift our understanding of algorithmic preprocessing to new heights and lead to a groundbreaking shift in the set of basic research questions attached to the study of preprocessing for specific problems. It will significantly advance the analysis of preprocessing and yield substantial technology transfer between adjacent subfields of computer science such as dynamic algorithms, streaming algorithms, property testing and graph theory.

Project End Date: **30-APR-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834115	**FUN2MODEL**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. MARTA KWIATKOWSKA**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Oxford, UK

From FUnction-based TO MOdel-based automated probabilistic reasoning for DEep Learning

Machine learning is revolutionising computer science and AI. Much of its success is due to deep neural networks, which have demonstrated outstanding performance in perception tasks such as image classification. Solutions based on deep learning are now being deployed in real-world systems, from virtual personal assistants to self-driving cars. Unfortunately, the black-box nature and instability of deep neural networks is raising concerns about the readiness of this technology. Efforts to address robustness of deep learning are emerging, but are limited to simple properties and function-based perception tasks that learn data associations. While perception is an essential feature of an artificial agent, achieving beneficial collaboration between human and artificial agents requires models of autonomy, inference, decision making, control and coordination that significantly go beyond perception. To address this challenge, this project will capitalise on recent breakthroughs by the PI and develop a model-based, probabilistic reasoning framework for autonomous agents with cognitive aspects, which supports reasoning about their decisions, agent interactions and inferences that capture cognitive information, in presence of uncertainty and partial observability. The objectives are to develop novel probabilistic verification and synthesis techniques to guarantee safety, robustness and fairness for complex decisions based on machine learning, formulate a comprehensive, compositional game-based modelling framework for reasoning about systems of autonomous agents and their interactions, and evaluate the techniques on a variety of case studies.
Addressing these challenges will require a fundamental shift towards Bayesian methods, and development of new, scalable, techniques, which differ from conventional probabilistic verification. If successful, the project will result in major advances in the quest towards provably robust and beneficial AI.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834228	**WhiteMech**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. GIUSEPPE DE GIACOMO**
Host Institution: Universita Degli Studi Di Roma La Sapienza, IT

White-Box Self-Programming Mechanisms

We are witnessing an increasing availability of mechanisms that operate in nondeterministic (uncertain) environments and offer some form of programmability. These include manufacturing devices, smart objects and spaces, intelligent robots, dynamic business process management systems, and many others. All these mechanisms are currently being revolutionized by advancements in sensing (vision, language understanding) and actuation components (autonomous mobile manipulators, automated storage and retrieval systems). However, such mechanisms are held back by the fact that their logic is still based on hard-wired rules encoded in hand-crafted programs. WhiteMech aims at developing the science and the tools for a new generation of mechanisms to emerge: mechanisms that are able to program themselves, automatically tailor their behavior so as to achieve desired goals, maintain themselves within safe boundaries in a changing environment, and follow regulations and conventions that evolve over time. Crucially, empowering mechanisms with self-programming carries significant risks and therefore we must be able to balance power with safety. For this reason WhiteMech intends to realize mechanisms that are white-box, that is, whose behavior is at any moment fully analyzable and comprehensible in human terms, and guarded by human oversight. Remarkable recent discoveries by the applicant in Reasoning about Action and Generalized Planning in Artificial Intelligence, and their connections to Verification and Synthesis in Formal Methods, and Data-Aware Processes in Databases, chart an unanticipated novel path to produce a breakthrough in realizing powerful self-programming mechanisms, while keeping them human- comprehensible and safe by design. WhiteMech will ground its scientific results upon three driving applications: smart manufacturing (Industry 4.0), smart spaces (IoT) and business process management systems (BPM).

Project End Date: **31-OCT-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834756	**XAI**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. FOSCA GIANNOTTI**
Host Institution: Consiglio Nazionale Delle Ricerche, IT

Science and technology for the explanation of AI decision making

A wealthy friend of mine asks for a vacation credit card to his bank, to discover that the credit he is offered is very low. The bank teller cannot explain why. My stubborn friend continues his quest for explanation up to the bank executives, to discover that an algorithm lowered his credit score. Why? After a long investigation, it turns out that the reason is: bad credit by the former owner of my friend's house.

Black box AI systems for automated decision making, often based on ML over (big) data, map a user's features into a class or a score without explaining why. This is problematic for lack of transparency, but also for possible biases inherited by the algorithms from human prejudices and collection artefacts hidden in the training data, which may lead to unfair or wrong decisions.

I strive for solutions of the urgent challenge of how to construct meaningful explanations of opaque AI/ML systems, introducing the local-to-global framework for black box explanation, articulated along 3 lines: a) the language for explanations in terms of expressive logic rules, with statistical and causal interpretation; b) the inference of local explanations for revealing the decision rationale for a specific case; c), the bottom-up generalization of many local explanations into simple global ones. An intertwined line of research will investigate both causal explanations, i.e., models that capture the causal relationships among the features and the decision, and mechanistic/physical models of complex system physics, that capture the data generation mechanism behind specific deep learning models.

I will also develop: an infrastructure for benchmarking, for the users' assessment of the explanations and the crowdsensing of observational decision data; an ethical-legal framework, for compliance and impact of our results on legal standards and on the "right of explanation" provisions of the GDPR; case studies in explanation-by-design, with a priority in health and fraud detection.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834862	**REBOUND**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. ARISTIDES GIONIS**
Host Institution: Kungliga Tekniska Hoegskolan, SE

An algorithmic framework for reducing bias and polarization in online media

Online media is an important part of modern information society, offering a podium for public discourse and hosting the opinions of hundreds of millions of individuals. Online media are often credited for providing a technological means to break information barriers and promote diversity and democracy. In practice, however, the opposite effect is often observed: users tend to favor content that agrees with their existing world-view, get less exposure to conflicting viewpoints, and eventually create information silos and increased polarization. Arguably, without any kind of mediation, current social-media platforms gravitate towards a state in which net-citizens are constantly reinforcing their existing opinions.

In this project we will develop theoretical foundations and a concrete set of algorithmic techniques to address deficiencies in today's online media. We will develop methods to discover structure and patterns of segregation, conflict, and closeness in social-media systems. We will address the issues of reducing bias and polarization, breaking information silos, and creating awareness of users to explore alternative viewpoints. We will also study the effect of different design features to the willingness of the users to explore viewpoints that conflict their opinion.

The project is structured along three interwined research thrusts: knowledge discovery, exploration, and content recommendation. To accomplish its aims the project will formulate novel problem representations that provide a deeper understanding of the undesirable phenomena observed in online media and allow for effective remedial actions. Strong emphasis will be given on designing algorithms that are scalable to large data, are able to deal with uncertainty, and offer theoretical guarantees. The end result will be a set of new methods and tools that will contribute to increasing exposure to diverse ideas and improving online deliberation.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
835197	**ViAjeRo**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. STEPHEN BREWSTER**
Host Institution: University Of Glasgow, UK

ViAjeRo: Virtual and Augmented Reality passenger experiences

ViAjeRo will radically improve passenger journeys using immersive Virtual and Augmented Reality to support entertainment, work and collaboration on the move. In Europe, people travel an average of 12,000km per year on private and public transport, in cars, buses, planes and trains. These journeys are often repetitive and wasted time. This total will rise with the arrival of fully autonomous cars, which free drivers to become passengers. The potential to recover this lost time is impeded by 3 significant challenges

. Confined spaces: These limit interactivity, and force us to rely on small displays such as phones or seatback screens

. Social acceptability: We may share the space with others, inducing a pressure to conform, inhibiting technology use

. Motion sickness: Many people get sick when they read or play games in vehicles. Once experienced, it can take hours for symptoms to resolve

VR/AR headsets could allow passengers to use their travel time in new, productive, exciting ways, but only if bold research is undertaken to overcome these fundamental challenges. ViAjeRo will use VR/AR to do adventurous multidisciplinary work, unlocking the untapped potential of passengers. They will be able to use large virtual displays for productivity; escape the physical confines of the vehicle and become immersed in virtual experiences; and communicate with distant others through new embodied forms of communication – all whilst travelling. This will be of great benefit to European society and open a new area for products and services. Our vision requires groundbreaking contributions at the intersection of HCI, neuroscience and sensing to:

1 Develop novel interaction techniques for confined, seated spaces

2 Support safe, socially acceptable use of VR/AR, providing awareness of others and the travel environment

3 Overcome motion sickness through novel multimodal countermeasures and neurostimulation

4 Tailor the virtual and physical passenger environment to support new,

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850533	**LEGO-3D**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. ANDREAS GEIGER**
Host Institution: Eberhard Karls Universitaet Tuebingen, DE

Learning Generative 3D Scene Models for Training and Validating Intelligent Systems

Recently, the field of computer vision has witnessed a major transformation away from expert designed shallow models towards more generic deep representation learning. However, collecting labeled data for training deep models is costly and existing simulators with artist-designed scenes do not provide the required variety and fidelity. Project LEGO-3D will tackle this problem by developing probabilistic models capable of synthesizing 3D scenes jointly with photo-realistic 2D projections from arbitrary viewpoints and with full control over the scene elements. Our key insight is that data augmentation, while hard in 2D, becomes considerably easier in 3D as physical properties such as viewpoint invariances and occlusion relationships are captured by construction. Thus, our goal is to learn the entire 3D-to-2D simulation pipeline. In particular, we will focus on the following problems:
(A) We will devise algorithms for automatic decomposition of real and synthetic scenes into latent 3D primitive representations capturing geometry, material, light and motion.
(B) We will develop novel probabilistic generative models which are able to synthesize large-scale 3D environments based on the primitives extracted in project (A). In particular, we will develop unconditional, conditioned and spatio-temporal scene generation networks.
(C) We will combine differentiable and neural rendering techniques with deep learning based image synthesis, yielding high-fidelity 2D renderings of the 3D representations generated in project (B) while capturing ambiguities and uncertainties.
Project LEGO-3D will significantly impact a large number of application areas. Examples include vision systems which require access to large amounts of annotated data, safety-critical applications such as autonomous cars that rely on efficient ways for training and validation, as well as the entertainment industry which seeks to automate the creation and manipulation of 3D content.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850868	**CodeSan**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. MATHIAS PAYER**
Host Institution: Ecole Polytechnique Federale De Lausanne, CH

Code Sanitization for Vulnerability Pruning and Exploitation Mitigation

Despite massive efforts in securing software, about 60 security bugs are publicly reported each month. Systems software is prone to low level bugs caused by undefined behavior (memory corruption, type confusion, or API confusion). Exploits abuse undefined behavior to execute attacker specified code, or to leak information. We propose code sanitization (CodeSan), a comprehensive approach to improve code quality. CodeSan will sanitize software by (i) automating bug discovery during development through software testing and (ii) protecting deployed software through reflective mitigations. CodeSan trades formal completeness for practical scalability in three steps: First, policy-based sanitization makes undefined behavior (through violations of memory safety, type safety, or API flow safety) explicit and detectable given concrete test inputs. Second, automatic test case generation increases testing coverage for large programs without the need for pre-existing test cases, enabling broader and automated use of policy-based sanitization. Third, for deployed software, reflective mitigations place runtime checks precisely where they are needed based on data-flow and control-flow coverage from our testing efforts. CodeSan complements formal approaches by protecting software that is currently out of reach due to its size, complexity, or low level nature.

CodeSan is a compelling, comprehensive, and adaptive approach to thoroughly address undefined behavior for complex software. The three proposed thrusts complement each other naturally and will immediately guard large software systems such as Google Chromium, Mozilla Firefox, the Android system, or the Linux kernel, making them resilient against attacks.

In line with PI Payer's track record on open sourcing his group's research artifacts on cast sanitization, transformative fuzzing, or control-flow hijacking mitigations, all prototypes produced during CodeSan will be released as open-source.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851093	**SAFEBIO**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. ALEXANDRU IOAN TOMESCU**
Host Institution: Helsingin Yliopisto, FI

Safe and Complete Algorithms for Bioinformatics

Many real-world problems are modeled as computational problems, but unfortunately with incomplete data or knowledge. As such, they may admit a large number of solutions, and we have no way of finding the correct one. This issue is sometimes addressed by outputting all solutions, which is infeasible for many practical problems. We aim to construct a general methodology for finding the set of all sub-solutions common to all solutions. We can ultimately trust these to be part of the correct solution. We call this set "safe". Ultimately, we aim at creating automated and efficient ways of reporting all safe sub-solutions of a problem. The main motivation of this project comes from Bioinformatics, in particular from the analysis of high-throughput sequencing (HTS) of DNA. One of the main applications of HTS data is to assemble it back into the original DNA sequence. This genome assembly problem admits many solutions, and current research has indeed considered outputting only partial solutions that are likely to be present in the correct original DNA sequence. However, this problem has been approached only from an experimental point of view, with no definite answer on what are all the safe sub-solutions to report. In fact, the issue of safe sub-solutions has been mostly overlooked in Bioinformatics and Computer Science in general. This project will derive the first safe algorithms for a number of fundamental problems about walks in graphs, network flows, dynamic programming. We will apply these inside practical tools for genome assembly, RNA assembly and pan-genome analysis. This is very relevant at the moment, because HTS goes from research labs to hospitals, and we need answers that are first of all accurate. Our approach changes the perspective from which we address all real-world problems, and could spur a new line of research in Computer Science/Bioinformatics. The grand aim is a mathematical leap into understanding what can be safely reported from the data.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851538	**BayesianGDPR**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. NOVI QUADRIANTO**
Host Institution: The University Of Sussex, UK

Bayesian Models and Algorithms for Fairness and Transparency

EU's GDPR prescribes that "Personal Data shall be processed lawfully, fairly, and in a transparent manner." The vision of this BayesianGDPR project is to integrate into automated machine learning systems using a novel Bayesian approach, in a transparent manner, the legal non-discriminatory principles of GDPR, taking into account feedback from humans and future consequences of their outputs. We aim to achieve this ambitious vision by 1) developing a machine learning framework for addressing fairness in classification problems and beyond, and under uncertainty about data, models, and predictions about future data (algorithmic fairness under uncertainty), 2) extending the framework to a setting where data points arrive over time, and models have to be dynamically updated when taking general feedback (feedback-driven setting), and 3) ensuring a human could understand how non-discrimination is defined and achieved by using, among others, uncertainty estimates for building interpretable models and/or explicitly explaining about changes being made to the models to enforce non-discriminatory principles (transparency in fairness). The BayesianGDPR project is "doubly timely"; not just in terms of the criticality of the fairness and transparency in machine learning at this point in time, but also because recent breakthroughs in scalability have finally made it feasible to explore Bayesian approaches that are uniquely capable of addressing one of the most central aspects of the problem, i.e. uncertainty. BayesianGDPR will, in the short term, ensure that organisations relying on machine learning technologies are provided with concrete tools to comply with the non-discriminatory principles of GDPR and similar laws. In the medium term, it will impact research in computational law, and its integration into mainstream legal practice. In the long term, it will also ensure continued confidence of the general public in the deployment of machine learning systems.

Project End Date: **31-MAR-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851716	**AlgoQIP**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. OMAR FAWZI**
Host Institution: Ecole Normale Superieure De Lyon, FR

Beyond Shannon: Algorithms for optimal information processing

In the road towards quantum technologies capable of exploiting the revolutionary potential of quantum theory for information technology, a major bottleneck is the large overhead needed to correct errors caused by unwanted noise. Despite important research activity and great progress in designing better error correcting codes and fault-tolerant schemes, the fundamental limits of communication/computation over a quantum noisy medium are far from being understood. In fact, no satisfactory quantum analogue of Shannon's celebrated noisy coding theorem is known.

The objective of this project is to leverage tools from mathematical optimization in order to build an algorithmic theory of optimal information processing that would go beyond the statistical approach pioneered by Shannon. Our goal will be to establish efficient algorithms that determine optimal methods for achieving a given task, rather than only characterizing the best achievable rates in the asymptotic limit in terms of entropic expressions. This approach will address three limitations — that are particularly severe in the quantum context — faced by the statistical approach: the non-additivity of entropic expressions, the asymptotic nature of the theory and the independence assumption.

Our aim is to develop efficient algorithms that take as input a description of a noise model and output a near-optimal method for reliable communication under this model. For example, our algorithms will answer: how many logical qubits can be reliably stored using 100 physical qubits that undergo depolarizing noise with parameter 5%? We will also develop generic and efficient decoding algorithms for quantum error correcting codes. These algorithms will have direct applications to the development of quantum technologies. Moreover, we will establish methods to compute the relevant uncertainty of large structured systems and apply them to obtain tight and non-asymptotic security bounds for (quantum) cryptographic protocols.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851811	**VAPLCS**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. ORI LAHAV**
Host Institution: Tel Aviv University, IL

Verification-Aware Programming Language Concurrency Semantics

With the proliferation of multi-core processors, concurrent programming regularly appears at the core of heavily relied-upon systems, where both performance and correctness are of paramount importance. The canonical concurrency model is sequential consistency-identifying concurrent programs with all possible interleavings of operations of their constitute threads. It is a simple model for programmers, but unsatisfactory as a programming language concurrency semantics. First, performance-wise, it is too costly to implement. In fact, no commodity hardware provides sequential consistency. Second, the number of interleavings is often so large, posing the infamous "state explosion problem" as the utmost obstacle to any verification attempt.

Our overarching goal is to develop a novel concurrency semantics for programming languages that will: allow efficient implementation; provide easily usable guarantees, sufficiently strong for concurrent algorithms; and be amenable to scalable verification. To achieve this, we will leverage our recent advances in addressing the flaws in the C/C++ and Java specifications and in model checking under certain weak concurrency semantics. Moreover, we will develop practical verification methods to facilitate the task of concurrent programming.

This proposal makes a conceptual leap beyond the state-of-the-art, by identifying the development of a weak concurrency semantics not only as an unfortunate necessity, but also as an opportunity to revolutionize software verification. It is high-risk: it tackles a longstanding open problem in programming languages. It is also high-gain: it will significantly increase the applicability of verification, bridge a major gap between verification research and practical concurrent programming, and shed light on the role of the underlying semantics. I aim for the proposed concurrency semantics to provide new foundations for the specifications of mainstream and emerging programming languages.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851895	**LearnBugs**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. MICHAEL PRADEL**
Host Institution: Universitaet Stuttgart, DE

Learning to Find Software Bugs

Learning to Find Software Bugs

Software has become the cornerstone of modern society, economy, and life. Since software is created by humans, though, every non-trivial program contains various bugs, i.e., programming errors that may have disastrous consequences. Traditional approaches to find bugs include automated bug detection tools. Such tools search for instances of bug patterns that recur across projects and application domains. However, automated bug detection currently cannot unleash its full potential because each bug detector addresses one bug pattern and one programming language, while creating new bug detectors is feasible only for program analysis experts.

The objective of this proposal is to radically change the way automated bug detection tools are created. The core idea is to replace manually written program analyses with trained machine learning models. To this end, developers will train a bug detector for a particular bug pattern with examples of buggy and non-buggy code, which the model learns to distinguish. The project will realize this vision by developing a reusable framework that addresses several fundamental challenges at the intersection of software engineering, programming languages, and machine learning, e.g.: (i) How to support developers in creating large amounts of training data of buggy and non-buggy code examples? (ii) How to represent programs in a way suitable for advanced machine learning techniques?

The proposed project has the potential to revolutionize how software developers find bugs. To date, no other research has addressed the problem of automatically learning bug detection tools. If successful, the project will "democratize" bug detection by enabling all software developers, instead of a few program analysis experts, to create and share bug detection tools. Ultimately, the project will contribute to increasing the reliability, security, and efficiency of complex software systems used by millions of people.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852769	**ARiAT**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. CHRISTOPH HAASE**
Host Institution: University College London, UK

Advanced Reasoning in Arithmetic Theories

Arithmetic theories are logical theories for reasoning about number systems, such as the integers and reals. Such theories find a plethora of applications across computer science, including in algorithmic verification, artificial intelligence, and compiler optimisation. The appeal of arithmetic theories is their generality: once a problem has been formalised in a decidable such theory, a dedicated solver can in principle be used in a push-button fashion to obtain a solution. Arithmetic theories are also of great importance for showing decidability and complexity results in a variety of domains. Decision procedures for quantifier-free and linear fragments of arithmetic theories have been among the most intensively studied and impactful topics in theoretical computer science. However, emerging applications require more expressive theories, including support for quantifiers, counting, and non-linear functions. Unfortunately, the lack of understanding of the computational properties of such extensions means that existing decision procedures are not applicable or do not scale. The overall goal of this proposal is to advance the state-of-the-art in decision procedures for expressive arithmetic theories. To this end, starting with a recent breakthrough made by the PI, we will develop novel and optimal quantifier-elimination procedures for linear arithmetic theories, which we plan to eventually integrate into mainstream SMT solvers. Furthermore, we aim to improve complexity bounds and push the decidability frontier of extensions of arithmetic theories with counting and non-linear operations. The proposed research requires to tackle long-standing open problems - some of them being decades old. In short, the project will lay algorithmic foundations on which next-generation decision procedures and reasoners for arithmetic theories will be built.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
853489	**DEXIM**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. ZEYNEP AKATA**
Host Institution: Eberhard Karls Universitaet Tuebingen, DE

Deeply Explainable Intelligent Machines

Explanations are valuable because they scaffold the kind of learning that supports adaptive behaviour, e.g. explanations enable users to adapt themselves to the situations that are about to arise. Explanations allow us to attain a stable environment and have the possibility to control it, e.g. explanations put us in a better position to control the future. Explanations in the medical domain can help patients identify and monitor the abnormal behaviour of their ailment. In the domain of self-driving vehicles they can warn the user of some critical state and collaborate with her to prevent a wrong decision. In the domain of satellite imagery, an explanatory monitoring system justifying the evidence of a future hurricane can save millions of lives. Hence, a learning machine that a user can trust and easily operate need to be fashioned with the ability of explanation. Moreover, according to GDPR, an automatic decision maker is required to be transparent by law.

As decision makers, humans can justify their decisions with natural language and point to the evidence in the visual world which led to their decisions. In contrast, artificially intelligent systems are frequently seen as opaque and are unable to explain their decisions. This is particularly concerning as ultimately such systems fail in building trust with human users.

In this proposal, the goal is to build a fully transparent end-to-end trainable and explainable deep learning approach for visual scene understanding. To achieve this goal, we will make use of the positive interactions between multiple data modalities, incorporate uncertainty and temporal continuity constraints, as well as memory mechanisms. The output of this proposal will have direct consequences for many practical applications, most notably in mobile robotics and intelligent vehicles industry. This project will therefore strengthen the user's trust in a very competitive market.

Project End Date: **30-NOV-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865170	**PropRT**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. JIAN-JIA CHEN**
Host Institution: Technische Universitat Dortmund, DE

Property-Based Modulable Timing Analysis and Optimization for Complex Cyber-Physical Real-Time Systems

Cyber-physical real-time systems are information processing systems that require both functional as well as timing correctness and have interactions with the physical world. Since time naturally progresses in the physical world, safe bounds of deterministic or probabilistic timing properties are required. PropRT will explore the possibilities to construct timing analysis for complex cyber-physical real-time systems from formal properties. The target properties should be modular so that safe and tight analysis as well as optimization can be performed (semi-)automatically. New, mathematical, modulable, and fundamental properties for property-based (schedulability) timing analyses and scheduling optimizations are needed to capture the pivotal properties of cyber-physical real-time systems, and thus enable mathematical and algorithmic research on the topic. Different flexibility and tradeoff options to achieve real-time guarantees should be provided in a modularized manner to enable tradeoffs between execution efficiency and timing predictability. The success of this project will provide a comprehensive view of the landscape of design, analysis, and optimization options for timing properties in cyber-physical real-time systems. Advanced optimization and analytical frameworks based on the formal properties of scheduling algorithms and schedulability analysis will serve as new ingredients for designing predictable cyber-physical systems, which will trigger a revolution of computer architectures, system modeling, communication mechanisms, and synchronization designs in the near future. The results will bring a new design process to further allow control designers and system integrators in cyber-physical real-time systems to jointly explore different configurations of controllers, computation, and communication parameters for designing timing predictable cyber-physical system applications.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
885107	**RLeap**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. HECTOR GEFFNER**
Host Institution: Universitat Pompeu Fabra, ES

From Data-based to Model-based AI: Representation Learning for Planning

Two of the main research threads in AI revolve around the development of data-based learners capable of inferring behavior and functions from experience and data, and model-based solvers capable of tackling well-defined but intractable models like SAT, classical planning, and Bayesian networks. Learners, and in particular deep learners, have achieved considerable success but result in black boxes that do not have the flexibility, transparency, and generality of their model-based counterparts. Solvers, on the other hand, require models which are hard to build by hand. RLeap is aimed at achieving an integration of learners and solvers in the context of planning by addressing and solving the problem of learning first-order planning representations from raw perceptions alone without using any prior symbolic knowledge. The ability to construct first-order symbolic representations and using them for expressing, communicating, achieving, and recognizing goals is a main component of human intelligence and a fundamental, open research problem in AI. The success of RLeap requires the development of radically new ideas and methods that will build on those of a number of related areas that include planning, learning, knowledge representation, combinatorial optimization and SAT. The approach to be pursued is based on a clear separation between learning the symbolic representations themselves, that is cast as a combinatorial problem, and learning the interpretations of those representations, that is cast as a supervised learning problem from targets obtained from the first part. RLeap will address both problems, not just in the planning setting but in the generalized planning setting as well where plans are general strategies. The project can make a significant difference in how general, explainable, and trustworthy AI can be understood and achieved. The PI has made key contribution to the main themes of the project that make him uniquely qualified to carry it forward.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681379	**SPRINT**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. MIRIAM SERENA VITIELLO**
Host Institution: Consiglio Nazionale Delle Ricerche, IT

Ultra-Short Pulse laser Resonators IN the Terahertz

Ultra-short light pulses with large instantaneous intensities can probe light-matter interaction phenomena, capture snapshots of molecular dynamics and drive high-speed communications. In a semiconductor laser, mode-locking is the primary way to generate ultrafast signals. Despite the intriguing perspectives, operation at Terahertz (THz) frequencies is facing fundamental limitations: engineering "ultrafast" THz semiconductor lasers from scratch or finding an integrated technology to shorten THz light pulses are currently two demanding routes.

SPRINT aims to innovatively combine the groundbreaking quantum cascade laser (QCL) technology with graphene, to develop a new generation of passive mode-locked THz photonic laser resonators, combined with unexplored electronic nanodetectors for ultrafast THz sensing and imaging.

To achieve these ambitious objectives, the versatile quantum design of QCLs will be exploited to engineer the laser gain spectrum on purpose. Resonators of unusual symmetry and shape, like photonic quasi-crystals or random patterns, will be implemented, offering the flexibility to control and guide photons and the lithographic capability to embed miniaturized intra-cavity passive components to probe and modulate light. Graphene, owing to its gapless nature and ultrafast, gating-tunable carrier dynamic, will lead to a major breakthrough: integration in the THz QCL cavity will allow superbly manipulating its functionalities. Antenna-coupled quantum-dot nanowires will be also devised to sense and probe ultra-short THz pulses.

The project will target radically new concepts and interdisciplinary approaches encompassing unconventional THz QCL micro-resonators, graphene and polaritonic THz saturable absorbers, non-linear ultra-low dimensional detection architectures.

Pushing forward the understanding of ultrafast dynamics in complex THz electronic and photonic systems, SPRINT prospects new directions and long-term impacts on fundamental and applied science.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694829	**neuroXscales**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. ANDREAS HIERLEMANN**
Host Institution: Eidgenoessische Technische Hochschule Zurich, CH

Microtechnology and integrated microsystems to investigate neuronal networks across scales

To advance knowledge in electrophysiology and information processing of neuronal networks, we propose employing microtechnology and microelectronics to rigorously study neural networks in vitro across scales. Across scales pertains to the spatial domain - from details of subcellular components through single neurons to entire networks - and the temporal domain - from single action potentials to long-term developmental processes. Besides our CMOS-microelectronics-based high-density microelectrode arrays for recording and stimulation, the methodology will encompass patch-clamping directly on the microelectrode chips, high-resolution microscopy, genetic methods, large-scale data handling strategies, and dedicated data analysis and modeling algorithms. We will use mammalian cortical neuron cultures and brain slices.

We will potentially have access to every neuron and every action potential. We aim at studying - at the same time in the same preparation - details of specific neurons and subcellular components (somas, axons, synapses, dendrites) in their functional context and the characteristics of the corresponding networks (functional connectivity, emergent properties, plasticity). We will study alterations of components and networks over time and upon defined perturbations and mutual interdependence of network and component characteristics.

The high-spatio-temporal-resolution methodology will enable new fundamental neuroscientific insights through, e.g., facilitating investigation of axonal and axonal initial segment signaling characteristics, with the “axonal” side of neuronal activity being largely inaccessible to established methods. It will also enable the mapping of the overall synaptic input to a specific neuron, or the high-throughput monitoring of all action potentials in a network over extended time to see developmental effects or effects of disturbances. Potential applications include research in neural diseases and pharmacology.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695495	**ATTO**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. PIET DEMEESTER**
Host Institution: Universiteit Gent, BE

A new concept for ultra-high capacity wireless networks

The project will address the following key question:

How can we provide fibre-like connectivity to moving objects (robots, humans) with the following characteristics: very high dedicated bitrate of 100 Gb/s per object, very low latency of <10 µs, very high reliability of 99.999%, very high density of more than one object per m2 and this at low power consumption?

Achieving this would be groundbreaking and it requires a completely new and high-risk approach: applying close proximity wireless communications using low interference ultra-small cells (called “ATTO-cells”) integrated in floors and connected to antennas on the (parallel) floor-facing surface of ground moving objects. This makes it possible to obtain very high densities with very good channel conditions. The technological challenges involved are groundbreaking in mobile networking (overall architecture, handover with extremely low latencies), wireless subsystems (60 GHz substrate integrated waveguide-based distributed antenna systems connected to RF transceivers integrated in floors, low crosstalk between ATTO-cells) and optical interconnect subsystems (simple non-blocking optical coherent remote selection of ATTO-cells, transparent low power 100 Gb/s coherent optical / RF transceiver interconnection using analogue equalization and symbol interleaving to support 4x4 MIMO). By providing this unique communication infrastructure in high density settings, the ATTO concept will not only support the highly demanding future 5G services (UHD streaming, cloud computing and storage, augmented and virtual reality, a range of IoT services, etc.), but also even more demanding services, that are challenging our imagination such as mobile robot swarms or brain computer interfaces with PFlops computing capabilities.
This new concept for ultra-high capacity wireless networks will open up many more opportunities in reconfigurable robot factories, intelligent hospitals, flexible offices, dense public spaces, etc.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714562	**PIONEER**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. CHRISTOS BERGELES**
Host Institution: King'S College London, UK

Peri-Ocularly Navigated Exteroceptive Snake Robot for Novel Retinal Interventions

Intraocular treatments require manipulation of structures with dimensions comparable to hand tremor. The demanded dexterity, coupled with reduced haptic and depth perception, calls for robotic assistance.

Despite notable benefits, existing robots are not clinically disruptive but follow well-trodden intervention protocols with significant limitations, e.g. lack of flexibility at the scleral incision and limited manipulation bandwidth, as to avoid scleral, lens, and retinal damage. Robotics also does not obviate the prerequisite of the risky, cataract-inducing vitrectomy, which may cause retinal detachment (RD) or sight loss.

Novel interventions like stem-cell delivery pose yet further challenges. Apart from removing healthy vitreous, they require millimetre-long retinal tears, lifting the retinal membrane, and injecting a stem-cell suspension or sheet. Current robots facilitate manipulations but conceivably neither enable alternative approaches nor reduce retinal-tear-induced risks.

PIONEER, the proposed snake robot, can disrupt clinical protocol by navigating peri-ocularly and around the orbital muscles to suprachoroidally reach the retina. Revolutionizing existing robot paradigms, PIONEER innovates both scientifically and technically.

Optimal robot compliance will ensure force-adaptive peri-ocular steering conforming to the eye's exterior. A tactile sleeve with micro-sensors will provide exteroceptive force sensing and shape estimation. Enhanced navigation, fusing optical coherence tomography with on-line vessel detection from novel tip-mounted probes, will ensure safe guidance to avoid vessels through imposed virtual fixtures and path planning. No vitrectomy will be required and the posterior scleral incision will leave the retinal membrane intact, minimising RD risk.

PIONEER can be an enabler of emerging stem-cell interventions and futuristic procedures like drug-implant insertion and nerve interfacing, currently at human-dexterity limits or impossible.

Project End Date: **31-MAR-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715362	**SMART**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. TAL ELLENBOGEN**
Host Institution: Tel Aviv University, IL

Structured nonlinear Metamaterials for efficient generation and Active functional control of Radiation of THz light

The terahertz optical regime, covering the long wavelength end of the optical spectrum, has been for many years the least explored spectral regime. Recent interest in this regime has led to important emerging applications spanning many disciplines including medical, biological, materials sciences, communications, security, and basic sciences. However, advances in these emerging applications are held back by the lack of good and controllable terahertz light sources.

I propose to lead a potential breakthrough in this field by developing a new family of THz sources with unmatched functionality. The developed sources will be based on nano-engineered nonlinear heterostructured metamaterials, man-made materials with artificial optical properties. The proposal is based on very recent studies that show that metamaterials can be used to emit THz light with excellent efficiency, comparable to the best available nonlinear materials in nature. In addition it relies on our recent experimental demonstrations of functional nonlinear metamaterials that allow unprecedented control of nonlinear optical interactions. We will apply this recent knowledge to design novel active metamaterials that efficiently emit THz light at any desired frequency, shape and polarization, focus it directly from the emitter to a desired sample location and even actively steer and modify its radiation properties all-optically. In addition, we will enhance the THz generation efficiency from metamaterials by more than three orders of magnitude compared to the state of the art. We will also use our expertise to fabricate large scale and multi-layered THz light emitting metamaterials by leveraging novel nanolithography methods. Overall I expect that the outcome of this research will be in development of one of a kind family of THz light emitters that will lead to the, long sought for, leap in THz technology and will open the door to new applications and to new tools for advancing fundamental science.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715770	**QD-NOMS**	**PE7** Systems and Communication Engineering

Principal Investigator:	**Dr. FEI DING**
Host Institution:	Gottfried Wilhelm Leibniz Universitaet Hannover, DE

Elementary quantum dot networks enabled by on-chip nano-optomechanical systems

Is there any limit to the size of a quantum system? How large and how small can it be? Both questions are related to scalability, a most critical issue in quantum technologies. A scalable quantum network, which can be extended almost infinitely, is built by entangling individual quantum systems, e.g. atoms. It will provide thrilling opportunities across a range of intellectual and technical frontiers in quantum information science. Building such a network is however a great challenge, in both physics and engineering.

Often referred to as artificial atoms, semiconductor quantum dots (QDs) are among the most promising single and entangled photon sources to build a photonic quantum network. However there is a longstanding and yet unsolved challenge on scalability, since, unlike real atoms, every QD is different. By engineering individual QDs with an innovative nano-optomechanical system (NOMS), elementary QD networks will be built via scalable interactions of single or entangled photons, in a fashion similar to that of real atoms.

The scientific goals are to upscale QD networks with the first demonstrations of (1) indistinguishable entangled photons from different QDs, (2) deterministic entanglement swapping, purification and graph states with multiple QDs (3) deterministic Boson sampling with more than 4 QDs on chip.

The technological goals are (1) to downscale the footprint (<50 μm) of individual QD sources with full tunabilities, and to realize (2) arrays (>4×4) of tunable single and entangled photon sources, (3) waveguide integration on III-V/silicon chips, and (4) compact quantum LED demonstrators.

QD-NOMS will address the physical and technological challenges in building a solid-state QD-based quantum network. Its success does not only provide a novel toolkit to realize scalable QD systems for cutting-edge fundamental researches but also brings the semiconductor QD based platforms, after a decade of development, to the attention of practical applications.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724295	**NeuroAgents**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. GIACOMO INDIVERI**
Host Institution: Universitaet Zuerich, CH

Neuromorphic Electronic Agents: from sensory processing to autonomous cognitive behavior

Neural networks and deep learning algorithms are currently achieving impressive state-of-the-art results. In parallel computational neuroscience has made tremendous progress with both theories of neural computation and with hardware implementations of dedicated brain-inspired computing platforms.

However, despite this remarkable progress, today's artificial systems are still not able to compete with biological ones in tasks that involve processing of sensory data acquired in real-time, in complex and uncertain settings. One of the reasons is that neural computation in biological systems is very different from the way today's computers operate: it is tightly linked to the properties of their computational embodiment, to the physics of their computing elements and to their temporal dynamics. Conventional computers on the other hand operate with mainly serial and synchronous logic gates, with functions that are decoupled from their hardware implementation, and with discretized and virtual time.

In this project we will combine the recent advancements in machine learning and neural computation with the latest developments in neuromorphic computing technology to design autonomous systems that can express robust cognitive behavior while interacting with the environment, through the physics of their computing substrate. To achieve this we will embed in robotic platforms microelectronic neuromorphic processors and sensors that implement biophysically realistic neural computational primitives and dynamics. We will adopt active-sensing and on-line spike-based learning strategies, context and state-dependent computation, and probabilistic inference methods for "programming" these neuromorphic cognitive agents to solve challenging tasks in real-time.

Our results will lead to compact low-power intelligent sensory-motor systems that will have a large impact on service and consumer robotics, Internet of Things, as well as prosthetics and personalized medicine.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724530	**LIFEGATE**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. TOMAS CIZMAR**
Host Institution: Leibniz-Institut Fuer Photonische Technologien E.V., DE

Holographic super-resolution micro-endoscopy for in-vivo applications

Complexity of living matter currently poses the most significant barrier to modern in-vivo microscopy. Fuelled by various branches of life sciences, the race is now to increase the penetration depth of super-resolution imaging inside living organisms. Additionally, no high-resolution in-vivo imaging technique has ever been introduced into medical, particularly surgical practice.

This proposal sets out to develop new, ultra-thin endoscopic devices exceeding by orders of magnitude the performance of the current state of the art, thus paving the way for acquiring high-quality images from unprecedented depths of the most delicate tissues of living organisms.

A team of transdisciplinary experts will push the fundamental and technological limits of the enabling principle - holographic control of light propagation in multimode fibres. Through advanced analytical and numerical modelling and major advancement of experimental methods, the project will develop a powerful platform for fast and efficient recovery of randomised imagery, retrieved from both rigid and flexible single-fibre endoscopes.

This 'gate-through-life' will enable the team to deploy several prominent light-based imaging methods, including super-resolution approaches, inside freely moving animal models and ultimately humans.

Supported by partners with broad expertise in in-vivo imaging, I will apply this methodology in the first instance to Neuroscience. This will provide a new, minimally invasive window into fundamental processes behind sub-cellular-scale functional connectivity of neurons and onset of common disabling neuronal disorders such as Alzheimer's disease.

Lastly, I will introduce the first technological basis for keyhole clinical diagnostics, enabling intra-operative live histology and microsurgery. This new imaging capacity will be able to reach currently inaccessible regions of the human body, while providing images with sub-cellular resolution in-situ.

Project End Date: **31-OCT-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725731	**FOGHORN**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. OSVALDO SIMEONE**
Host Institution: King'S College London, UK

FOG-aided wireless networks for communication, cacHing and cOmputing: theoRetical and algorithmic fouNdations

The FOGHORN project aims at developing the theoretical and algorithmic foundations of fog-aided wireless networks. This is an emerging class of wireless systems that leverages the synergy and complementarity of cloudification and edge processing, two key technologies in the evolution towards 5G systems and beyond. Fog-aided wireless networks can reap the benefits of centralization via cloud processing, in terms of capital and operating cost reductions, greening, and enhanced spectral efficiency, while, at the same time, being able to cater to low-latency applications, such as the “tactile” internet, by means of localized intelligence at the network edge.

The operation of fog-aided wireless networks poses novel fundamental research problems pertaining to the optimal management of the communication, caching and computing resources at the cloud and at the edge, as well as to the transmission on the fronthaul network connecting cloud and edge. The solution of these problems challenges the theoretical principles and engineering insights which have underpinned the design of existing networks. The initial research activity on the topic, of which the EU is at the forefront, focuses, by and large, on ad hoc solutions and technologies. In contrast, the goal of this project is to develop fundamental theoretical insights and algorithmic principles with the main aim of guiding engineering choices, unlocking new academic opportunities and disclosing new technologies. The theoretical framework is grounded in network information theory, which enables the distillation of design principles, along with signal processing, (non-convex) optimization, queuing and distributed computing to develop and analyse algorithmic solutions. FOGHORN builds on the PI’s unique research experience on the information-theoretic and algorithmic analysis of wireless networks. If granted, this project will enable to start up his research group in an EU member state, transferring his know-how and experience.

Project End Date: **31-MAY-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
740355	**STEMS**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. STEFAN WABNITZ**
Host Institution: Universita Degli Studi Di Roma La Sapienza, IT

Spatiotemporal multimode complex optical systems

The STEMS project is about exploiting the new concept that has been recently introduced by the PI and his co-workers, namely the self-control of the spatial coherence of optical beams in multimode nonlinear optical fibers. This concept will enable a breakthrough technology, capable of delivering high-energy optical pulses with high-average powers and much higher beam quality from fiber lasers than what is possible today. High-power fiber lasers are largely limited by transverse mode instabilities, and the loss of spatial coherence in delivery fibers. Optical fibers provide the backbone of today's internet communication networks, and enable compact, low cost light sources for a variety of industrial and biomedical applications. In most of these applications, single-mode fibers are used. Replacing single-mode fibers with multimode fibers leads to a dramatic growth of transmission capacity, and a substantial increase of average power and pulse energy from fiber lasers. However, because of spatial dispersion and resulting mode interference, multimode fibers suffer from an inherent randomization of the spatial transverse beam profile, leading to a loss of spatial coherence. My approach is to exploit the intensity dependent refractive index, or Kerr nonlinearity, of glass fibers to recover the spatial coherence of a multimode wave, and compensate for temporal modal dispersion.

First, I propose to develop methods to control fiber nonlinearity, to compensate for temporal and spatial dispersion, thus preventing information spreading in the temporal domain, and coherence loss in the spatial domain. Second, by adding rare-earth dopants to multimode fibers, I will demonstrate self-control of modal dispersion and beam quality in active multimode fibers. Third, via the spatio-temporal control of beam propagation, I will introduce a new fast saturable absorber mechanism for the mode-locking of high-power fiber lasers, analogous to Kerr-lens mode-locking with bulk crystals.

Project End Date: **31-OCT-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
742745	**CAPABLE**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. ROBERTO OSELLAME**
Host Institution: Consiglio Nazionale Delle Ricerche, IT

Composite integrated photonic platform by femtosecond laser micromachining

The quantum technology revolution promises a transformational impact on the society and economics worldwide. It will enable breakthrough advancements in such diverse fields as secure communications, computing, metrology, and imaging. Quantum photonics, which recently received an incredible boost by the use of integrated optical circuits, is an excellent technological platform to enable such revolution, as it already plays a relevant role in many of the above applications. However, some major technical roadblocks needs to be overcome. Currently, the various components required for a complete quantum photonic system are produced on very different materials by dedicated fabrication technologies, as no single material is able to fulfil all the requirements for single-photon generation, manipulation, storage and detection. This project proposes a new hybrid approach for integrated quantum photonic systems based on femtosecond laser microfabrication (FLM), enabling the innovative miniaturization of various components on different materials, but with a single tool and with very favourable integration capabilities.

This project will mainly focus on two major breakthroughs: the first one will be increasing the complexity achievable in the photonic platform and demonstrating unprecedented quantum computation capability; the second one will be the integration in the platform of multiple single-photon quantum memories and their interconnection.

Achievement of these goals will only be possible by taking full advantage of the unique features of FLM, from the possibility to machine very different materials, to the 3D capabilities in waveguide writing and selective material removal.

The successful demonstration and functional validation of this hybrid, integrated photonic platform will represent a significant leap for photonic microsystems in quantum computing and quantum communications.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
755705	**FlexAnalytics**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. JUAN MIGUEL MORALES**
Host Institution: Universidad De Malaga, ES

Advanced Analytics to Empower the Small Flexible Consumers of Electricity

David against Goliath: Could small consumers of electricity compete in the wholesale markets on equal footing with the other market agents? Yes, they can and FlexAnalytics will show how.

Activating the demand response, although a major challenge, may also bring tremendous benefits to society, with potential cost savings in the billions of euros. This project will exploit methods of inverse problems, multi-level programming and machine learning to develop a pioneering system that enables the active participation of a group of price-responsive consumers of electricity in the wholesale electricity markets. Through this, they will be able to make the most out of their flexible consumption. FlexAnalytics proposes a generalized scheme for so-called inverse optimization that materializes into a novel data-driven approach to the market bidding problem that, unlike existing approaches, combines the tasks of forecasting, model formulation and estimation, and decision-making in an original unified theoretical framework. The project will also address big-data challenges, as the proposed system will leverage weather, market, and demand information to capture the many factors that may affect the price-response of a pool of flexible consumers. On a fundamental level, FlexAnalytics will produce a novel mathematical framework for data-driven decision making. On a practical level, FlexAnalytics will show that this framework can facilitate the best use of a large amount and a wide variety of data to efficiently operate the sustainable energy systems of the future.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
755953	**SENTIENT**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. MANUEL MAZO ESPINOSA**
Host Institution: Technische Universiteit Delft, NL

SCHEDULING OF EVENT-TRIGGERED CONTROL TASKS

The advances in electronic communication and computation have enabled the ubiquity of Cyber-Physical Systems (CPS): digital systems that regulate and control all sorts of physical processes, such as chemical reactors, water distribution and power networks. These systems require the timely communication of sensor measurements and control actions to provide their prescribed functionalities. Event-triggered control (ETC) techniques, which communicate only when needed to enforce performance, have attracted attention as a mean to reduce the communication traffic and save energy on (wireless) networked control systems (NCS). However, despite ETC's great communication reductions, the scheduling of the aperiodic and largely unpredictable traffic that ETC generates remains widely unaddressed – hindering its true potential for energy and bandwidth savings.

To address this problem, I will take up the following scientific challenges: (1) the construction of models for ETC's communication traffic; (2) the design of schedulers based on such models guaranteeing prescribed performance levels. To reach these goals, I will employ scientific methods at the cross-roads between theoretical computer science, control systems and communications engineering. I propose to follow a two step approach that I have recently demonstrated:
(i) modeling as timed-priced-game-automata (TPGA) the timing of communications of event-triggered control systems; and (ii) solving games over TPGAs to prevent data communication collisions and ensure prescribed performances for the control tasks.

I will produce algorithms facilitating the efficient implementation of control loops over shared communication resources and increasing the energy efficiency of wireless NCS by orders of magnitude. The advances will be demonstrated on automotive and wireless water-distribution control applications, showcasing the potential economic impact from the reduction of implementation and maintenance costs on CPSs.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757259	**Real-PIM-System**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. SHAHAR KVATINSKY**
Host Institution: Technion - Israel Institute Of Technology, IL

Memristive In-Memory Processing System

Our project aims to develop a new computer architecture that enables true in-memory processing based on a unit that can both store and process data using the same cells. This unit, called a memristive memory processing unit (mMPU), will substantially reduce the necessity to move data in computing systems, solving the two main bottlenecks exist in current computing systems, i.e., speed ('memory wall') and energy efficiency ('power wall'). Emerging memory technologies, namely memristive devices, are the enablers of the mMPU. While memristors are naturally used as memory, these novel devices can also perform logical operations using a technique we have invented called Memristor Aided Logic (MAGIC). This combination is the basis of mMPU.

The goal of this research is to design a fully functional mMPU, and by that, to demonstrate a real computing system with significantly improved performance and energy efficiency. We have identified four main research tasks which must be completed to demonstrate a full system utilizing mMPU: mMPU design, system architecture and software, modeling and evaluation, and fabrication. Both memristive memory array and mMPU control will be designed and optimized for different technologies in the first objective. The second objective will deal with the different aspects of the system, including programming model, different mMPU modes of operation and their corresponding system implications, compiler and operating systems. For system evaluation, we will develop models and tools in the third objective in order to measure the performance, area and energy and to compare them to other state-of-the-art computing systems. Lastly, we will fabricate the different parts of the system to demonstrate the full system.

Encouraged from our preliminary experimental results, we expect to achieve 10X improvement in performance, and 100X improvement in energy efficiency as compared to state-of-the-art von Neumann systems when working with appropriate workloads.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757444	**SONGBIRD**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. MARIA TENJE**
Host Institution: Uppsala Universitet, SE

SOphisticated 3D cell culture scaffolds for Next Generation Barrier-on-chip In vitro moDels

The blood-brain barrier is a sophisticated biological barrier comprising several different cell types, structured in a well-defined order with the task to strictly control the passage of molecules - such as drugs against neurodegenerative diseases - from the blood into the brain. To reduce the ethical and economic costs of drug development, which in EU today uses
~10 million experimental animals every year, we must develop in vitro models of the blood-brain barrier with high in vivo correlation, as these are completely missing today.

SONGBIRD aims to achieve this with the scientific approach to
- Develop advanced microfabrication methods to handle biologically derived materials
- Structure the materials into heterogeneous 3D multi-layer suspended cell culture scaffolds
- Incorporate blood-brain barrier cells with precise control on location and order
- Integrated the 3D scaffolds into a microfluidic network as a miniaturised screening platform

The vision is to develop and validate versatile microfabrication methods to mechanically structure and physically handle soft biological materials to unlock the use of next generation animal-free barrier-on-chip models that can be used to speed up drug development, serve as screening platforms for nanotoxicology and help medical researchers to gain mechanistic insight in drug delivery. During SONGBIRD, I will focus on the blood-brain barrier due to its urgent relevance for drug development for the ageing population but the final processing tool-box will be suitable for realising in vitro models of any biological barrier in the future.

SONGBIRD is proposed to run for 60 months and will include researchers with expertise in microsystem engineering (PI), hydrogel synthesis and drug delivery. The expected output is a validated 3D barrier-on-chip model as well as a microfabrication toolbox for biological materials enabling transformation from 2D to 3D cell cultures in several other life science research areas.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757791	**FUN-NOTCH**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. ALEX ALVARADO**
Host Institution: Technische Universiteit Eindhoven, NL

Fundamentals of the Nonlinear Optical Channel

Fibre optics are critical infrastructure for society because they carry nearly all the global Internet traffic. For a long time, optical fibre systems were thought to have infinite information-carrying capabilities. With current traffic demands growing by a factor between 10 and 100 every decade, however, this is no longer the case. In fact, it is currently unknown if the installed optical infrastructure will manage to cope with these demands in the future, or if we will face the so-called "capacity crunch".

To satisfy traffic demands, transceivers are being operated near the nonlinear regime of the fibres. In this regime, a power-dependent nonlinear phenomenon known as the Kerr effect becomes the key impairment that limits the information-carrying capability of optical fibres. The intrinsic nonlinear nature of these fibres makes the analysis very difficult and has led to a series of unanswered fundamental questions about data transmission in nonlinear optical fibres, and nonlinear media in general. For example, the maximum amount of information that optical fibres can carry in the highly nonlinear regime is still unknown, and the design of transceivers well-suited for this regime is also completely unexplored.

In this project, the PI will answer these fundamental questions by studying the simplest nontrivial building blocks underlying optical fibres, and will give a definitive answer to the capacity crunch question. The PI will use a systematic methodology that aims at embracing nonlinear effects, consider the continuous-time channel as the correct starting point for analysis, and redesign optical transceivers from scratch, lifting all linear assumptions. The proposed methodology is in sharp contrast with current research trends, which aim at mitigating nonlinearities, and consider discrete-time models in the linear regime. Due to the central role of information transmission in modern society, the results in this project will have broad societal impact.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757800	**QuadraComb**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. FRANÇOIS LEO**
Host Institution: Universite Libre De Bruxelles, BE

Quadratic dispersive resonators for optical frequency comb generation

Optical frequency combs are made of thousands of equally spaced spectral lines, each an ultra-stable laser in its own right. They act as “spectral rulers” against which unknown optical frequencies can be measured, and they have had a revolutionary impact on numerous fields ranging from the detection of extra-solar planets to precision metrology, winning its inventors a Nobel prize in 2005. Traditionally, frequency combs have been generated by ultrashort pulsed lasers, but in 2007 an important observation changed the research landscape: a continuous-wave laser coupled into a microscopic resonator was shown to spontaneously transform into thousands of comb lines via third-order nonlinear optical effects. I believe that yet another revolution lies at the horizon. Specifically, recent experiments have alluded to the possibility of realizing optical frequency combs purely through second order (quadratic) nonlinear effects. The intrinsic features of the second order nonlinearity hold promise to deliver access to new regions of the electro-magnetic spectrum beyond all conventional frequency comb technologies. But unfortunately, experimental investigations are scarce and the physics that underlie frequency comb formation in quadratic resonators is poorly understood. The goal of the QuadraComb project is to pursue a complete characterization of frequency comb generation in dispersive quadratically nonlinear resonators. I plan to (i) develop theoretical models to describe quadratic frequency combs, and (ii) develop novel platforms for the experimental realization of quadratic frequency combs.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758843	**SBS3-5**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. KRISHNA COIMBATORE BALRAM**
Host Institution: University Of Bristol, UK

Stimulated Brillouin Scattering based RF to Optical Signal Transduction and Amplification

While the detection of weak signals (down to the single photon level) in the optical frequency range is routine on account of the high photon energy (compared to thermal excitation energy kBT) and the availability of efficient detectors, this is not the case in the radio frequency (RF) and microwave frequency regimes wherein thermal (Johnson) noise in detectors swamps out the faint RF signals (in applications from radio astronomy, MRI to radar) and requires the use of cryogenic amplifiers. The ability to map signals efficiently from the microwave to optical regime becomes paramount for distant systems to communicate with each other using low loss telecom fibers. Both classical (radio over fiber systems) and quantum (linking two superconducting qubit processors in two dilution fridges) information processing systems will benefit greatly from the development of an efficient RF to optical signal transducer.

I have been developing efficient RF to optical transduction schemes in GaAs cavity optomechanical systems (KC Balram et al., Nature Photonics (2016)) by exploiting its favorable piezoelectric (for coupling RF signals to propagating acoustic waves) and elasto-optic (for engineering strong acousto-optic interactions) properties. In this project, I would like to extend this work and address the issue of weak RF signal detection by up-converting RF signals to the optical domain using integrated Stimulated Brillouin Scattering (SBS) and shot-noise limited optical detection. Piezoelectric SBS systems can also be used to build high frequency, high gain RF amplifiers with noise figures that can be lower than conventional RF amplifiers. Working in a novel GaAs on insulator platform helps provide some unique advantages (tightly confined acoustic and optical modes with large modal overlap and a large elasto-optic coefficient leading to significant Brillouin gain) while holding the potential for interfacing complex circuitry in a well-established III-V materials platform.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758973	**sCENT**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. JANA JAGERSKA**
Host Institution: Universitetet I Tromsoe - Norges Arktiske Universitet, NO

Cryptophane-Enhanced Trace Gas Spectroscopy for On-Chip Methane Detection

Sensitivity of on-chip gas sensors is still at least 2-3 orders of magnitude lower than what is needed for applications in atmospheric monitoring and climate research. For optical sensors, this comes as a natural consequence of miniaturization: sensitivity scales with interaction length, which is directly related to instrument size. The aim of this project is to explore a new concept of combined chemical and spectroscopic detection for on-chip sensing of methane, the principal component of natural gas and a potent climate forcer.

The sought-after sensitivity will be achieved by pre-concentrating gas molecules directly on a chip surface using cryptophanes, and subsequently detecting them using slow-light waveguides and mid-infrared laser absorption spectroscopy. Cryptophanes are macromolecular structures that can bind and thus pre-concentrate different small molecules, including methane. Spectroscopic detection of methane in a cryptophane host is an absolute novelty, and, if successful, it will not only contribute to unprecedented sensitivity enhancement, but will also address fundamental questions about the dynamics of small molecules upon encapsulation. The actual gas sensing will be realized using evanescent field interaction in photonic crystal waveguides, which exhibit both large evanescent field confinement and long effective interaction pathlengths due to the slow-light effect. The waveguide design alone is expected to improve the per-length sensitivity up to 10 times, while another 10 to 100-fold sensitivity enhancement is expected from the pre-concentration.

The targeted detection limit of 10 ppb will revolutionize current methods of atmospheric monitoring, enabling large-scale networks of integrated sensors for better quantification of global methane emissions. Beyond that, this method can be extended to the detection of other gases, e.g. CO2 and different volatile organic compounds with equally relevant applications in the medical domain.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759483	**ELECTRIC**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. BART KUYKEN**
Host Institution: Universiteit Gent, BE

Chip Scale Electrically Powered Optical Frequency Combs

In ELECTRIC, I will integrate electrically powered optical frequency combs on mass manufacturable silicon chips. This will allow for making use of all the advantageous properties of these light sources in real-life situations.

Optical frequency combs are light sources with a spectrum consisting of millions of laser lines, equally spaced in frequency. This equifrequency spacing provides a link between the radio frequency band and the optical frequency band of the electromagnetic spectrum. This property has literally revolutionized the field of frequency metrology and precision laser spectroscopy. Recently, their application field has been extended. Amongst others, their unique properties have been exploited in precision distant measurement experiments as well as optical waveform and microwave synthesis demonstrators. Moreover, so called “dual-comb spectroscopy” experiments have demonstrated broadband Fourier Transform Infrared spectroscopy with ultra-high resolution and record acquisition speeds. However, most of these demonstrations required large bulky experimental setups which hampers wide deployment.

I will build frequency combs on optical chips that can be mass-manufactured. Unlike the current chip scale Kerr comb based solutions they do not need to be optically pumped with a powerful continuous wave laser and can have a narrower comb spacing. The challenge here is two-fold. First, we need to make electrically powered integrated low noise oscillators. Second, we need to lower the threshold of current on-chip nonlinear optical interactions by an order of magnitude to use them in on-chip OFC generators.

Specifically I will achieve this goal by:

- Making use of ultra-efficient nonlinear optical interactions based on soliton compression in dispersion engineered III-V waveguides and plasmonic enhanced second order nonlinear materials.
- Enhance the performance of ultra-low noise silicon nitride mode locked lasers with these nonlinear components.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771410	**DarkComb**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. VICTOR TORRES COMPANY**
Host Institution: Chalmers Tekniska Hoegskola Ab, SE

Dark-Soliton Engineering in Microresonator Frequency Combs

The continuing increase in Internet data traffic is pushing the capacity of single-mode fiber to its fundamental limits. Space division multiplexing (SDM) offers the only remaining physical degree of freedom – the space dimension in the transmission channel – to substantially increase the capacity in lightwave communication systems.

The microresonator comb is an emerging technology platform that enables the generation of an optical frequency comb in a micrometer-scale cavity. Its compact size and compatibility with established semiconductor fabrication techniques promises to revolutionize the fields of frequency synthesis and metrology, and create new mass-market applications.

I envision significant scaling advantages in future fiber-optic communications by merging SDM with microresonator frequency combs. One major obstacle to overcome here is the poor conversion efficiency that can be fundamentally obtained using the most stable and broadest combs generated in microresonators today. I propose to look into the generation of dark, as opposed to bright, temporal solitons in linearly coupled microresonators. The goal is to achieve reliable microresonator combs with exceptionally high power conversion efficiency, resulting in optimal characteristics for SDM applications. The scientific and technological possibilities of this achievement promise significant impact beyond the realm of fiber-optic communications.

My broad international experience, unique background in fiber communications, photonic waveguides and ultrafast photonics, the preliminary results of my group and the available infrastructure at my university place me in an outstanding position to pioneer this new direction of research.

Project End Date: **30-APR-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771687	**CORNEA**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. MING CAO**
Host Institution: Rijksuniversiteit Groningen, NL

Controlling evolutionary dynamics of networked autonomous agents

Large-scale technological, biological, economic, and social complex systems act as complex networks of interacting autonomous agents. Large numbers of interacting agents making self-interested decisions can result in highly complex, sometimes surprising, and often suboptimal, collective behaviors. Empowered by recent breakthroughs in data-driven cognitive learning technologies, networked agents collectively give rise to evolutionary dynamics that cannot be easily modeled, analysed and/or controlled using current systems and control theory. Consequently, there is an urgent need to develop new theoretical foundations to tackle the emerging challenging control problems associated with evolutionary dynamics for networked autonomous agents.

The aim of this project is to develop a rigorous theory for the control of evolutionary dynamics so that interacting autonomous agents can be guided to solve group tasks through the pursuit of individual goals in an evolutionary dynamical process. The theory will then be tested, validated and improved against experimental results using robotic fish.

To achieve the aim, I will: (1) develop a general formulation for stochastic evolutionary dynamics with control inputs, enabling the study on controllability and stabilizability for evolutionary processes; (2) introduce stochastic control Lyapunov functions to design control laws; (3) construct new classes of conditional strategies that may propagate controlled actions effectively from focal agents in multiple time scales; and (4) validate experimentally on tasks with unknown difficulties that require a group of robotic fish to evolve and adapt.

The project will result in a major advance from the conventional usage of evolutionary game theory with the systematic design to actively control evolutionary outcomes. The combination of theory with experimentation and the multi-disciplinary nature of the approach will lead to new applications of autonomous robotic systems.

Project End Date: **30-APR-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772539	**SCATTERERID**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. ETIENNE PERRET**
Host Institution: Institut Polytechnique De Grenoble, FR

Analysis and synthesis of wideband scattered signals from finite-size targets – aspect-independent RF analog footprint

The need for information identification and capture is a matter of prime importance in modern societies. Every sectors of society rely on the identification of data exchanged, the updating of the data recorded on a tag and the measurement of physical parameters. The ability to make objects interact with one another or with humans is an important factor in many applications, all the more so if this interaction can occur without human presence. The way to reduce power consumption, improve the communication quality-of-service and enhance connectivity has become key issues for lots of industries. Researchers need to consider the multiple factors simultaneously to design state-of-the-art RF devices for the next generation of identification services. One important direction is to develop low-power, low cost tags for wireless identification and sensing. Lots of improvements have been done today on communication systems based on electronic devices where an integrated circuit is at the heart of the whole system. The democratisation of these chipped based systems like the RFID one will give rise to environmental issues in the future. However, these improvements pave the way for the development of new concepts based on approaches where the presence of the chip is not mandatory. These approaches are based on radar or reflectometry principles; these are non-invasive techniques but they require specific theoretical and practical developments. The difficulty is to be able to retrieve a small signal coming from a totally passive label placed in an unknown and movable environment. The objective of this project is to introduce the paradigm of RF communication system based on chipless labels, i.e. tags without any chip, bringing an ID, able to communicate with radio waves and having extremely low costs. This project aims at showing that it is possible to associate the paper based chipless label ID with other features like the ability to write and rewrite the ID, or a sensor function.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788298	**ROBOTGENSKILL**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. JORIS DE SCHUTTER**
Host Institution: Katholieke Universiteit Leuven, BE

Generalizing human-demonstrated robot skills

Future robots are expected to perform a multitude of complex tasks with high variability, in close collaboration or even physical contact with humans, and in industrial as well as in non-industrial settings. Both human-robot interaction and task variability are major challenges. A lot of progress is needed so that: (1) robots recognize the intention of the human and react with human-like motions; (2) robot end-users, such as operators on the factory floor or people at home, are able to deploy robots for new tasks or new situations in an intuitive way, for example by just demonstrating the task to the robot.

The fundamental challenge addressed in this proposal is: how can a robot generalize a skill that has been demonstrated in a particular situation and apply it to new situations? This project focuses on skills involving rigid objects manipulated by a robot or a human and follows a model-based approach consisting of: (1) conversion of the demonstrated data to an innovative invariant representation of motion and interaction forces; (2) generalization of this representation to a new situation by solving an optimal control problem in which similarity with the invariant representation is maintained while complying with the constraints imposed by the new context. Additional knowledge about the task can be added in the constraints.

Major breakthroughs are that the required number of demonstrations and hence the training effort decrease drastically, similarity with the demonstration is maintained in view of preserving the human-like nature, and task knowledge is easily included.

The methodology is applied to program robot skills involving motion in free space (e.g. human-robot hand over tasks) as well as advanced manipulation skills involving contact (e.g. assembly, cleaning), aiming at impact in industrial and non-industrial settings.

Application of the invariant motion representation in the neighbouring field of biomechanics will further leverage impact.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788793	**BACKUP**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. LORENZO PAVESI**
Host Institution: Universita Degli Studi Di Trento, IT

Unveiling the relationship between brain connectivity and function by integrated photonics

I will address the fundamental question of which is the role of neuron activity and plasticity in information elaboration and storage in the brain. I, together with an interdisciplinary team, will develop a hybrid neuro-morphic computing platform. Integrated photonic circuits will be interfaced to both electronic circuits and neuronal circuits (in vitro experiments) to emulate brain functions and develop schemes able to supplement (backup) neuronal functions. The photonic network is based on massive reconfigurable matrices of nonlinear nodes formed by microring resonators, which enter in regime of self-pulsing and chaos by positive optical feedback. These networks resemble human brain. I will push this analogy further by interfacing the photonic network with neurons making hybrid network. By using optogenetics, I will control the synaptic strengthen-ing and the neuron activity. Deep learning algorithms will model the biological network functionality, initial-ly within a separate artificial network and, then, in an integrated hybrid artificial-biological network.
My project aims at:
1. Developing a photonic integrated reservoir-computing network (RCN);
2. Developing dynamic memories in photonic integrated circuits using RCN;
3. Developing hybrid interfaces between a neuronal network and a photonic integrated circuit;
4. Developing a hybrid electronic, photonic and biological network that computes jointly;
5. Addressing neuronal network activity by photonic RCN to simulate in vitro memory storage and retrieval;
6. Elaborating the signal from RCN and neuronal circuits in order to cope with plastic changes in pathologi-cal brain conditions such as amnesia and epilepsy.
The long-term vision is that hybrid neuromorphic photonic networks will (a) clarify the way brain thinks, (b) compute beyond von Neumann, and (c) control and supplement specific neuronal functions.

Project End Date: **31-OCT-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
789028	**QuantCom**	**PE7** Systems and Communication Engineering

Principal Investigator:	**Dr. LAJOS HANZO**
Host Institution:	University Of Southampton, UK

Ubiquitous Quantum Communications

'It is difficult to make predictions, especially about the future'' - Mark Twain. Yet, Gordon Moore's predictions - known as Moore's Law - made in 1965 remained valid for half a century! As a result, semi-conductor technology is approaching nano-scale integration and on this journey to quantum futures the traveller enters the world of quantum physics, where many of the phenomena are rather different from those of classical physics. This proposal contributes to the 'quantum jig-saw puzzle', with special emphasis on the enabling techniques of ubiquitous quantum communications, potentially leading to job- and wealth-creation on a similar scale to the economic benefits of flawless classic wireless communications. My ultimate goal as a telecommunications researcher is to build bridges across the exciting fields of quantum physics, mathematics, computer science and hardware aspects of quantum communications. Specifically, the three Key Challenges of Work-Packages 1-3 on the new concept of Pareto-optimum error control, secret key-distribution, network coding and entanglement distribution will lead to creating stepping-stones for the Grand Challenge of Work-Package 4, dedicated to the support of quantum-communications for aircraft 'above the clouds'. Methodology: theoretical performance bounds will be established based on the hitherto unexplored Pareto-optimum quantum design philosophy using multi-component optimization. Explicitly, the Pareto-front of optimal solutions will be found off-line, where none of the conflicting parameters, such as the bit-error ratio, transmit power, delay and implementation complexity can be improved without degrading some of the others. A suite of new soft-decision aided components will be conceived by invoking code-specific quantum syndrome decoders to be designed for iterative soft-information exchange without perturbing the fragile quantum states. Finally, quantum communications solutions will be created for drones and planes.

Project End Date: **31-MAY-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
789051	**OCONTSOLAR**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. EDUARDO CAMACHO**
Host Institution: Universidad De Sevilla, ES

Optimal Control of Thermal Solar Energy Systems

OCONTSOLAR aims to develop new control methods to use mobile sensors mounted on drones and unmanned ground vehicles (UGV) as an integral part of the control systems. Sensors mounted on vehicles have been used for surveillance and for gathering information, however these mobile sensors have not been used so far as an integral part of control systems.

Solar power plants will be used as a case study, with the aim of optimizing their operation using spatial irradiance estimations and predictions. Many results will be applicable to other systems such as traffic control in highways and cities, energy management in buildings, micro-grids, agriculture (irrigation and plague control) and flood control. The main objectives and challenges are:

1. Methods to control mobile sensor fleets and integrate them as an essential part of the overall control systems.
2. Spatially distributed solar irradiance estimation methods using a variable fleet of sensors mounted on drones and UGVs.
3. New model predictive control (MPC) algorithms that use mobile solar sensor estimations and predictions to yield safer and more efficient operation of the plants allowing the effective integration of solar energy in systems delivering energy to grids or other systems while satisfying production commitments.

OCONTSOLAR includes proofs of concepts by implementation on the Solar Platform of Almeria and on a solar air conditioning plant installed at the host institution.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
789190	**CARENET**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. GIUSEPPE CAIRE**
Host Institution: Technische Universitat Berlin, DE

Content-Aware Wireless Networks: Fundamental Limits, Algorithms, and Architectures

Wireless communication networks are the essential connectivity tissue of the modern digital age. Wireless data traffic is predicted to increase by almost three orders of magnitude in the next five years. It is unlikely that such increase can be tackled by an incremental “more-of-the-same” approach. This proposal stems from the observation that the killer application for wireless networks is on-demand access to Internet content. CARENET advocates a novel content-aware approach to wireless networks design that can provably solve the scalability problem of current systems, thus supporting the paradigmatic shift “from Gigabits per second for a few to Terabytes per month for all”. CARENET’s vision is to serve an arbitrarily large number of users with bounded transmission resources (bandwidth, number of transmit antennas, and power). The fundamental question is: how can such a per-user throughput scalability be achieved in the presence of on-demand requests, for which users do not access simultaneously the same content? CARENET builds on a novel information theoretic formulation of content-aware networks and on several recent results in information theory, network coding, channel coding, and protocol design, stimulated by the PI’s recent work. Key elements of the proposed content-aware architectures are new caching strategies, where content is stored across the wireless network nodes. These strategies are supported by the ever-growing on-board memory of wireless devices and by the new features of the forthcoming 5G-like technology. Our thesis is that scalability is possible through the novel content-aware design, while it is information-theoretically impossible otherwise. Our overarching goal envisions the delivery of one Terabyte per month to each user at an affordable cost and good Quality of Experience, rather than the traditional Gigabit per second peak rates targeted by conventional technology development.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
789340	**iCOMM**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. ANATOLY ZAYATS**
Host Institution: King'S College London, UK

New Frontiers in Nanophotonics: Integrating Complex Beams and Active Metasurface Devices

Complex, structured optical beams have unique properties offering new degrees of freedom for achieving unusual wavefront, polarisation and optical angular momentum demanded in microscopy, optical trapping and manipulation of nano-objects, information encoding in optical communications, holography, quantum technologies and laser micromachining. Metasurfaces, a subwavelength-thin nanostructured films, which were initially developed for controlling the phase of light and its reflection and transmission beyond the Snell's law, provide a rich playground for generation and manipulation of structured beams. iCOMM will establish a metasurface platform for generating and controlling complex vector beams in space and time and develop its applications in sensing and identification of chiral molecules and nonlinear optical trapping. Using unique optical properties of designer-metasurfaces capable of controlling both phase and amplitude of light, nonlinear interactions of pulsed vector beams will be optimised and explored. We will aim to develop a series of active metamaterial chips for nonlinear control of CVBs, linear and nonlinear sensing of chiral molecules and optical trapping applications, opening new application areas in information processing and biochemical technologies. This will be a transformative development for the applications of complex vector beams and metasurfaces in optical communications, displays, security and bio- and chemical sensing and optical trapping. The success of the project will unlock the potential of metasurfaces in providing tuneability for the improvement of the real-world photonic devices and provide insight into physical phenomena which are vital for various areas of photonics and sensing, demonstrating commercially-viable application of metasurfaces and complex beams. It will transform the areas of both complex beams and metasurfaces by introducing real-time active control and consolidate and enhance the European leadership in this field.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
801434	**inCREASE**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. ANTONIA WACHTER-ZEH**
Host Institution: Technische Universitaet Muenchen, DE

Coding for Security and DNA Storage

Communication and data storage systems are indispensable parts of our every-day life. However, these systems deal with severe challenges in security and reliability. Security is important whenever a user communicates or stores sensitive data, e.g., medical information; reliability has to be guaranteed to be able to transmit or store information while noise occurs. Algebraic codes (ACs) are a powerful means to achieve both.

Within inCREASE, I will construct and evaluate special codes for security applications and DNA storage.
The tasks are structured into three work packages: (1) post-quantum secure code-based cryptosystems, (2) secure key regeneration based on ACs, (3) ACs for DNA-based storage systems. The focus of inCREASE
lies on innovative theoretical concepts.

The goal of work package (1) is to investigate and design code-based cryptosystems; one promising idea is to apply insertion/deletion correcting codes. The security of these systems will be analysed from two points of view: structural attacks on the algorithms and hardware implementations with side-channel attacks.

Secure cryptographic key regeneration is the goal of (2) and can be achieved by physical unclonable functions (PUFs). Here, ACs are necessary to reproduce the key reliably. This project will study the error patterns that occur in PUFs, model them theoretically, and design suitable coding schemes.

The investigation on (3) will start with a study of the data of existing DNA storage systems. The outcome will be an error model that will include insertions, deletions, substitutions, and duplications. Therefore, inCREASE will design ACs for these error types. This will be especially challenging regarding the mathematical concepts. These codes will be evaluated by simulations and using data sets of DNA storage systems.

This project is high risk/high gain with impact not only to storage and security, but to the methodology as well as other areas such as communications.

Project End Date: **29-FEB-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802348	**COSMOS**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. SERGIO GRAMMATICO**
Host Institution: Technische Universiteit Delft, NL

Game theoretic Control for Complex Systems of Systems

Modern society is based on large-scale, interconnected, complex infrastructures, e.g. power, transportation and communication systems, with network structure and interacting subsystems controlled by autonomous components and human users, generically called “agents”. These systems possess the features of “complex” systems of systems (C-SoS), such as rationality and autonomy of the agents, and require effective multi-agent coordination and control actions for their safe and efficient operation. Multi-agent optimization has attracted an extraordinary amount of research attention as a methodology to let agents cooperatively coordinate their actions, but it is inappropriate and ineffective for systems with noncooperative (selfish) agents, virtually all modern C-SoS.

A paradigm shift is necessary to ensure safe and efficient operation of complex systems with possibly noncooperative agents. With this aim, COSMOS shall embrace dynamic game theory and pursue a twofold scientific and technical objective: 1) to conceive a unifying framework for the analysis and control of complex, multi-agent, mixed cooperative and noncooperative, systems; 2) to provide automated computational methods for solving coordination, decision and control problems in C-SoS. To achieve these goals, COSMOS will adopt a novel operator-theoretic approach, and integrate methods within and across dynamic game theory, networked multi-agent systems and control, statistical learning, stochastic and mixed-integer optimization.

The expected project outcomes are a mathematical theory, algorithms and automated software that can ensure safe and efficient operation of C-SoS populated by mixed cooperative and noncooperative agents, in the presence of network coupling, adversarial and stochastic uncertainty, discrete and continuous decision variables. COSMOS shall develop the potential of dynamic game theory and raise it to a whole new level where it can have a high impact on fundamental sciences and engineering.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804233	**3D-nanoMorph**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. KRISHNA AGARWAL**
Host Institution: Universitetet I Tromsoe - Norges Arktiske Universitet, NO

Label-free 3D morphological nanoscopy for studying sub-cellular dynamics in live cancer cells with high spatio-temporal resolution

Label-free optical nanoscopy, free from photobleaching and photochemical toxicity of fluorescence labels and yielding 3D morphological resolution of <50 nm, is the future of live cell imaging. 3D-nanoMorph breaks the diffraction barrier and shifts the paradigm in label-free nanoscopy, providing isotropic 3D resolution of <50 nm. To achieve this, 3D-nanoMorph performs non-linear inverse scattering for the first time in nanoscopy and decodes the information of multiple scattering between sub-cellular structures (organelles).

3D-nanoMorph innovatively devises complementary roles of light measurement system and computational nanoscopy algorithm. A novel imaging system serves the specific purpose of collecting side-scattered light from the organelles only, such that measured data is rich of multiple scattering information. Novel photonic-chip illumination system (PIS) and perturbation optical microscope (POM) accomplish this purpose and create a fresh perspective about label-free measurements. A new computational nanoscopy approach employs non-linear inverse scattering (IS). IS is empowered with pre-estimation of the locations and shapes of the organelles and exploitation of apriori information about refractive index of organelles such as lysosomes. Harnessing non-linear IS for resolution enhancement in nanoscopy opens new possibilities in label-free 3D nanoscopy.

I will apply 3D-nanoMorph to study organelle degradation (autophagy) in live cancer cells over extended duration with high spatial and temporal resolution, presently limited by the lack of high-resolution label-free 3D morphological nanoscopy. Successful 3D mapping of nanoscale biological process of autophagy will open new avenues for cancer treatment and showcase 3D-nanoMorph for wider applications.

My cross-disciplinary expertise of 14 years spanning inverse problems, electromagnetism, optical microscopy, integrated optics and live cell nanoscopy paves path for successful implementation of 3D-nanoMorph.

Project End Date: **30-JUN-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804626	**PhotUntangle**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. DAVID PHILLIPS**
Host Institution: The University Of Exeter, UK

Rendering the opaque transparent: Untangling light with bespoke optical transforms to see through scattering environments

When light propagates through an opaque material, such as living tissue or a multi-mode optical fibre, it fragments and scatters multiple times. The emergent wavefront no longer forms an image because the spatial information it carries has been scrambled. Reversing this scattering offers the prospect of using visible light for high-resolution imaging of structures deep inside the human body in a safe, non-ionising way. It has recently been shown that this light scattering can be characterised and inverted. Yet arbitrary spatial mode inverters that can unscramble hundreds of light modes simultaneously to efficiently reform an image do not currently exist. The aim of this project is to understand how to design and build them.

I will pioneer the use of focused lasers to write intricate nano-structures directly into glass. The key advancement will be to overcome extreme fabrication tolerances by employing a fluid design approach, whereby the design will be modified during the fabrication process. In parallel, I will develop dynamic transformers, capable of rapidly reprogrammable optical transformations. Further, I will create new computational techniques to overcome residual levels of crosstalk, and develop new ultra-fast scattering characterisation methods based on compressed sensing. This project will advance our fundamental understanding of how to control optical scattering in complex media. Key aims are to:

- Understand how to design a new class of optical elements that can perform efficient spatial mode transforms on demand.
- Build both passive spatial mode transformers to manipulate hundreds of modes simultaneously, and active transformers that can perform dynamically reconfigurable transformations at video-rates.
- Apply this technology to unscramble light that has propagated through a moving multi-mode optical fibre in real-time, pushing towards ultra-thin micro-endoscopy, and explore an array of applications to next generation imaging systems and beyond.

Project End Date: **31-OCT-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804639	**AutoCPS**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. MAJID ZAMANI**
Host Institution: Ludwig-Maximilians-Universitaet Muenchen, DE

Automated Synthesis of Cyber-Physical Systems: A Compositional Approach

Embedded Control software plays a critical role in many safety-critical applications. For instance, modern vehicles use interacting software and hardware components to control steering and braking. Control software forms the main core of autonomous transportation, power networks, and aerospace. These applications are examples of cyber-physical systems (CPS), where distributed software systems interact tightly with spatially distributed physical systems with complex dynamics. CPS are becoming ubiquitous due to rapid advances in computation, communication, and memory. However, the development of core control software running in these systems is still ad hoc and error-prone and much of the engineering costs today go into ensuring that control software works correctly.

In order to reduce the design costs and guaranteeing its correctness, I aim to develop an innovative design process, in which the embedded control software is synthesized from high-level correctness requirements in a push-button and formal manner. Requirements for modern CPS applications go beyond conventional properties in control theory (e.g. stability) and in computer science (e.g. protocol design). Here, I propose a compositional methodology for automated synthesis of control software by combining compositional techniques from computer science (e.g. assume-guarantee rules) with those from control theory (e.g. small-gain theorems). I will leverage decomposition and abstraction as two key tools to tackle the design complexity, by either breaking the design object into semi-independent parts or by aggregating components and eliminating unnecessary details. My project is high-risk because it requires a fundamental re-thinking of design techniques till now studied in separate disciplines. It is high-gain because a successful method for automated synthesis of control software will make it finally possible to develop complex yet reliable CPS applications while considerably reducing the engineering cost.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
816006	**CaLA**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. BASTIAN RAPP**
Host Institution: Albert-Ludwigs-Universitaet Freiburg, DE

The Capillary Lock Actuator: A novel bistable microfluidic actuator for cost-effective high-density actuator arrays suitable for large-scale graphical tactile displays

According to the World Health Organization more than 285 million people worldwide are visually impaired. In a world where graphics and online content (images, webpages) become increasingly important the inability to perceive information visually is the primary inhibitor for inclusion. In contrast to display technology for sighted people, tactile displays which translate text and graphics to touchable pixels (taxels) have seen little progress in recent decades. So-called Braille lines which display only a single line of text are still the norm. The reason why graphical tactile displays do not exist is the lack of a suitable actuator technology which allows generating massively parallelized individually addressable cost-effective taxel arrays.

This ERC Consolidator project aims at a revolution in microactuator array technology with a fundamentally new concept termed the Capillary Lock Actuator (CaLA). CaLA is a novel bistable massively parallelizable microfluidic microactuator which overcomes many of the limitations currently associated with microactuators. It can be operated with low-voltage control signals and requires virtually no power for actuation. CaLA harnesses three concepts inherent to microfluidics: positive capillary pressure, segmented flow and controllable locally confined changes in wetting. The project will use CaLA actuator arrays for setting up the very first portable tactile graphic display with 30.000 individually addressable taxels thereby significantly outperforming the state-of-the-art. It will be based on manufacturing techniques for highly complex microstructures in glass invented by my group.

CaLA will be a significant breakthrough in actuator technology and enabling for many applications in microsystem technology. Most importantly, it will be a significant step towards making the information technology inclusive for the visually impaired by providing the first robust cost-effective solution to large-scale tactile displays.

Project End Date: **30-APR-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818669	**BrightEyes**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. GIUSEPPE VICIDOMINI**
Host Institution: Fondazione Istituto Italiano Di Tecnologia, IT

Multi-Parameter Live-Cell Observation of Biomolecular Processes with Single-Photon Detector Array

Fluorescence single-molecule (SM) detection techniques have the potential to provide insights into the complex functions, structures and interactions of individual, specifically labelled biomolecules. However, current SM techniques work properly only when the biomolecule is observed in controlled environments, e.g., immobilized on a glass surface. Observation of biomolecular processes in living (multi)cellular environments – which is fundamental for sound biological conclusion – always comes with a price, such as invasiveness, limitations in the accessible information and constraints in the spatial and temporal scales.

The overall objective of the BrightEyes project is to break the above limitations by creating a novel SM approach compatible with the state-of-the-art biomolecule-labelling protocols, able to track a biomolecule deep inside (multi)cellular environments – with temporal resolution in the microsecond scale, and with hundreds of micrometres tracking range – and simultaneously observe its structural changes, its nano- and micro-environments.

Specifically, by exploring a novel single-photon detectors array, the BrightEyes project will implement an optical system, able to continuously (i) track in real-time the biomolecule of interest from which to decode its dynamics and interactions; (ii) measure the nano-environment fluorescence spectroscopy properties, such as lifetime, photon-pair correlation and intensity, from which to extract the biochemical properties of the nano-environment, the structural properties of the biomolecule – via SM-FRET and anti-bunching – and the interactions of the biomolecule with other biomolecular species – via STED-FCS; (iii) visualize the sub-cellular structures within the micro-environment with sub-diffraction spatial resolution – via STED and image scanning microscopy.

This unique paradigm will enable unprecedented studies of biomolecular behaviours, interactions and self-organization at near-physiological conditions.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819346	**AMPHIBIANS**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. ANDREA DI FALCO**
Host Institution: The University Court Of The University Of St Andrews, UK

All Optical Manipulation of Photonic Metasurfaces for Biophotonic Applications in Microfluidic Environments

The current trend in biophotonics is to try and replicate the same ease and precision that our hands, eyes and ears offer at the macroscopic level, e.g. to hold, observe, squeeze and pull, rotate, cut and probe biological specimens in microfluidic environments. The bidding to get closer and closer to the object of interest has prompted the development of extremely advanced manipulation techniques at scales comparable to that of the wavelength of light. However, the fact that the optical beam can only access the microfluidic chip from the narrow aperture of a microscopic objective limits the versatility of the photonic function that can be realized.

With this project, the applicant proposes to introduce a new biophotonic platform based on the all optical manipulation of flexible photonic metasurfaces. These artificial two-dimensional materials have virtually arbitrary photonic responses and have an intrinsic exceptional mechanical stability. This cross-disciplinary project, bridging photonics, material sciences and biology, will enable the adoption of the most modern and advanced photonic designs in microfluidic environments, with transformative benefits for microscopy and biophotonic applications at the interface of molecular and cell biology.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819819	**APOLLO**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. IOANNIS KRIKIDIS**
Host Institution: University Of Cyprus, CY

Advanced Signal Processing Technologies for Wireless Powered Communications

Wireless power transfer (WPT), pioneered by Tesla, is an idea at least as old as radio communications. However, on the one hand, due to health concerns and the large antenna dimensions required for transmission of high energy levels, until recently WPT has been limited mostly to very short distance applications. On the other hand, recent advances in silicon technology have significantly reduced the energy needs of electronic systems, making WPT over radio waves a potential source of energy for low power devices. Although WPT through radio waves has already found various short-range applications (such as the radio-frequency identification technology, healthcare monitoring etc.), its integration as a building block in the operation of wireless communications systems is still unexploited. On the other hand, conventional radio wave based information and energy transmissions have largely been designed separately. However, many applications can benefit from simultaneous wireless information and power transfer (SWIPT).

The overall objective of the APOLLO project is to study the integration of WPT/SWIPT technology into future wireless communication systems. Compared to past and current research efforts in this area, our technical approach is deeply interdisciplinary and more comprehensive, combining the expertise of wireless communications, control theory, information theory, optimization, and electronics/microwave engineering.

The key outcomes of the project include: 1) a rigorous and complete mathematical theory for WPT/SWIPT via information/communication/control theoretic studies; 2) new physical and cross-layer mechanisms that will enable the integration of WPT/SWIPT into future communication systems; 3) new network architectures that will fully exploit potential benefits of WPT/SWIPT; and 4) development of a proof-of-concept by implementing highly-efficient and multi-band metamaterial energy harvesting sensors for SWIPT.

Project End Date: **30-JUN-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850932	**Ergo-Lean**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. ARASH AJOUDANI**
Host Institution: Fondazione Istituto Italiano Di Tecnologia, IT

Rethinking Human Ergonomics in Lean Manufacturing and Service Industry: Towards Adaptive Robots with Anticipatory Behaviors

Occupational ergonomics is facing a new complex challenge caused by the adaptation of industrial processes to the demands of the high-mix, low-volume production. In such processes, humans operate in, and interact with dynamically changing environments. The underlying physical interactions can cause variations of human states, and make a traditionally identified ergonomic pose of a human non-efficient and unproductive, or vice versa. This challenge has contributed to the growth of musculoskeletal disorders in manufacturing and service industries undergoing a lean transformation, and calls for new thinking on occupational ergonomics.

Ergo-Lean proposes to study, for the first time, human ergonomics during complex human-robot-environment interactions, and investigate methods to anticipate the effect of worker actions in the short, middle and long term. It explores the potential of collaborative robotics technology to deliver an original set of anticipatory behaviors that contribute to the improvement of human physical factors during interaction. Ergo-Lean will create radically new Human-Robot Collaboration (HRC) systems where the robot and human directly interact, forming a dyad which optimally solves manufacturing problems in the environment, with the robot flexibly contributing to ergonomic improvement of workplace conditions. To achieve this, the research will be articulated along five multidisciplinary scientific objectives to: i) Understand and formulate human ergonomics during dynamic interactions; ii) Investigate ways of applying the HRC technology to the mitigation of occupational risks; iii) Evaluate the influence of feedback interfaces for ergonomic coordination of motor redundancy; iv) Study shared authority models for ergonomic HRC systems; and v) Challenge and demonstrate the improved adaptability and acceptability of Ergo-Lean systems. Ergo-Lean will have profound socio-economic impacts by improving workers' wellbeing and contributing to productivity.

Project End Date: **31-OCT-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852455	**BRILLIANCE**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. ALEXANDRA PACUREANU**
Host Institution: European Synchrotron Radiation Facility, FR

Bright, coherent and focused light to resolve neural circuits

The overarching goal of this project is to establish a novel technique for neuroimaging to probe large tissue volumes at the nanometre scale. Currently only electron microscopes are capable of generating data with sufficient resolving power for comprehensive exploration of the neural circuits that underlie brain function. With state of the art systems, imaging just one cubic mm of brain entails years of data collection, ultra-thin sectioning which is prone to errors and data loss, and prohibitive costs. Each circuit unit spans over large distances, thus access to millimetre sized volumes of view is essential for both fundamental and therapeutic discoveries in neurosciences. Today this is an unreachable goal. In contrast, X-ray microscopy facilitates rapid imaging of large samples but the resolving power is not sufficient to visualize neural connections. Thus, at present, resolving large neural circuits is hardly imaginable. The aim of this project is to overcome these limitations and to develop an integrative approach which will open new research perspectives. X-ray holographic nano-tomography is a 3D coherent imaging technique which is capable of generating exceptional contrast in soft tissue through phase contrast. The penetrating power of X-rays and the full-field, free space propagation setup enable rapid multiscale imaging of large samples which are opaque to visible light. By combining a highly brilliant X-ray nanoprobe, a carefully designed nanopositioning system, a cutting edge detection system and cryogenics for sample preservation, isotropic 3D spatial resolution better than 30 nm is conceivable. The objectives of this interdisciplinary project are to 1) develop a system for imaging neural circuits at synaptic level in large tissue volumes, including methods for sample preparation, image acquisition and image reconstruction 2) develop an automatic image analysis tool 3) create unprecedented maps of brain circuits with immediate impact in neurosciences.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
853309	**SONOBOTS**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. DANIEL AHMED**
Host Institution: Eidgenoessische Technische Hochschule Zurich, CH

Acousto-Magnetic Micro/Nanorobots for Biomedical Applications

Micro/nanorobots can transform many aspects of medicine by enabling tasks, such as delivering drugs or genes precisely to targeted areas, transducing force on individual cells or tissues, performing biopsies, and facilitating non-invasive surgeries. Numerous propulsion mechanisms have been developed, but their low propulsion speed, lack of biocompatibility, and poor navigation capabilities have limited their use. The objective of this proposal is to develop wireless micro/nanorobots using acoustic and magnetic actuation modalities that will be used to navigate in microfluidics and zebrafish disease models to help better understand and treat diseases. The combination of ultrasound and magnetic fields is capable of overcoming the limitations encountered using a single actuation technique, and both are used extensively in clinical diagnostics and therapeutics. This proposal is divided into three research areas. 1) To date, no systematic studies have been conducted utilizing micro/nanorobotics on living animals. The research will address many of the fundamental challenges of using micro/nanorobots in living animals, followed by testing in microfluidics, 3D arbitrarily-shaped fluidic devices, and the vasculature of zebrafish embryos. Propulsion will be studied in the direction of and against blood flow, a 3D propulsion will be developed, and a swarm of nanorobots will be studied. 2) A platform will be developed that involves the trapping and manipulation of nanorobots in an animal model, such as zebrafish embryos. 3) We will develop an active drug delivery platform combined with other methods to study numerous disease models using the models based on live zebrafish embryos. We believe the results of the proposed research will have a significant impact in the field.

Project End Date: **31-OCT-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864017	**L2C**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. RAPHAEL JUNGERS**
Host Institution: Universite Catholique De Louvain, BE

Learning to Control - Smart and Data-Driven Formal Methods for Cyber-Physical Systems control

The engineered systems surrounding us are increasingly hard to control. Not only the complicated interaction of the physical processes with the machines that control them, but also specifications (cyber-security, safety, privacy, resilience, resource-efficiency, decentralization) are more and more complex, and critical. Last but not least, in an increasing number of situations, no model of the system is available (or the model is too complex), and one needs to 'learn' the optimal way of controlling the system by the mere observation of data. Our technological world is living a paradigm shift, which is often coined as the Cyber-Physical Revolution, or the Industry 4.0.

In view of these specificities, the only sensible way of controlling these complex systems is often by discretizing the different variables, thus transforming the model into a simple combinatorial problem on a finite-state automaton, called an abstraction of this system. Until now, this approach has not been proved useful beyond academic, small examples, as it scales very poorly.

The goal of L2C is to transform this approach into an effective, scalable, cutting-edge technology that will address the CPS challenges and unlock their potential. This ambitious goal will be achieved by leveraging powerful tools from Mathematical Engineering. Out of this research, a state-of-the-art software platform will promote our results and translate them into directly usable solutions for the scientific and industrial communities.

L2C is a pluridisciplinary project at the frontier between Control Engineering, Computer Science and Applied Mathematics. It bridges the gap between rich innovative techniques and emerging challenges in Control. It impacts both fundamental Science and Engineering, as the theoretical research is driven and fostered by cutting edge technological challenges.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864299	**ELFO**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. MARIO CAIRONI**
Host Institution: Fondazione Istituto Italiano Di Tecnologia, IT

Electronic Food: enabling edible electronic systems for biomedical and food monitoring applications

ELFO will provide the foundations of a new enabling technology for disruptive edible electronic systems, with applications in advanced biomedical devices for continuous monitoring of the health status within the gastro-intestinal (GI) tract, as well as in electronic tags for food monitoring, serving public health and providing at the same time a very powerful tool against counterfeiting. These systems will be unperceivable and mass produced mainly with mask-less, printing and direct-writing methods. Besides being completely safe for ingestion, such devices will also be perceived as food, favouring public acceptance. Such an ambitious plan will be implemented by: i) creating knowledge on electronic properties of food and food derivatives and complementing them with edible solution-processable, mainly carbon-based semiconductors, thus developing an extended library of edible electronic materials; ii) developing large-area, solution-based, printing and direct-writing scalable processes with high lateral resolution for the precise patterning of edible functional materials; iii) developing edible electronic components required in systems, from logic to power and sensors; iv) validating the progress with two proof-of-concept systems, an edible radio-frequency pill with controlled drug delivery, answering the need for compliance monitoring devices and actuators within the gut, and an edible passive food Radio-Frequency identification tag, answering the need for certification and anti-counterfeiting devices directly onto or into food products. ELFO will give solid engineering grounds to the visionary perspectives of edible electronics, introducing imperceptible intelligence in any edible item, thus accessing more information on what we eat, how it is assimilated and enabling biomedical devices for mass health screening.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864483	**NOTICE**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. CLEMENT MERCKLING**
Host Institution: Interuniversitair Micro-Electronica Centrum, BE

Novel Oxides and Topological Interfaces for quantum Computing Electronics

Today's quantum computers are suffering from a very high error rate due to decoherence (i.e. loss of quantum information) in their qubits fabricated with superconductors junctions or semiconductors quantum dots. The goal of this proposal is to research radically new materials and architectures to build a "fault-tolerant" qubit device on Silicon substrate (i.e. scalable), that will be immune to decoherence problems.

In NOTICE, we will design and synthetize novel crystalline perovskite materials, monolithically integrated on a Silicon substrate, with topological insulating properties to enable the generation of Majorana fermions at the heterointerface with a superconductor. The generated Majorana fermions will hold the quantum information in such "Majorana qubit" which will be resistant to noises and fluctuations due to the topology effect if stable and robust materials presenting the desired properties can be obtained.

Bismuth-based perovskites were down-selected as topological insulator (BaBi(O,F)3) and superconductor ((Ba,K)BiO3) oxides due to the very strong Spin Orbit Coupling present in Bi which will favorize the efficient generation of Majorana fermions at the perfect (pristine) BaBi(O,F)3/(Ba,K)BiO3 heterointerface. With Molecular Beam Epitaxy growth approach together with advanced characterization techniques such as Angle-Resolved PhotoEmission Spectroscopy measurements and ab-initio simulations on the topological insulating properties of the perovskites, we aim to generate a stable topological interface leading to the efficient generation of Majorana fermions. This breakthrough will enable us to fabricate chiral Majorana devices on a Silicon technology platform, providing both reliability and manufacturing scalability.

NOTICE results will pave the way to "fault-tolerant" qubit, bringing a paradigm shift in quantum computing by reducing drastically the gap between logical and physical qubits and the need for quantum error correction algorithms.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864686	**CO-MAN**	**PE7** Systems and Communication Engineering

Principal Investigator:	**Dr. SANDRA HIRCHE**
Host Institution:	Technische Universitaet Muenchen, DE

Safe data-driven control for human-centric systems

Many control systems of the future involve a tight interaction or even symbiosis with the human user. High-impact application domains of human-centric systems include healthcare, mobility, and infrastructure systems. In human-centric systems the human is both, an element of the control system, and a design criterion with individual requirements that need to be satisfied. Safety - despite the high uncertainty of human behavior - and maximization of individual user experience are the primary objectives for control design in human-centric systems. The visionary goal of CO-MAN is to contribute to the fundamental understanding and principled approach to the control of smart human-centric systems. We will develop a novel framework for user-adaptive data-driven control with performance guarantees in order to address the scientific challenges of high uncertainty and individual user requirements. The grand challenge is to unify the two previously separate paradigms of model-based control with its rigorous guarantees but limited modeling base and machine learning algorithms with its flexible modeling concepts but lack of guarantees. The breakthrough enabling idea is to merge probabilistic non-parametric modeling techniques from statistical learning theory with novel risk-aware control methodologies while including active user modeling. The game changer is the current push towards reliable machine learning with novel results on theoretical bounds for learning behavior. Because of favorable properties we will focus on Gaussian Processes to model user behavior and preferences and translate the naturally quantified model uncertainty into closed loop behavior guarantees through a confidence-driven human-interactive control approach. The PI is in a perfect position to achieve the envisioned goal of super-individualized data-driven control with performance guarantees given the highly visible preliminary results and leadership in the area of human-cyber-physical systems.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864720	**LEAFHOUND**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. DIMOS DIMAROGONAS**
Host Institution: Kungliga Tekniska Hoegskolan, SE

Leader-follower hybrid control and task planning for multi-agent systems under spatiotemporal logic specifications

Multi-agent control is a popular research topic due to its applications in a variety of areas. The main approach has been to incorporate tools from single-agent control to the multi-agent setup. However, many applications involve more complex tasks that may not be cast as a classic control objective, while the agents may be subject to constraints in space and time. A current trend is thus to use formal verification in order to specify more general task specifications that induce a sequence of control actions rather than a stand-alone objective. Spatiotemporal logics are based on continuous time signals and allow formulating space and time constraints, and thus are suitable for defining such specifications in multi-agent systems. Existing solutions do not take into account quantitative transient constraints, nor consider the high computational cost that may be endured by controlling the whole agent group when the number of agents grows. We instead consider here a heterogeneous, leader-follower approach, which relies on three design stages. At a first stage, we derive transient controllers for cooperative control objectives in leader-follower networks; at a second stage, these controllers are employed in order to satisfy tasks given to the network as spatiotemporal logic specifications; and at a third stage, we tackle task dependencies and infeasibilities through a refinement process both in the transient control design as well as in the leader-follower group structure, by using notions of network controllability. The proposed leader-follower approach to the spatiotemporal task planning problem, combining elements from cooperative multi-agent systems under transient constraints, formal verification and graph theoretic network controllability, requires for new ways of thinking and approaches to analysis and design; it thus constitutes the proposal a beyond the SoA and groundbreaking approach to the fields of control, robotics and formal methods based synthesis.

Project End Date: **31-OCT-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865230	**UNITY**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. NIELS GREGERSEN**
Host Institution: Danmarks Tekniske Universitet, DK

A Single-Photon Source Featuring Unity Efficiency And Unity Indistinguishability For Scalable Optical Quantum Information Processing

Within optical quantum information processing, the quantum bits are encoded on single photons and their quantum mechanical properties are exploited to build new functionality. A prime example is the quantum computer, which can be built simply from single-photon sources and detectors, and simple optical components. However for scalable optical quantum computing involving hundreds of photons, the performance requirements for the single-photon source are daunting: the source must feature near-unity efficiency and near-unity indistinguishability simultaneously! Today, all known source designs suffer from inherent trade-offs between efficiency and indistinguishability and their performance is insufficient for scalable quantum computing.

The project objective is to realize a source of single indistinguishable photons with performance of ground-breaking nature. The break-through lies in the simultaneous realization of near-unity efficiency and indistinguishability, a combination which overcomes the limitations of present state-of-the-art and ventures far into the regime of scalable quantum computing.

As an expert in single-photon source engineering I find myself in a unique position to address this challenge. Since it is unknown how to design such a source, I will first establish a new understanding of the physics of the near-unity regime, where phonon-induced decoherence represents a main limitation for the indistinguishability. I will then advance state-of-the-art in optical engineering by proposing a novel design, where all physical parameters can be controlled independently. The modelling of the near-unity performance source is extremely demanding, and the analysis requires additional advances within optical simulations and open quantum systems theory. Once this is achieved, I will fabricate a prototype and test it in a multi-photon interference boson sampling experiment to unambiguously prove that scalable optical quantum information processing is indeed within reach.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865622	**UV-LASE**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. ASA HAGLUND**
Host Institution: Chalmers Tekniska Hoegskola Ab, SE

Out of the blue: membrane-based microcavity lasers from the blue to the ultraviolet wavelength regime

Achieving ultraviolet (UV) emission has proven to be difficult, in particular for microcavity lasers due to high optical losses and defect densities. Our group, with a world-leading position in microcavity laser research, has identified new possibilities to combat these challenges in both ultraviolet and blue-emitting devices. By using these breakthroughs, we aim to develop the first electrically injected blue microcavity laser with good enough performance to be useful in real-world applications and project out of the blue and into the ultraviolet to realize the very first electrically injected UV microcavity laser. Our two recent breakthroughs are:

1. The discovery of an overlooked loss mechanism in microcavities and schemes to circumvent it. Our proposed designs to circumvent this unintentional anti-guiding are being implemented worldwide and have led to a tenfold increase in optical output power in blue lasers.
2. A unique membrane technique to enable microcavity lasers with highly reflective dielectric mirrors on both sides of the cavity – a device concept previously un-realizable for UV-lasers. The method is based upon electrochemical etching of the chemically inert material AlGaN (the material of choice for UV), which enables lift-off of device membranes with smooth surfaces from the substrate and mirror-deposition on the bottom side. Our recent demonstration of the world's first thin-film, flip-chip UV-B LED with this technique holds great promises for microcavity lasers.

These two new approaches will be combined with a focused effort to circumvent the problem of low electrical conductivity of p-doped materials. We will strengthen our capabilities by developing tunnel junctions, allowing highly conductive n-doped material to be used throughout virtually the entire laser. This will drastically reduce losses, which cause degradation within minutes in blue microcavity lasers, and might be the only solution to electrically driven UV microcavity lasers.

Project End Date: **31-JUL-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866259	**SILENT**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. CHRISTOPHE COLLETTE**
Host Institution: Universite De Liege, BE

Seismic Isolation of Einstein Telescope

With the first direct detection of gravitational waves on the 14th of September 2015, a new window has been opened on the Universe. This was the starting point of new science, complementary to the measurement of electromagnetic signals by optical telescopes. Since that date, several detections have been made, offering wonderful validation of Einstein's theory of general relativity, and extraordinary insight on the dynamics of heavy black hole binaries and binaries of neutron stars. The exploration of the Universe through this new window using Earth-based instruments will continue with more sensitive instruments, but will ultimately depend on our capability to isolate them from the two main sources of low-frequency disturbances on Earth: seismic activity and fluctuations of gravity field (Newtonian noise). Due to the extremely small amplitude of gravitational waves, it is a prior concern to carefully isolate the detector from any type of disturbance.

In order to address the aforementioned limitations, this project proposes to develop a completely novel platform, controlled by optical seismometers, liquid inclinometers and a gravimeter. It will virtually float in the inertial space, decoupled from ground motion for periods at least as large as 100 seconds. The controlled platform will be the most stable ever build on Earth. Such performance will be obtained thanks to a revolutionary approach, combining three major innovations: (1) Novel optical inertial sensors, (2) Efficient controllers, combining sensor fusion methods, and dedicated mechatronic architectures, (3) Direct measurement of Newtonian noise.

This project will contribute to prepare the third generation of low-frequency gravitational wave detectors. The outcomes will be also applicable to a large class of other instruments (e.g. particle colliders, atomic force microscopes, lithography machines, medical imaging instruments), ensuring a generic character to this project, and a major scientific impact.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
884807	**BIRD**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. DANICA KRAGIC JENSFELT**
Host Institution: Kungliga Tekniska Hoegskolan, SE

Bimanual Manipulation of Rigid and Deformable Objects

All day long, our fingers touch, grasp and move objects in various media such as air, water, oil. We do this almost effortlessly - it feels like we do not spend time planning and reflecting over what our hands and fingers do or how the continuous integration of various sensory modalities such as vision, touch, proprioception, hearing help us to outperform any other biological system in the variety of the interaction tasks that we can execute. Largely overlooked, and perhaps most fascinating is the ease with which we perform these interactions resulting in a belief that these are also easy to accomplish in artificial systems such as robots. However, there are still no robots that can easily hand-wash dishes, button a shirt or peel a potato. Our claim is that this is fundamentally a problem of appropriate representation or parameterization. When interacting with objects, the robot needs to consider geometric, topological, and physical properties of objects. This can be done either explicitly, by modeling and representing these properties, or implicitly, by learning them from data. The main scientific objective of this project is to create new informative and compact representations of deformable objects that incorporate both analytical and learning-based approaches and encode geometric, topological, and physical information about the robot, the object, and the environment. We will do this in the context of challenging multimodal, bimanual object interaction tasks. The focus will be on physical interaction with deformable objects using multimodal feedback. To meet these objectives, we will use theoretical and computational methods together with rigorous experimental evaluation to model skilled sensorimotor behavior in bimanual robot systems.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
648161	**PHOROSOL**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. MARIA CONCEPCION OVIN ANIA**
Host Institution: Centre National De La Recherche Scientifique, FR

Integrating photochemistry in nanoconfined carbon-based porous materials in technological processes

The aim of this proposal is to exploit the potentialities of confined pore spaces in technological processes related to applied photochemistry for gas sensing, energy conversion and environmental protection. I will focus on new light responsive nanoporous carbons which characteristics can be tailored at two levels (pore void at the nanometric scale and surface functionalization) during the synthesis to modulate their selectivity towards a given molecule (i.e. gas sensing) or efficiency in a given reaction (i.e. energy conversion, environmental protection).

The dual nature of the nanoporous carbons with ad-hoc designed pore architectures acting as nanoreactors (confinement) and photoactivity defined by composition (chromophoric groups) offers new perspectives in the fields of light harvesting of applied photochemistry, and shows multitude of fundamental questions that are worth investigating to exploit this concept. Understanding of the confinement effects and the light/solid/molecule interactions is the key for integrating carbon nanostructures in a whole new array of applications. An example would be the design of multifunctional spatially organized photoactive carbons with high electron mobility, multimodal pore systems and chromophoric groups. These systems are expected to show enhanced diffusion and mass transport, with great potential in gas sensing applications where a fast, sensitivity and selective response is needed.

I plan to work with functionalized light-responsive polymeric nanoporous carbons (mainly gels, graphene-oxide frameworks). A smart design of hybrid nanostructures introducing other confined photoactive elements will also be studied. The outcome of the proposal is to understand the fundamentals of photochemistry of carbon nanostructures for the implementation of best performing materials in different technological processes related to photochemical energy conversion for H2 and O2 generation, gas sensing and environmental protection.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681813	**FricLess**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. LUCIA NICOLA**
Host Institution: Universita Degli Studi Di Padova, IT

A seamless multi-scale model for contact, friction, and solid lubrication

Friction and wear are liable for enormous losses in terms of energy and resources in modern society. Costs related to unwanted friction in industrialised countries are estimated to be about 3% of the gross domestic product. Urgency is even greater nowadays as friction between micro-components has become the bottleneck of several applications for which miniaturisation is critical.

Lubrication is a commonly adopted solution to reduce friction. Graphite is a broadly used solid lubricant for large scale applications, while the lubricating properties of a few-layers graphene hold great promise especially for smaller scale applications. At present, our knowledge of the friction and lubrication of rough surfaces is essentially phenomenological. This is because friction is only deceivingly a simple mechanisms, which instead requires understanding of physical phenomena simultaneously acting at different length scales. The change in contact size, which controls the friction stress, depends on nano-scale phenomena such as atomic de-adhesion, sliding, dislocation nucleation in metals, but also on micro- and macro-scale phenomena as (size-dependent) plastic deformation.

The objective of this proposal is to reach an unprecedented understanding of metal friction and lubrication by accounting, for the first time, for all relevant phenomena occurring from the atomic to the macro-scale, and their interplay.
To this end, a seamless concurrent multi-scale model will be developed. The power of this new model lies in its capability of describing three-dimensional bodies with realistic roughness in sliding lubricated contact, with the accuracy of an atomistic simulation.

This research builds towards a complete picture of metal friction and lubrication. The materials chosen for the proposed research are copper and multi-layer graphene. However, the model that will be developed is general and can be used to study different materials, lubricants and environmental conditions.

Project End Date: **30-NOV-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695116	**AMETIST**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. MIRCEA GUINA**
Host Institution: Tampereen Korkeakoulusaatio Sr, FI

Advanced III-V Materials and Processes Enabling Ultrahigh-efficiency (50%) Photovoltaics

Compound semiconductor solar cells are providing the highest photovoltaic conversion efficiency, yet their performance lacks far behind the theoretical potential. This is a position we will challenge by engineering advanced III-V optoelectronics materials and heterostructures for better utilization of the solar spectrum, enabling efficiencies approaching practical limits. The work is strongly motivated by the global need for renewable energy sources. To this end, AMETIST framework is based on three vectors of excellence in: i) material science and epitaxial processes, ii) advanced solar cells exploiting nanophotonics concepts, and iii) new device fabrication technologies.

Novel heterostructures (e.g. GaInNAsSb, GaNAsBi), providing absorption in a broad spectral range from 0.7 eV to 1.4 eV, will be synthesized and monolithically integrated in tandem cells with up to 8-junctions. Nanophotonic methods for light-trapping, spectral and spatial control of solar radiation will be developed to further enhance the absorption. To ensure a high long-term impact, the project will validate the use of state-of-the-art molecular-beam-epitaxy processes for fabrication of economically viable ultra-high efficiency solar cells. The ultimate efficiency target is to reach a level of 55%. This would enable to generate renewable/ecological/sustainable energy at a levelized production cost below ~7 ¢/kWh, comparable or cheaper than fossil fuels. The work will also bring a new breath of developments for more efficient space photovoltaic systems.

AMETIST will leverage the leading position of the applicant in topical technology areas relevant for the project (i.e. epitaxy of III-N/Bi-V alloys and key achievements concerning GaInNAsSb-based tandem solar cells). Thus it renders a unique opportunity to capitalize on the group expertize and position Europe at the forefront in the global competition for demonstrating more efficient and economically viable photovoltaic technologies.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695206	**NANOFACTORY**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. OLIVIER MARTIN**
Host Institution: Ecole Polytechnique Federale De Lausanne, CH

Building tomorrow's nanofactory

The aim of this project is to translate the concept of production line to the nanoworld to develop what could become tomorrow's nanofactory. So far, nanostructures are either chemically synthesized or produced using top-down approaches such as nanolithography, but no processes exist to take a few nanostructures and perform the basic operations required to assemble them into a more complex system. This proposal aims at addressing this need by realizing at the nanoscale the different functions that are required for a production line: receiving and moving raw nanomaterial in position, where it can be immobilized and worked on or transformed; combining different elements into more complex systems that support new functionalities. The project uses optical forces generated by plasmonic traps as enabling mechanism to act on raw material and the entire production line will be integrated into microfluidics, which will perform as an advanced conveyor belt. Local electrophoresis and photo-curable polymerization are used to locally modify and assemble raw nanoparticles. In addition to implementing challenging nanotechnologies, such as nanoscale electric contacts and perforated membranes, this project will also explore a fair amount of completely new physics, including the van der Waals interaction – which will be studied numerically and experimentally – the competition between optical and chemical forces or electrostatic attraction, and the detailed determination of the trapping potential produced by plasmonic nanostructures. The foreseen research is very comprehensive, including modelling, nanofabrication and explorations at the nanoscale. This ground-braking proposal will demonstrate how additive manufacturing can be implemented at the nanoscale.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
709613	**SLaMM**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. GIANNI CIOFANI**
Host Institution: Fondazione Istituto Italiano Di Tecnologia, IT

Magnetic Solid Lipid Nanoparticles as a Multifunctional Platform against Glioblastoma Multiforme

Central nervous system (CNS) tumors are an important cause of morbidity and mortality worldwide. Among them, glioblastoma multiforme (GBM) is the most aggressive and lethal, characterized by extensive infiltration into the brain parenchyma. Under the standard treatment protocols, GBM patients can expect a median survival of 14.6 months, while less than 5% of patients live longer than 5 years. This poor prognosis is due to several factors, including the highly aggressive and infiltrative nature of GBM, resulting in incomplete resection, and the limited delivery of therapeutics across the blood-brain-barrier (BBB).

The present project aims at addressing these therapeutic challenges by proposing a nanotechnology-based approach for the treatment of GBM, focused on the selective uptake of drug-loaded multifunctional magnetic solid lipid nanoparticles (SLNs). An external magnetic guidance will help the SLN accumulation on the cerebral endothelium, where, owing to their lipid nature, they will be allowed to enter the CNS. Here, appropriate surface ligands will drive their internalization inside cancer cells. The chemotherapeutic payload will undergo release, allowing a targeted pharmaceutical treatment that will be combined to hyperthermia upon appropriate radiofrequency application. A synergic attack against GBM will thus be performed, consisting of a chemical attack thanks to the drug, and a physical attack thanks to hyperthermia, that will dramatically enhance the possibilities of therapeutic success.

By demonstrating the effectiveness of the platform to cross the BBB and to support tumor regression, a huge impact on human healthcare is envisioned. Moreover, further outcomes of this project are expected by considering the development of nanotechnology-based, multi-functional solutions that can easily be adapted to many other high-impact diseases, in particular at the brain level, where BBB crossing poses a crucial obstacle to many therapeutic approaches.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714080	**SCARCE**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. EWAN MCADAM**
Host Institution: Cranfield University, UK

Sustainable Chemical Alternatives for Re-use in the Circular Economy

This proposal seeks to develop a novel non-invasive, real-time direct observation methodology to provide new knowledge on the mechanisms underpinning crystal growth and harvesting within membrane crystallisation reactor technology. Crystallisation represents one of the most important separation processes in the chemical industry and will play a critical role in the circular economy through enabling the recovery of resources from wastewater to yield an array of sustainable low cost chemicals for use in European industries. Existing crystallisation reactor designs suffer from imperfect mixing and inhomogeneous solvent removal which makes control of crystal quality and consistency problematic and can limit application of the final product.

Membrane crystallisation reactor technology is a disruptive innovation that combines process intensification with the capability to achieve significant control over the crystallisation process at a fraction of the scale thus ameliorating many of the problems associated with existing crystallisers. However, before this disruptive membrane based technology can be realised at full scale, there is a critical need to understand the role of shear forces in mediating the growth and harvesting of crystals at the solvent-membrane boundary which has to date received little attention. With no reliable and accurate description of the shear force behaviour within the boundary layer, there is considerable risk incurred in the scaling up of membrane crystallisation reactor design which could lead to inconsistent and inefficient performance. Development of the novel non-invasive, real-time direct observation methodology will enable direct measurement of these discrete forces. The arising new knowledge will be challenged at various process sizes to evolve the science underlying process scale-up of membrane crystallisers and in doing so will deliver internationally competitive research, placing the applicant at the forefront of his academic field.

Project End Date: **31-MAR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714177	**ELECTRON4WATER**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. JELENA RADJENOVIC**
Host Institution: Fundacio Institut Catala De Recerca De L'Aigua, ES

Three-dimensional nanoelectrochemical systems based on low-cost reduced graphene oxide: the next generation of water treatment systems

The ever-increasing environmental input of toxic chemicals is rapidly deteriorating the health of our ecosystems and, above all, jeopardizing human health. Overcoming the challenge of water pollution requires novel water treatment technologies that are sustainable, robust and energy efficient. ELECTRON4WATER proposes a pioneering, chemical-free water purification technology: a three-dimensional (3D) nanoelectrochemical system equipped with low-cost reduced graphene oxide (RGO)-based electrodes. Existing research on graphene-based electrodes has been focused on supercapacitor applications and synthesis of defect-free, superconductive graphene. I will, on the contrary, use the defective structure of RGO to induce the production of reactive oxygen species and enhance electrocatalytic degradation of pollutants. I will investigate for the first time the electrolysis reactions at 3D electrochemically polarized RGO-coated material, which offers high catalytic activity and high surface area available for electrolysis. This breakthrough approach in electrochemical reactor design is expected to greatly enhance the current efficiency and achieve complete removal of persistent contaminants and pathogens from water without using any chemicals, just by applying the current. Also, high capacitance of RGO-based material can enable further energy savings and allow using intermittent energy sources such as photovoltaic panels. These features make 3D nanoelectrochemical systems particularly interesting for distributed, small-scale applications. This project will aim at: i) designing the optimum RGO-based material for specific treatment goals, ii) mechanistic understanding of (electro)catalysis and (electro)sorption of persistent pollutants at RGO and electrochemically polarized RGO, iii) understanding the role of inorganic and organic matrix and recognizing potential process limitations, and iv) developing tailored, adaptable solutions for the treatment of contaminated water.

Project End Date: **30-APR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714605	**VADEMECOM**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. ALESSANDRO PARENTE**
Host Institution: Universite Libre De Bruxelles, BE

VAlidation driven DEvelopment of Modern and Efficient COMbustion technologies

Combustion science will play a major role in the future quest for sustainable, secure and environmentally friendly energy sources. Two thirds of the world energy supply rely on combustion of fossil and alternative fuels, and all scenarios forecast an increasing absolute energy supply through combustion, with an increasing share of renewables. Thus, combustion will remain the major actor in transportation and power generation as well as in manufacturing processes, like steel and glass.
Nevertheless, combustion science will need profound innovation to meet future energy challenges, such as energy efficiency and fuel flexibility, and ensure future generations with affordable and sustainable energy and healthy environment. In this context, MILD combustion represents a very attractive solution for its fuel flexibility and capability to deliver very high combustion efficiency with virtually zero pollutant emissions. Such a combustion regime is the result of a very strong interaction between turbulent mixing and chemical kinetics. The fundamental mechanism of this interaction is not fully understood, thus justifying the need for experimental and numerical investigations.
The overall objective of the present research proposal is to drive the development of modern and efficient combustion technologies, by means of experimental, theoretical, and numerical simulation approaches. New-generation simulation tools for MILD combustion will be developed, to reduce the dependence on sub-grid models and increase the fidelity of numerical simulations. High-fidelity experimental data will be collected on quasi-industrial systems, to disclose the nature of the interactions between fluid dynamics, chemistry and pollutant formation processes in MILD combustion. Experiment and numerical simulations will be tied together by Validation and Uncertainty Quantification techniques, to allow the ground-breaking application of the developed approaches and promote innovation in the energy sector.

Project End Date: **31-MAR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714712	**NICEDROPS**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. MANISH TIWARI**
Host Institution: University College London, UK

Precise and smart nanoengineered surfaces: Impact resistance, icephobicity and dropwise condensation

Water freezing (icing) and condensation are ubiquitous in our life. Preventing undesirable icing on surfaces with minimal energy and chemical use, and improving the efficiency of condensation heat exchangers has broad societal value. Thus, I aim to use fundamental insights to offer energy-efficient solutions for undesirable ice formation and promoting dropwise condensation using novel and robust nanoengineered surfaces. My objectives are:

i) to realise thermodynamically guided metallic surfaces with precise (<10 nm) morphology and controlled superficial stiffness for energy-efficient icing prevention and sustaining dropwise flow condensation
ii) to rationally intercalate polymers and/or suspensions into surface nanotextures and exploit nanomechanics in order to enable robust and smart nanoengineered surfaces for high speed impact, abrasion and chemical resistance; stable icephobicity (delaying freezing); and sustained dropwise condensation.
iii) to develop new fundamental insights to: a) prevent icing due to high speed (~100 m/s) supercooled droplet/ice crystal impact; b) realise icephobicity down to -30 degrees Celsius; c) minimise ice-surface adhesion; and d) sustain dropwise condensation at high (50-100 m/s) vapour speeds.

The proposal emphasis on energy efficiency is aligned with the EU's 20/20/20 Strategic Energy Technology (SET) Plan. To exemplify their salient impact, the proposed smart nanoengineered surfaces offer a passive solution for airplane icing (and related accidents) and will delay evaporator icing on air source heat pumps and refrigerators, thereby helping to lower the energy use in buildings and cold storages. The latter are tied to the global food storage and distribution challenges. Similarly, sustained dropwise condensation will make condensers in process industry and steam power plants compact and efficient. Optimally, only ~1 micron of the surface depth will require treatment – this will minimize chemical use and promote sustainability.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714754	**INTERDIFFUSION**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. NELE MOELANS**
Host Institution: Katholieke Universiteit Leuven, BE

Unraveling Interdiffusion Effects at Material Interfaces -- Learning from Tensors of Microstructure Evolution Simulations

Multi-materials, combining various materials with different functionalities, are increasingly desired in engineering applications. Reliable material assembly is a great challenge in the development of innovative technologies. The interdiffusion microstructures formed at material interfaces are critical for the performance of the product. However, as more and more elements are involved, their complexity increases and their variety becomes immense. Furthermore, interdiffusion microstructures evolve during processing and in use of the device. Experimental testing of the long-term evolution in assembled devices is extremely time-consuming. The current level of materials models and simulation techniques does not allow in silico (or computer aided) design of multi-component material assemblies, since the parameter space is much too large.

With this project, I aim a break-through in computational materials science, using tensor decomposition techniques emerging in data-analysis to guide efficiently high-throughput interdiffusion microstructure simulation studies. The measurable outcomes aimed at, are

1) a high-performance computing software that allows to compute the effect of a huge number of material and process parameters, sufficiently large for reliable in-silico design of multi-materials, on the interdiffusion microstructure evolution, based on a tractable number of simulations, and

2) decomposed tensor descriptions for important multi-material systems enabling reliable computation of interdiffusion microstructure characteristics using a single computer.

If successful, the outcomes of this project will allow to significantly accelerate the design of innovative multi-materials. My expertise in microstructure simulations and multi-component materials, and access to collaborations with the top experts in tensor decomposition techniques and materials characterization are crucial to reach this ambitious aim.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715027	**Uniting PV**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. BART VERMANG**
Host Institution: Interuniversitair Micro-Electronica Centrum, BE

Applying silicon solar cell technology to revolutionize the design of thin-film solar cells and enhance their efficiency, cost and stability

Thin film (TF) photovoltaics (PV) hold high potential for Building Integrated PV, an important market as European buildings require to be nearly zero-energy by 2020. Currently, Cu(In,Ga)(S,Se)2 (= CIGS(e)) TF solar cells have high efficiency, but also a simple one-dimensional cell design with stability and reliability concerns. Furthermore, its present research has been mainly focused on improving the absorber and buffer layers.

Scientifically, Uniting PV aims to study the practical boundaries of CIGS(e) TF solar cell efficiency. For that reason, its goal is to revolutionize the design of CIGS(e) solar cells through implementation of advanced three-dimensional silicon (Si) solar cell concepts. This novel design consists of (i) surface passivation layers and (ii) light management methods integrated into ultra-thin (UT) CIGS(e) solar cells: (i) Passivation layers will be studied to reduce charge carrier recombination at CIGS(e) surfaces. The aim is to create new understanding and thus scientific models. (ii) Light management methods will be studied to optimize optical confinement in UT CIGS(e) layers. The aim is to examine the interaction between light management and charge carrier recombination in UT CIGS(e), and to create scientific models. The main reasons to introduce these developments is to reduce charge carrier recombination at the CIGS(e) surfaces and in the CIGS(e) bulk, while maintaining optical confinement.

Technologically, the project targets to establish a solar cell with: (1) Increased cell efficiency, at least 23.0 % and up to 26.0 %; (2) improved stability and reliability, due to reduced CIGS(e) thickness and passivation layers hindering alkali metal movement; and (3) reduced cost, due to the use of less Ga and In, and industrially viable materials, methods and equipment. Hence, its outcome will be upscalable, valuable for other TF PV materials, and start a new wave of innovation in and collaboration between TF and Si PV research fields.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716510	**TREND**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. PEDRO BARQUINHA**
Host Institution: Nova Id Fct - Associacao Para A Inovacao E Desenvolvimento Da Fct, PT

Transparent and flexible electronics with embedded energy harvesting based on oxide nanowire devices

The Internet of Things is shaping the evolution of information society, requiring an increasing number of objects with embedded electronics, sensors and connectivity. This spurs the need for systems where summing to performance and low cost, multifunctionality has to be assured. In this context, TREND aims to take transparent electronics into as-of-yet unexplored levels of integration, by combining on flexible substrates transparent and high-speed nanocircuits with energy harvesting capabilities, all based on multicomponent metal oxide nanowires (NWs). For this end, sustainable and recyclable materials as ZnO, SnO2, TiO2 and Cu2O will be synthesized in different forms of heterostructured NWs, using low-temperature and low-cost solution processes. For precise positioning, NWs will be directly grow on flexible substrates using seed layers patterned by nanoimprint lithography. This will be crucial for integration in different nanotransistor structures, which will be combined into digital/analog nanocircuits following planar and 3D approaches. Energy will be provided by piezoelectric nanogenerators with innovative structures and materials. Final platform of nanocircuits+nanogenerators will make use of NW interconnects, bringing a new dimension to the systems-on-foil concept.

The research will be carried out at FCT-UNL, in a group pioneering transparent electronics. My PhD on oxide materials/devices and proven expertise on circuit integration, oxide nanostructure synthesis and nanofabrication/characterization tools will be a decisive contribute to the implementation of the proposal. TREND is an ambitious multidisciplinary project motivating advances in materials science, engineering, physics and chemistry, with impact extending from consumer electronics to health monitoring wearable devices. By promoting new ideas for practical ends, it will contribute to place Europe in the leading position of such strategic areas, where sustainability and innovation are key factors.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716678	**ALUFIX**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. AUDE SIMAR**
Host Institution: Universite Catholique De Louvain, BE

Friction stir processing based local damage mitigation and healing in aluminium alloys

ALUFIX proposes an original strategy for the development of aluminium-based materials involving damage mitigation and extrinsic self-healing concepts exploiting the new opportunities of the solid-state friction stir process. Friction stir processing locally extrudes and drags material from the front to the back and around the tool pin. It involves short duration at moderate temperatures (typically 80% of the melting temperature), fast cooling rates and large plastic deformations leading to far out-of-equilibrium microstructures. The idea is that commercial aluminium alloys can be locally improved and healed in regions of stress concentration where damage is likely to occur. Self-healing in metal-based materials is still in its infancy and existing strategies can hardly be extended to applications. Friction stir processing can enhance the damage and fatigue resistance of aluminium alloys by microstructure homogenisation and refinement. In parallel, friction stir processing can be used to integrate secondary phases in an aluminium matrix. In the ALUFIX project, healing phases will thus be integrated in aluminium in addition to refining and homogenising the microstructure. The “local stress management strategy” favours crack closure and crack deviation at the sub-millimetre scale thanks to a controlled residual stress field. The “transient liquid healing agent” strategy involves the in-situ generation of an out-of-equilibrium compositionally graded microstructure at the aluminium/healing agent interface capable of liquid-phase healing after a thermal treatment. Along the road, a variety of new scientific questions concerning the damage mechanisms will have to be addressed.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724480	**EXSEED**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. DAVID GROJO**
Host Institution: Centre National De La Recherche Scientifique, FR

Extreme-Light Seeded Control of Ultrafast Laser Material Modifications

High-peak power compact femtosecond lasers allow strong-field interactions that are the basis for high-precision laser micro-fabrication. They also create extreme conditions within the matter, leading to the generation of rainbow light used to produce even shorter pulses and new frequencies that can extend from the X-ray to the TeraHertz domain. However, due to the low conversion efficiencies, these attractive light pulses remain unexploited in the context of laser nano-/micro-fabrication.

The main objective of this project is to exceed the intrinsic limits of ultrafast laser material processing by developing novel seeded-control technologies with extreme light pulses. In the proposed concept, seed free carriers are injected into materials from extreme light and then avalanched with perfectly synchronized infrared pulses to extract all potential benefits from modest energy new types of radiation.

The project includes the study of interactions seeded with deep-ultraviolet, few-optical-cycle and mid-infrared ultrashort pulses. The expected nonlinear processes with these radiations open new and exciting opportunities to tailor material properties with nanometer-scale spatial resolutions and in the three dimensions (3D) for materials inside which the occurrence of breakdown is, today, inaccessible (e.g. semiconductors). This will lead to the first demonstrations of rapid 3D prototyping by laser of silicon photonics microdevices.

A long term objective is to open the door to the use of the most extreme ultrashort laser-induced radiations, including extreme-ultraviolet attosecond pulses that hold promises to reach the highest degree of control in the time and space of the interactions.

These and other ideas require investigations on ionization physics by ultrashort pulses at extreme wavelengths. They also require tight control of the ultrafast pulses, broadband manipulations and novel interaction diagnostics technologies that will be developed as parts of the project.

Project End Date: **30-APR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725034	**Des.solve**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. ANA RITA CRUZ DUARTE**
Host Institution: Nova Id Fct - Associacao Para A Inovacao E Desenvolvimento Da Fct, PT

When solids become liquids: natural deep eutectic solvents for chemical process engineering

Sugars, aminoacids or organic acids are typically solid at room temperature. Nonetheless when combined at a particular molar fraction they present a high melting point depression, becoming liquids at room temperature. These are called Natural Deep Eutectic Solvents – NADES. NADES are envisaged to play a major role on different chemical engineering processes in the future. Nonetheless, there is a significant lack of knowledge on fundamental and basic research on NADES, which is hindering their industrial applications. For this reason it is important to extend the knowledge on these systems, boosting their application development. NADES applications go beyond chemical or materials engineering and cover a wide range of fields from biocatalysis, extraction, electrochemistry, carbon dioxide capture or biomedical applications. Des.solve encompasses four major themes of research: 1 – Development of NADES and therapeutic deep eutectic solvents – THEDES; 2 – Characterization of the obtained mixtures and computer simulation of NADES/THEDES properties; 3 – Phase behaviour of binary/ternary systems NADES/THEDES + carbon dioxide and thermodynamic modelling 4 – Application development. Starting from the development of novel NADES/THEDES which, by different characterization techniques, will be deeply studied and characterized, the essential raw-materials will be produced for the subsequent research activities. The envisaged research involves modelling and molecular simulations. Des.solve will be deeply engaged in application development, particularly in extraction, biocatalysis and pharmaceutical/biomedical applications. The knowledge that will be created in this proposal is expected not only to have a major impact in the scientific community, but also in society, economy and industry.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725513	**SuperRepel**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. ROBIN RAS**
Host Institution: Aalto-Korkeakoulusaatio, FI

Superslippery Liquid-Repellent Surfaces

I aim to progress substantially the understanding and applications of extremely non-wetting surfaces, tying together basic research and attractive technological advancements.
The first part focuses on robust synthesis methods for superslippery liquid-repellent (SS-LR) surfaces. I will use vapor deposition towards ultradense surfactant monolayers to reach extremely low surface energies, not only for planar surfaces but also for more challenging nanostructured substrates. Furthermore, using new types of ultrasensitive force measurement for droplets, I will investigate in depth the dissipation dynamics of mobile water droplets and adhesion of droplets to surfaces, to promote understanding on low-friction surfaces.
The second part aims at applying these SS-LR surfaces in droplet actuation with potential to outperform existing technologies. Additionally, the potential of SS-LR surfaces for anti-icing and for preventing bio-fouling will be investigated.
The research results will have a major impact on superhydrophobic research and will explore the fundamental physical limits of non-wetting.

Project End Date: **31-MAY-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725762	**LIGNINFIRST**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. ROBERTO RINALDI**
Host Institution: Imperial College Of Science, Technology And Medicine, UK

The Lignin-First Approach for the Full Valorisation of Lignocellulosic Biomass

Early-stage Catalytic Conversion of Lignin (ECCL), or the 'Lignin-First' approach, constitutes an emerging multidisciplinary research field targeting the valorisation of lignin. ECCL involves the concurrent extraction and catalytic conversion of the lignin fragments released from plant biomass in a one-pot process. In this manner, ECCL benefits from the intrinsically high reactivity of the lignin oligomers, leading to further depolymerisation (via hydrogenolysis of ether linkages) and, most importantly, to the passivation of the intermediates (via hydrodeoxygenation of aldehyde and ketone groups), thus protecting the lignin fragments from recondensation. In short, this novel approach renders a high yield of mono-aromatic products (>60%) and highly delignified pulps, allowing for the full utilisation of lignocellulose. LIGNINFIRST objectives will be achieved by high-risk/high-gain research into: (1) understanding (and control over) the solvolytic release of lignin fragments; (2) advancing the molecular understanding of H-transfer reactions catalysed by sponge Ni catalysts to accelerate the discovery of catalytic methods for lignin valorisation, and; (3) reaction engineering of the interdependent processing steps for fractionation of the initial biomass feedstock (catalytic upstream biorefining) to the intended value-added products (catalytic downstream processing). The full impact of LIGNINFIRST will be realised by undertaking pioneering research at the border of Wood Chemistry, Catalysis and Reaction Engineering. The most significant anticipated outcome is a profound understanding of the synergy between deconstruction of lignin, occurring in the plant tissue throughout the 'cooking process', and ECCL. The new scientific insights that will emerge from the implementation of this proposal have the great potential for revolutionising the utilisation of lignin in biorefineries.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
726360	**MOLEMAT**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. SHAHZADA AHMAD**
Host Institution: Fundacion Bcmaterials - Basque Centre For Materials, Applications And Nanostructures, ES

Molecularly Engineered Materials and process for Perovskite solar cell technology

Societal pressure to develop inexpensive yet efficient solar energy conversion requires a new approach. Recently emerged organic-inorganic perovskites, offer to harvest light at cost effective price. Perovskites hold merits to the existing materials, however, a fundamental challenge for high performance devices is to optimize the crystals for maximize charge carrier generation and minimize recombination losses. Their widespread use is, however, limited by insufficient stability, scalability and reproducibility. We have recently developed new concepts to fabricate efficient and stable perovskite solar cells at lab scale that are potentially up-scalable to industrial production. MOLEMAT will accomplish this by, pioneering innovative methods and will demonstrate that molecularly engineered materials enable the tuning of the charge transport and interface. Our interdisciplinary approach, combining materials science, chemistry, device physics and engineering, will not only lead to improvements in the performance and stability of perovskite solar cell beyond 24% at lab scale, but will also provide deep insights in the functioning of solar cells. The success of MOLEMAT will rapidly advance the field by enabling reproducible and stable performance adding a significant value with respect to current state of the art. However, for making it marketable product, several developments are required and the MOLEMAT targets will provide relevant answers to three key limitations: encapsulation, stability and cost competitive materials. MOLEMAT envisages the development of 30×30 cm2 modules, with a power conversion efficiency of c.a 18% and a lifetime of 10+ years. MOLEMAT is divided into two parallel research directions, a fundamental research line, dealing with rational design of materials and to gain its understanding. Simultaneously an applied research line targets the development of module by the identification of scale up process to pave the way for its industrialization.

Project End Date: **31-OCT-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
741883	**MechAGE**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. RALPH MÜLLER**
Host Institution: Eidgenoessische Technische Hochschule Zurich, CH

In Vivo Single-Cell Mechanomics of Bone Adaptation and Regeneration in the Aging Mouse

Osteoporosis, one of the most prevalent degenerative diseases, is characterized by a reduction in bone mass and increased fracture risk and has been partly attributed to the decrease in mechanical usage of the skeleton. A detailed understanding of the molecular mechanisms governing load-regulated bone remodeling could therefore lead to the identification of molecular targets for the development of novel therapies. Bone remodeling is a multiscale process mediated through complex interactions between multiple cell types and their local 3D environments. However, the underlying mechanisms of how cells respond to mechanical signals are still unclear. By combining single-cell “omics” technologies with well-established tissue-scale models of bone mechanobiology, MechAGE proposes to develop the technology required to allow spatially resolved in vivo single-cell mechanomics of bone adaptation and regeneration. CRISPR/Cas technology will be exploited to generate fluorescent reporter mice to identify the different cell types involved in the bone remodeling process. By combining RNA-sequencing of single cells isolated by laser-capture microdissection with micro-finite element analysis and time-lapsed in vivo micro-CT, MechAGE will link the transcriptome of hundreds of single cells to their local mechanical in vivo environment (LivE). This will allow investigation of molecular responses of the cells to LivE changes with aging in established mouse models of bone adaptation and regeneration. In addition to in vivo mechanomics, MechAGE proposes to use cellular and multiscale computational modeling to run in silico simulations of real-world events for better understanding of diseases of aging in mice and to maximize the use of the high quality in vivo mechanomic data. Findings from MechAGE will lead to a systems level understanding of the spatio-temporal regulation of gene expression during the process of load-induced bone adaptation and regeneration in the aging mouse.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
742004	**CREAM4**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. HAN GARDENIERS**
Host Institution: Universiteit Twente, NL

Chemical Reaction Engineering by Additive Manufacturing of Mesoscale MetaMaterials

The management of mesoscale dynamics is the missing link in gaining complete control over chemical processes like heterogeneous catalysis. The ability to accurately position nanoscale active elements in cellular mesoscale (nm to µm-range) structures with high symmetrical order is instrumental in streamlining vital molecular or energetic paths. 3D periodicity in the structure that supports active or adsorption sites minimizes spatial variations in mass transport, whereas mesoscale control of the location of these sites gives a route to tuning activity and functionality. The introduction of mesoscale metamaterials expands the on-going trend in chemistry, of more and more dimensionally refined structured elements, a so to speak "Moore's law in Process Intensification". The roadmap to higher process efficiency dictates a next, disruptive step in mastering manufacturing control at smaller dimensions. The proposed disruptive technology to realize the required mesoscale features is Additive Manufacturing, which is the only method offering the desired freedom in shape, symmetry and composition. More specifically, this project explores electrospinning methods with precise intra-wire control of the position of active sites and accurately tuneable 3D inter-wire distances. This is seen as the ideal technique to reach the mesoscale material target, as the method is scalable to practical device volumes. The main ingredients of the novel technology are microfluidic networks to line up nanoparticles, before electrospinning them with integrated micromachined nozzles, and depositing them accurately in the form of 3D nanowire networks, using integrated circuit collector electrodes. Flow-through, cellular materials which are highly homogeneous in size and composition, or with intentionally embedded gradients, having features designed at the mesoscale, will be investigated for applications in the fields of heterogeneous catalysis and solar energy capture and conversion.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
742684	**CADENCE**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. JESUS SANTAMARIA**
Host Institution: Universidad De Zaragoza, ES

Catalytic Dual-Function Devices Against Cancer

Despite intense research efforts in almost every branch of the natural sciences, cancer continues to be one of the leading causes of death worldwide. It is thus remarkable that little or no therapeutic use has been made of a whole discipline, heterogeneous catalysis, which is noted for its specificity and for enabling chemical reactions in otherwise passive environments. At least in part, this could be attributed to practical difficulties: the selective delivery of a catalyst to a tumour and the remote activation of its catalytic function only after it has reached its target are highly challenging objectives. Only recently, the necessary tools to overcome these problems seem within reach.

CADENCE aims for a breakthrough in cancer therapy by developing a new therapeutic concept. The central hypothesis is that a growing tumour can be treated as a special type of reactor in which reaction conditions can be tailored to achieve two objectives: i) molecules essential to tumour growth are locally depleted and ii) toxic, short-lived products are generated in situ.

To implement this novel approach we will make use of core concepts of reactor engineering (kinetics, heat and mass transfer, catalyst design), as well as of ideas borrowed from other areas, mainly those of bio-orthogonal chemistry and controlled drug delivery. We will explore two different strategies (classical EPR effect and stem cells as Trojan Horses) to deliver optimized catalysts to the tumour. Once the catalysts have reached the tumour they will be remotely activated using near-infrared (NIR) light, that affords the highest penetration into body tissues.

This is an ambitious project, addressing all the key steps from catalyst design to in vivo studies. Given the novel perspective provided by CADENCE, even partial success in any of the approaches to be tested would have a significant impact on the therapeutic toolbox available to treat cancer.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
742685	**MEMS 4.0**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. JUERGEN BRUGGER**
Host Institution: Ecole Polytechnique Federale De Lausanne, CH

Additive Micro-Manufacturing for Plastic Micro-flectro-Mechanical-Systems

The manufacturing of silicon-based MEMS today is well advanced because the micro-electro-mechanical devices for automotive, domestic, health-care and consumer electronics can be fabricated with methods from IC industry. Polymer-based MEMS have a great potential for flexible electronics and biomedical applications, but to date, the techniques to engineer functional polymers into 3D microsystems, are still at their beginning because a coherent fabrication platform with the right tools and processes does not yet exist. The field could tremendously benefit from a coordinated effort in materials and manufacturing, in particular with a focus on biocompatible plastic materials for biomedical applications. Additive manufacturing such as 3D printing and associated processing such as sintering has already started to transform traditional industry, but is not scalable much below a micrometer because the thermal processing is done in bulk or by lasers on surfaces. MEMS 4.0, in analogy with the industry 4.0 concept, aims to perform concerted research in additive manufacturing at the micro/nanoscale and associated key techniques. Using my expertise in MEMS and Nanotechnology, MEMS 4.0 will push the frontiers in new materials and new processing for MEMS by setting a focus on stencilling, printing, self-assembly and local thermal processing. This coherent processing framework will permit the use of delicate, soft, polymer materials to engineer the next generations of plastic MEMS. We are primarily targeting biodegradable implantable MEMS and permanently implantable glassy carbon MEMS. They are the most challenging to fabricate, but if successful, they also have an enormous impact for future wearables and implantables.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757333	**SpdTuM**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. ANDREA BACHMAIER**
Host Institution: Oesterreichische Akademie Der Wissenschaften, AT

SPD nanostructured magnets with tuneable properties

The decrease of weight and the increase of efficiency of magnetic components are essential for the reduction of CO2-emission and an improvement of their performance. Nanostructuring can dramatically improve the magnetic properties of soft and hard magnetic materials, hence opening up entirely new possibilities for the development of novel magnets. Nanocomposite magnets, for example, have been the focus of research since two decades. One of the remaining key challenges is to synthesize bulk nanostructured magnets of a reasonable size. In this project, this challenge is explicitly addressed and the potential to fabricate bulk nanostructured magnets by severe plastic deformation (SPD) as an innovative processing route is evaluated. The aim of the project is not only to synthesize different nanostructured magnets by SPD, but also to tailor their microstructure to attain the desired magnetic properties. It has been shown by the applicant that the magnetic properties of SPD processed nanocrystalline materials can be modified in wide range by decomposition of metastable solid solutions. By using different immiscible systems, decomposition mechanisms and annealing treatments, unique nanostructures can be obtained and the magnetic properties can be optimized. Through the choice of different magnetic starting materials, such as soft, hard and antiferromagnetic-ferromagnetic powders, different types of hard magnetic nanocomposites will also be obtained. Fine tuning of the microstructure and resulting magnetic properties through adjustments in the composition, SPD processing parameters and annealing treatments is planned. The project systematically addresses the entire process from the synthesis to the in-depth microstructural characterization by electron microscopy and atom probe tomography. In combination with simultaneous measurements of magnetic properties, the newly developed knowledge will be used to improve the performance of SPD processed nanostructured magnets.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757848	**CoQuake**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. IOANNIS STEFANOU**
Host Institution: Ecole Nationale Des Ponts Et Chaussees, FR

Controlling earthQuakes

According to the Centre for Research on the Epidemiology of Disasters (CRED), earthquakes are responsible for more than half of the total human losses due to natural disasters from 1994 to 2003. There is no doubt that earthquakes are lethal and costly. CoQuake proposes an alternative, ground-breaking approach for avoiding catastrophic earthquakes by inducing them at a lower energetic level. Earthquakes are a natural phenomenon that we cannot avoid, but –for the first time– in CoQuake I will show that it is possible to control them, hence reducing the seismic risk, fatalities and economic cost. CoQuake goes beyond the state-of-the-art by proposing an innovative methodology for investigating the effect and the controllability of various stimulating techniques that can reactivate seismic faults. It involves large-scale, accurate simulations of fault systems based on constitutive laws derived from micromechanical, grain-by-grain simulations under Thermo-Hydro-Chemo-Mechanical couplings (THMC), which are not calibrated on the basis of ad-hoc empirical and inaccurate constitutive laws. A pioneer experimental research programme and the design and construction of a new apparatus of metric scale, will demonstrate CoQuake's proof-of-principle and it will help to explore the transition from aseismic to seismic slip. CoQuake is an interdisciplinary project as it takes knowledge from various fields of engineering, computational mechanics, geomechanics, mathematics and geophysics. CoQuake opens a new field and new line of research in earthquake mechanics and engineering, with a direct impact on humanity and science.

Project End Date: **31-MAY-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758056	**PURPOSE**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. JOSE ANTONIO RODRÍGUEZ**
Host Institution: Universidad Carlos Iii De Madrid, ES

Opening a new route in solid mechanics: Printed protective structures

Dynamic fragmentation of metals is typically addressed within a statistical framework in which material and geometric flaws limit the energy absorption capacity of protective structures. This project is devised to challenge this idea and establish a new framework which incorporates a deterministic component within the fragmentation mechanisms.

In order to check the correctness of this new theory, I will develop a comprehensive experimental, analytical and numerical methodology to address 4 canonical fragmentation problems which respond to distinct geometric and loading conditions which make easily identifiable from a mechanical standpoint. For each canonical problem, I will investigate traditionally-machined and 3D-printed specimens manufactured with 4 different engineering metals frequently used in aerospace and civilian-security applications. The goal is to elucidate whether at sufficiently high strain rates there may be a transition in the fragmentation mechanisms from defects–controlled to inertia–controlled. If the new statistical-deterministic framework is proven to be valid, defects may not play the major role in the fragmentation at high strain rates. This would bring down the entry barriers that the 3D-printing technology has found in energy absorption applications, thus reducing production transportation and repairing, energetic and economic costs of protective structures without impairing their energy absorption capacity.

It is anticipated that leading this cutting-edge research project will enable me to establish my own research team and help me to achieve career independence in the field of dynamic behaviour of ductile solids.

Project End Date: **28-FEB-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758653	**CATACOAT**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. JEREMY LUTERBACHER**
Host Institution: Ecole Polytechnique Federale De Lausanne, CH

Nanostructured catalyst overcoats for renewable chemical production from biomass

In the CATACOAT project, we will develop layer-by-layer solution-processed catalyst overcoating methods, which will result in catalysts that have both targeted and broad impacts. We will produce highly active, stable and selective catalysts for the upgrading of lignin – the largest natural source of aromatic chemicals – into commodity chemicals, which will have an important targeted impact. The broader impact of our work will lie in the production of catalytic materials with unprecedented control over the active site architecture.

There is an urgent need to provide these cheap, stable, selective, and highly active catalysts for renewable molecule production. Thanks to its availability and relatively low cost, lignocellulosic biomass is an attractive source of renewable carbon. However, unlike petroleum, biomass-derived molecules are highly oxygenated, and often produced in dilute-aqueous streams. Heterogeneous catalysts – the workhorses of the petrochemical industry – are sensitive to water and contain many metals that easily sinter and leach in liquid-phase conditions. The production of renewable chemicals from biomass, especially valuable aromatics, often requires expensive platinum group metals and suffers from low selectivity.

Catalyst overcoating presents a potential solution to this problem. Recent breakthroughs using catalyst overcoating with atomic layer deposition (ALD) showed that base metal catalysts can be stabilized against sintering and leaching in liquid phase conditions. However, ALD creates dramatic drops in activity due to excessive coverage, and forms an overcoat that cannot be tuned.

Our materials will feature the controlled placement of metal sites (including single atoms), several oxide sites, and even molecular imprints with sub-nanometer precision within highly accessible nanocavities. We anticipate that such materials will create unprecedented opportunities for reducing cost and increasing sustainability in the chemical industry and beyond.

Project End Date: **30-NOV-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758887	**REACT**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. EDUARDO RUIZ-HERNANDEZ**
Host Institution: The Provost, Fellows, Foundation Scholars & The Other Members Of Board Of The College Of The Holy & Undivided Trinity Of Queen Elizabeth Near Dublin, IE

REsponsive theranostic nanosystems for Advanced Cancer Treatment

REACT aims to dramatically impact the targeted release of diagnostic agents and drugs with nanomedicines that respond to biological cues or changing pathophysiological conditions, thus enabling ultrasensitive diagnosis and exquisite therapy selectivity. Nanomedicine research against cancer focuses on the local targeted delivery of chemotherapeutics to enhance drug efficacy and reduce side effects. Despite all the efforts in the design of chemotherapeutic agents as nanomedicines, hardly any improvement has been translated into benefits for patients' survival. There is an urgent need for improved carrier systems able to deliver high doses of diagnostic agents and anti-cancer drugs to the tumor. Stimuli responsive carriers are promising candidates since the release of the cargo can be triggered locally in the tumor environment. Currently, there exists an unparalleled effort to identify genes, proteins and metabolites implicated in human disease and utilize systems biology and mathematical approaches in order to develop new prognostic tools for the treatment of cancer and develop more targeted therapies for patients. As an expert in drug delivery systems, the PI intends to bring all these efforts and advances into the design of stimuli responsive organic-inorganic hybrid nanoparticles that can adapt their response to the biological milieu. The novel engineered delivery systems will consist of an inorganic porous matrix surface-modified with tumor-specific molecules with the ability to sense changes in the environmental conditions and react by providing a proportional release. These nanosystems can potentially be employed for early in vitro diagnosis through effective screening of deadly tumors, such as neuroblastoma and glioblastoma. Moreover, through the sustained delivery of the nanosystems from injectable gels that can be locally implanted in patients at risk of developing a tumor, a clinically relevant tool for in vivo diagnosis and targeted therapy can be achieved.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759603	**IMMOCAP**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. KRZYSZTOF FIC**
Host Institution: Politechnika Poznanska, PL

'If immortality unveil…'– development of the novel types of energy storage systems with excellent long-term performance

The major goal of the project is to develop a novel type of an electrochemical capacitor with high specific power (up to 5 kW/kg) and energy (up to 20 Wh/kg) preserved along at least 50 000 cycles. Thus, completion of the project will result in remarkable enhancement of specific energy, power and life time of modern electrochemical capacitors. Advanced electrochemical testing (galvanostatic cycling with constant power loads, electrochemical impedance spectroscopy, accelerated aging and kinetic tests) will be accompanied by materials design and detailed characterization. Moreover, the project aims at the implementation of novel concepts of the electrolytes and designing of new operando technique for capacitor characterization. All these efforts aim at the development of sustainable and efficient energy conversion and storage system.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759959	**INTERCELLMED**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. LORETTA DEL MERCATO**
Host Institution: Consiglio Nazionale Delle Ricerche, IT

SENSING CELL-CELL INTERACTION HETEROGENEITY IN 3D TUMOR MODELS: TOWARDS PRECISION MEDICINE

This project aims to investigate the role of potassium (K+), protons (H+) and oxygen (O2) gradients in the extracellular space of tumour cells grown in 3D cultures by using a combination of imaging, cell biology and in silico analyses. By embedding ratiometric fluorescent particle-based sensors within 3D scaffolds, the changes in target analyte concentrations can be monitored and used to study the interactions between tumour cells and stromal cells in 3D tumoroids/scaffolds and to monitor response of the cells to drug treatments. I was the first to demonstrate successful fabrication of barcoded capsules for multiplex sensing of H+, K+, and Na+ ions. Next, I demonstrated the use of pH-sensing capsules as valid real time optical reporter tools to sense and monitor intracellular acidification in living cells. Thus, I can fabricate capsule sensors for investigating the role of key analytes that are involved in regulation of crucial physiological mechanisms. In addition, I successfully integrated pH-sensing capsules within 3D nanofibrous matrices and demonstrated their operation under pH switches. INTERCELLMED will engineer 3D nanofibrous scaffolds that do not only sense extracellular pH but are also able to sense K+ and O2 changes. To this aim, a novel set of anisotropic analyte-sensitive ratiometric capsules will be developed and electrospinning will be applied for fabrication of robust and flexible capsules-embedded sensing scaffolds. To validate the functions of the 3D sensing platform, cocoltures of tumour cells and stromal cells will be grown and their interaction and response to drug treatments will be studied by mapping the K+/H+/O2 gradients in and around the cell aggregates. Finally, the 3D sensing platform will be adapted for growing tumour tissue-derived cells that will be tested ex-vivo with anticancer dugs. Specific mathematical models of cellular interactions will be developed to represent the biological processes occurring within the 3D sensing platform.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771146	**TOUGHIT**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. DANIEL KIENER**
Host Institution: Montanuniversitaet Leoben, AT

Tough Interface Tailored Nanostructured Metals

The ideal structural material should excel in strength and toughness. Strength describes the capability of a defect free component to carry load during operation, while toughness defines the load-bearing capability and ductility in the presence of a crack. For an energy-efficient and safe design, both quantities should be simultaneously high. Unfortunately, they are mutually exclusive, rendering their combination a Holy Grail in materials science.

The reason for this incompatibility is rooted in the inverse strength-ductility paradigm. Focussing on metals, the strength is enhanced via microstructure refinement to the nanometer scale, but ductility and damage tolerance simultaneously drop dramatically. Safety-related or highly stressed components are thus made from rather soft metals, indicating tremendous economic impact conceivable.

The objective of this project is to design new bulk materials that uniquely combine high strength and toughness.

Severe plastic deformation will be employed to create novel nanostructured bulk metals and nanocomposites, utilizing atomistically informed alloy and interface design to promote plastic deformation. The largely unknown nanoscale processes that limit fracture toughness of nanostructured materials will for the first time be directly identified by quantitative nanomechanical fracture experiments performed in-situ in high resolution electron microscopes. Correlation of these unique insights with ab-initio calculations and energy-based elastic-plastic fracture mechanics computations will guide paths for further improvement of the fracture resistance.

By combining a versatile synthesis technique with highly advanced in-situ nanomechanical testing permitting unique atomistic-level insights into nanoscale fracture processes and a scale-bridging modelling approach, new mechanism-based strategies to tailor innovative nanostructured metals and composites with unprecedented strength and toughness will be established.

Project End Date: **30-APR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771237	**TriboKey**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. CHRISTIAN GREINER**
Host Institution: Karlsruher Institut Fuer Technologie, DE

Deformation Mechanisms are the Key to Understanding and Tayloring Tribological Behaviour

Tribology, the science of interacting surfaces in relative motion, is crucial for many aspects of modern life. Friction and wear decisively impact the lifetime and durability of many products-from nanoelectromechanical systems to gears and engines. In the USA alone, an estimated 1E18 joules of energy could be saved each year through improved tribological practices.

During sliding of a metallic contact, a mutated surface layer forms, carries most further plastic deformation and largely determines friction and wear. The origin and evolution of this distinct subsurface layer remains elusive, since our knowledge of the elementary mechanisms promoting these changes is limited. Only this knowledge however will allow for a strategic tailoring of tribologically loaded metals.

In this project, we will elucidate these elementary mechanisms for a wide range of alloys and strain rates. We will develop ground-breaking new strategies for probing the subsurface microstructure during the tribological test itself with non-destructive testing sensors like ultrasound and eddy current, resulting in subsurface in situ tribology. The data from these sensors will be analysed online, during the tribological experiment, relying on cutting edge data science methods as they have already been applied for fatigue testing. Based on these analyses, implemented on a Field Programmable Gate Array, we will interrupt the test exactly when the dominating elementary mechanisms manifest themselves. These mechanisms will then be revealed by sophisticated electron microscopy and be visualized in deformation mechanism maps for unidirectional and reciprocating sliding. Such maps have proven very successful in other fields of materials science, e.g. creep at elevated temperatures. They are used to guide material selection and alloy development processes, yielding materials tailored for each specific tribological scenario, promising enormous savings in energy and resources, an important challenge of our time.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771567	**CABUM**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. MATEVZ DULAR**
Host Institution: Univerza V Ljubljani, SI

An investigation of the mechanisms at the interaction between cavitation bubbles and contaminants

A sudden decrease in pressure triggers the formation of vapour and gas bubbles inside a liquid medium (also called cavitation). This leads to many (key) engineering problems: material loss, noise and vibration of hydraulic machinery. On the other hand, cavitation is a potentially a useful phenomenon: the extreme conditions are increasingly used for a wide variety of applications such as surface cleaning, enhanced chemistry, and waste water treatment (bacteria eradication and virus inactivation).

Despite this significant progress a large gap persists between the understanding of the mechanisms that contribute to the effects of cavitation and its application. Although engineers are already commercializing devices that employ cavitation, we are still not able to answer the fundamental question: What precisely are the mechanisms how bubbles can clean, disinfect, kill bacteria and enhance chemical activity? The overall objective of the project is to understand and determine the fundamental physics of the interaction of cavitation bubbles with different contaminants. To address this issue, the CABUM project will investigate the physical background of cavitation from physical, biological and engineering perspective on three complexity scales: i) on single bubble level, ii) on organised and iii) on random bubble clusters, producing a progressive multidisciplinary synergetic effect.

The proposed synergetic approach builds on the PI's preliminary research and employs novel experimental and numerical methodologies, some of which have been developed by the PI and his research group, to explore the physics of cavitation behaviour in interaction with bacteria and viruses.

Understanding the fundamental physical background of cavitation in interaction with contaminants will have a ground-breaking implications in various scientific fields (engineering, chemistry and biology) and will, in the future, enable the exploitation of cavitation in water and soil treatment processes.

Project End Date: **30-JUN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771602	**SHINE**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. BAPTISTE GAULT**
Host Institution: Max Planck Institut Fur Eisenforschung Gmbh, DE

Seeing hydrogen in matter

Observing hydrogen (H) in matter is a formidable challenge. Despite being ubiquitous in nature, it is elusive to scientific scrutiny like no other element. It is often portrayed as either a blessing or a curse. Certainly, it is a prime candidate for producing low-carbon emission power. But no less important is the effect of hydrogen embrittlement which has resulted in many catastrophic failures of engineering alloys. In aid of this, SHINE will realise multiple ambitions. It will facilitate the direct imaging and quantification of H atoms in candidate metallic alloys and metal-organic frameworks for gaseous storage, allow the discovery of new solid-state hydrides with controlled release, and help the improvement of fuel cell materials for energy generation. All these applications have relevance to a 'low-carbon-emission economy' that humanity must develop in the 21st century. SHINE will exploit a novel and entirely unique infrastructure, designed and currently implemented in the PI's group. It will directly provide three-dimensional hydrogen mapping at the near-atomic scale. By connecting and relating this fundamental knowledge and observed physical properties, we will enable unprecedented precision in the prediction of material behaviour and so resolve to unlock control over the behaviour of hydrogen in such materials. Atom probe tomography will be the principal method of a correlative microscopy and spectroscopy approach to investigate materials where precise knowledge of the distribution of H is crucial. Informed by experimental data, modelling and simulations will provide a mechanistic understanding of the behaviour of H in materials. Novel hardware and data-treatment approaches will be developed to maximise data quality and provide new insights of the behaviour of H in the complex and dynamic microstructures of engineering materials, thereby allowing us to devise manufacturing strategies to enhance their performance and durability.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772168	**BIORECAR**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. VALERIA CHIONO**
Host Institution: Politecnico Di Torino, IT

Direct cell reprogramming therapy in myocardial regeneration through an engineered multifunctional platform integrating biochemical instructive cues

In BIORECAR I will develop a new breakthrough multifunctional biomaterial-based platform for myocardial regeneration after myocardial infarction, provided with biochemical cues able to enhance the direct reprogramming of human cardiac fibroblasts into functional cardiomyocytes.
My expertise in bioartificial materials and biomimetic scaffolds and the versatile chemistry of polyurethanes will be the key elements to achieve a significant knowledge and technological advancement in cell reprogramming therapy, opening the way to the future translation of the therapy into the clinics.
I will implement this advanced approach through the design of a novel 3D in vitro tissue-engineered model of human cardiac fibrotic tissue, as a tool for testing and validation, to maximise research efforts and reduce animal tests.
I will adapt novel nanomedicine approaches I have recently developed for drug release to design innovative cell-friendly and efficient polyurethane nanoparticles for targeted reprogramming of cardiac fibroblasts.
I will design an injectable bioartificial hydrogel based on a blend of a thermosensitive polyurethane and a natural component selected among a novel cell-secreted natural polymer mixture ("biomatrix") recapitulating the complexity of cardiac extracellular matrix or one of its main protein constituents. Such multifunctional hydrogel will deliver in situ agents stimulating recruitment of cardiac fibroblasts together with the nanoparticles loaded with reprogramming therapeutics, and will provide biochemical signalling to stimulate efficient conversion of fibroblasts into mature cardiomyocytes.
First-in-field biomaterials-based innovations introduced by BIORECAR will enable more effective regeneration of functional myocardial tissue respect to state-of-the art approaches. BIORECAR innovation is multidisciplinary in nature and will be accelerated towards future clinical translation through my clinical, scientific and industrial collaborations.

Project End Date: **30-JUN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772261	**XFab**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. ALESSANDRO MOLLE**
Host Institution: Consiglio Nazionale Delle Ricerche, IT

Xene Fabrication for a Two-Dimensional Nanotechnology Platform

Xenes denote two-dimensional (2D) monoelemental (X) crystals beyond graphene with a honeycomb lattice. Unlike graphene, Xenes do not exist in Nature, but they become stable via epitaxy on substrates. So far experimental evidences of Xene epitaxy have been reported for X=Si, Ge, Sn, B, P, and Sb (named silicene, germanene, stanene, borophene, phosphorene, and antimonene, respectively). Xene single layers also serve as a background for the synthesis of new Xene-related materials (XRMs) such as Xene heterostructures and functionalized Xenes. Xenes can appear as metals, semimetals, semiconductors, and topological insulators thus allowing for a broad range of applications in nanotechnology. However only silicene has been integrated into transistors operating at room temperature albeit fast degradation. Nonetheless, a viable Xene-based nanotechnology is currently missing due to the lack of reliable standards for the Xene production and implementation. For this purpose, the proposal aims at developing viable schemes for high-quality crystal growth, environmental stabilization, and device integration of Xenes and XRMs frameworks. At first the effort will be focused on the high-quality synthesis of selected Xenes and XRMs by means of molecular beam epitaxy, and on their stabilization in encapsulated structures enabling subsequent processing into Xene-based device platforms. Validation of the Xene properties, quality, and performances will be carried out by means of advanced in situ and ex situ characterization of the atomic and electronic structure. Secondly, prototypical electronic device (e.g. field effect transistors or vertical diodes) incorporating stabilized Xene frameworks as active elements will be used to assess the Xene electrical behaviour and performances so as to establish a reliable Xene-based nanotechnology.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772873	**ARTISTIC**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. ALEJANDRO A. FRANCO**
Host Institution: Centre National De La Recherche Scientifique, FR

Advanced and Reusable Theory for the In Silico-optimization of composite electrode fabrication processes for rechargeable battery Technologies with Innovative Chemistries

The aim of this project is to develop and to demonstrate a novel theoretical framework devoted to rationalizing the formulation of composite electrodes containing next-generation material chemistries for high energy density secondary batteries. The framework will be established through the combination of discrete particle and continuum mathematical models within a multiscale computational workflow integrating the individual models and mimicking the different steps along the electrode fabrication process, including slurry preparation, drying and calendering. Strongly complemented by dedicated experimental characterizations which are devoted to its validation, the goal of this framework is to provide insights about the impacts of material properties and fabrication process parameters on the electrode mesostructures and their corresponding correlation to the resulting electrochemical performance. It targets self-organization mechanisms of material mixtures in slurries by considering the interactions between the active and conductive materials, solvent, binders and dispersants and the relationship between the materials properties such as surface chemistry and wettability. Optimal electrode formulation, fabrication process and the arising electrode mesostructure can then be achieved. Additionally, the framework will be integrated into an online and open access infrastructure, allowing predictive direct and reverse engineering for optimized electrode designs to attain high quality electrochemical performances. Through the demonstration of a multidisciplinary, flexible and transferable framework, this project has tremendous potential to provide insights leading to proposals of new and highly efficient industrial techniques for the fabrication of cheaper and reliable next-generation secondary battery electrodes for a wide spectrum of applications, including Electric Transportation.

Project End Date: **31-MAR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787410	**DIGISMART**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. ELVIRA FORTUNATO**
Host Institution: Universidade Nova De Lisboa, PT

Multifunctional Digital Materials Platform for Smart Integrated Applications

DIGISMART creates new avenues into two main areas: 1) processing nanomaterials/nanostructures applied to electronic devices by exploring a new digital multifunctional direct laser writing (LDW) method for in situ synthesis of small-sized nanomaterials/nanofilms micro-patterned growth by selective photothermal decomposition of semiconductors, dielectrics and conductors precursors and 2) provide simultaneously multifunction to single based metal oxide devices (like thin film transistors, the workhorses for large area electronics having electron, charge and color modulation), as the basic unit to promote systems' integration by exploring the use of new advanced materials with unique multi-functionalities using low cost process solutions.

This new fabrication process will be very useful for low-cost, eco-friendly, and efficient fabrication of nanostructures and thin films-integrated microelectronic devices due to its low-power, simple setup as well as excellent reliability. This new and disruptive concept will be achieved with low cost and non-toxic materials (new metal oxides, MO semiconductors, conductors, dielectrics and electrochromics free of In and Ga) associated to a low cost process multifunctional platform technology (ALL-IN-ONE TOOL) well supported by high-resolution nano-characterization techniques. With DIGISMART new and unexplored materials will be produced as well as to boost the original properties of conventional materials in order to contribute to the needs for low cost and flexible electronics. If we succeed to embed some level of intelligence in every object, this would change electronics and it would change society, ranging from embedded window displays to a wide range of biomedical electronics, just to mention a few and this is what the Internet of Things is looking for.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787446	**GB-CORRELATE**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. GERHARD DEHM**
Host Institution: Max Planck Institut Fur Eisenforschung Gmbh, DE

Correlating the State and Properties of Grain Boundaries

Phase diagrams revolutionized materials development by predicting the conditions for phase stability and transformations, providing a thermodynamic concept for materials design including synthesis, processing and application. Similarly, surface science has established thermodynamic concepts for surface states and transitions, but the analogon for grain boundaries (GB) is just emerging due to their complexity. GB are among the most prominent microstructure defects separating grains in polycrystalline materials spanning a multidimensional space. Unlocking control of GB phases and their transitions will enable a new level of materials design allowing to tailor functional & structural properties. This proposal targets on (i) predicting and resolving GB phase transitions, (ii) establishing guidelines for GB phase transitions and GB phase diagrams, (iii) correlating GB phase transitions with property changes, (iv) providing compositional-structural design criteria for GB engineering, (v) which will be tested by demonstrators with tailored GB strength and GB mobility. GB-CORRELATE focusses on Cu and Al alloys in form of thin films as this allows to implement a hierarchical strategy expanding from individual special GB to GB networks and a transfer of the GB concepts to thin film applications. The infinite number of GB requires also statistical approaches; combinatorial thin film deposition will be used to establish Cu and Al alloy films with substitutional (Ag, Al, Cu, Si, Ni) and interstitial (B) solute elements. High throughput grain growth experiments will be employed to detect GB phase transitions by changes in GB mobility. Advanced atomic resolved correlated microscopy and spectroscopy supported by powerful computational approaches will identify GB phases and correlate them with transport properties. Sophisticated in-situ micromechanical studies lay the ground for interlinking GB phases and GB mechanics, finally harvested to create mechanically exceptional materials.

Project End Date: **31-JUL-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788587	**BIOGEOS**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. LYESSE LALOUI**
Host Institution: Ecole Polytechnique Federale De Lausanne, CH

Bio-mediated Geo-material Strengthening for engineering applications

Given the increasing scarcity of suitable land for development, soil strengthening technologies have emerged in the past decade and go hand-in-hand with the implementation of the majority of foundation solutions. The goal is to alter the soil structure and its mechanical properties for ultimately securing the integrity of structures. The BIOGEOS project puts the focus on bio-mediated soil improvement, which falls within the broader framework of multi-physical processes in geo-mechanics. The goal of the project is to engineer a novel, natural material under controlled processes, for ultimately providing solutions to real problems in the geo-engineering and geo-energy fields by advancing knowledge around complex multi-physical phenomena in porous media. The bio-cemented geo-material, which is produced by carefully integrating the metabolic activity of native soil bacteria, is produced through the bio-mineralization of calcite bonds, which act as natural cementation for endowing the subsurface with real cohesion and increased resistance. A principal characteristic of the project is its multi-scale approach through advanced experimentation to identify the main physical mechanisms involved in the formation of the bio-mineralized bonds and their behaviour under mechanical loading. The development of such a bio-mediated technology will lead to innovative applications in a series of engineering problems such as the restoration of weak foundations, seismic retrofitting, erosion protection, and the enhancement of heat transfer in thermo-active geo-structures. The project foresees to adopt multiple loading conditions for its laboratory characterization and ultimately pass to the large experimental scale. BIOGEOS further aims to provide new knowledge around the way we perceive materials in relation with their micro-structure by implementing state-of-the-art inspection of the material's structure in 3D space and subsequent prediction of their behaviour through numerical tools.

Project End Date: **31-OCT-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788753	**ReCaP**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. FERGAL O'BRIEN**
Host Institution: Royal College Of Surgeons In Ireland, IE

Regeneration of Articular Cartilage using Advanced Biomaterials and Printing Technology

Adult articular cartilage has a limited capacity for repair and when damaged or injured, experiences a loss of function which leads to joint degeneration and ultimately osteoarthritis. Biomaterials-based treatments have had very limited success due to the complex zonal structure of the articular joint, problems with biomaterial retention at the joint surface and achieving integration with the host tissue while also maintaining load bearing capacity. Stem cell therapies have also failed to live up to significant hype for a number of reasons including the challenges with achieving formation of stable hyaline cartilage which does not undergo hypertrophy. Building on a wealth of experience in the area, we propose a solution. ReCaP will initially overcome the problems with traditional biomaterials approaches by utilising recent advances in the area of advanced manufacturing and 3D printing to develop a 3D printed multi-layered scaffold with pore architecture, mechanical properties and bioactive composition tailored to regenerate articular cartilage, intermediate calcified cartilage and subchondral bone. Following this, and building on internationally recognised pioneering research in the applicant's lab on scaffold-mediated nanomedicine delivery, this system will be functionalised for the controlled non-viral delivery of nucleic acids (including plasmid DNA and microRNAs) to direct host stem cells to produce stable hyaline cartilage at the joint surface and encourage the rapid formation of vascularised bone in the subchondral region. A new paradigm-shifting surgical procedure will then be applied to allow this system to be anchored to the joint surface while directing host cell infiltration and tissue repair, thus promoting restoration of even large regions of the damaged joint through a joint surfacing approach. The proposed ReCaP platform is thus a paradigm shifting disruptive technology that will revolutionise the way joint injuries are treated.

Project End Date: **31-JUL-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
801809	**GEoREST**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. VICTOR VILARRASA**
Host Institution: Agencia Estatal Consejo Superior De Investigaciones Cientificas, ES

predictinG EaRthquakES induced by fluid injecTion

Fluid injection related to underground resources has become widespread, causing numerous cases of induced seismicity. If felt, induced seismicity has a negative effect on public perception and may jeopardise wellbore stability, which has led to the cancellation of several projects. Forecasting injection-induced earthquakes is a big challenge that must be overcome to deploy geo-energies to significantly reduce CO2 emissions and thus mitigate climate change and reduce related health issues. The basic conjecture is that, while initial (micro)seisms are caused by well-known mechanisms that could be predicted, subsequent activity is caused by harder to understand and, at present, unpredictable coupled thermo-hydro-mechanical-seismic (THMS) processes, which is the reason why available models fail to forecast induced seismicity. The objective of this project is to develop a novel methodology to predict and mitigate induced seismicity. We propose an interdisciplinary approach that integrates the THMS processes that occur in the subsurface as a result of fluid injection. The methodology, based on new analytical and numerical solutions, will concentrate on (1) understanding the processes that lead to induced seismicity by model testing of specific conjectures, (2) improving and extending subsurface characterization by using industrial fluid injection operations as a long-term continuous characterization methodology, so as to reduce prediction uncertainty, and (3) using the resulting understanding and site specific knowledge to predict and mitigate induced seismicity. Project developments will be tested and verified against fluid-induced seismicity at field sites that present diverse characteristics. Arguably, the successful development of this project will provide operators with concepts and tools to perform pressure management to reduce the risk of inducing seismicity to acceptable levels and thus, improve safety and reverse public perception on fluid injection activities.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802093	**ENIGMA**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. FARBOD ALIJANI**
Host Institution: Technische Universiteit Delft, NL

EXPLORING NONLINEAR DYNAMICS IN GRAPHENE NANOMECHANICAL SYSTEMS

Micro and nanomechanical systems are being adopted in billions of products, that address a wide range of sensor and actuator applications in modern technology. The advent of graphene, and the ability to fabricate single atom thick membranes, promises further device downscaling, enabling ultimate sensing capabilities that until recently seemed utopical. But, these atomically thin membranes are in essence nonlinear and exhibit nonlinear dynamic behavior at forces of only a few pN, which needs to be understood to harness their full potential.

Although the field of nonlinear dynamics dates back several centuries, its implications at the atomic scale have remained relatively unexplored. Thermal fluctuations due to Brownian motion and nanoscale forces become dominant at this scale, and when combined with graphene's exotic elasticity, give rise to phenomena that are not observed before, and cannot be explained by classical approaches. Our poor understanding of these complex features at the same time, have made characterization of graphene very challenging. An example is its bending modulus that is evaluated orders of magnitude higher than theoretical predications, by the available experimental methods.

In this project, I aim at providing full understanding of nonlinearities of these one atom thick membranes, not only to unveil the enigmatic behavior of graphene but also to improve current nanomaterial characterization methods. The distinguishing feature of my methodology is that on the one side, it will be based on atomistic simulations combined with modal order reduction techniques, to predict the complexities at the single atom level; on the other side, experimental nonlinear dynamic data will be analyzed for evaluating nonlinear effects and extracting material properties using nonlinear resonances in the MHz range. My methodology will have the potential to serve as the next generation of characterization techniques for nanomaterial science and nanomechanics communities.

Project End Date: **31-OCT-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803074	**BEBOP**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. YOHAN DAVIT**
Host Institution: Centre National De La Recherche Scientifique, FR

Bacterial biofilms in porous structures: from biomechanics to control

The key ideas motivating this project are that: 1) precise control of the properties of porous systems can be obtained by exploiting bacteria and their fantastic abilities; 2) conversely, porous media (large surface to volume ratios, complex structures) could be a major part of bacterial synthetic biology, as a scaffold for growing large quantities of microorganisms in controlled bioreactors.

The main scientific obstacle to precise control of such processes is the lack of understanding of biophysical mechanisms in complex porous structures, even in the case of single-strain biofilms. The central hypothesis of this project is that a better fundamental understanding of biofilm biomechanics and physical ecology will yield a novel theoretical basis for engineering and control.

The first scientific objective is thus to gain insight into how fluid flow, transport phenomena and biofilms interact within connected multiscale heterogeneous structures - a major scientific challenge with wide-ranging implications. To this end, we will combine microfluidic and 3D printed micro-bioreactor experiments; fluorescence and X-ray imaging; high performance computing blending CFD, individual-based models and pore network approaches.

The second scientific objective is to create the primary building blocks toward a control theory of bacteria in porous media and innovative designs of microbial bioreactors. Building upon the previous objective, we first aim to extract from the complexity of biological responses the most universal engineering principles applying to such systems. We will then design a novel porous micro-bioreactor to demonstrate how the permeability and solute residence times can be controlled in a dynamic, reversible and stable way - an initial step toward controlling reaction rates.

We envision that this will unlock a new generation of biotechnologies and novel bioreactor designs enabling translation from proof-of-concept synthetic microbiology to industrial processes.

Project End Date: **30-JUN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803082	**GLOWING**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. MARIOS KOTSONIS**
Host Institution: Technische Universiteit Delft, NL

Spatio-temporal measurement and plasma-based control of crossflow instabilities for drag reduction

Delay of laminar-turbulent flow transition on aircraft wings can potentially reduce aerodynamic drag by up to 15%, reducing emissions and fuel consumption considerably. The main cause of laminar-turbulent transition on commonly used swept wings is the development of crossflow (CF) instabilities. Despite their importance, our fundamental understanding of CF instabilities is limited due to inability of current measurement techniques to capture their complex and multi-scale spatio-temporal features. This severely limits our ability to delay CF transition, which is further impeded by the lack of simple, robust and efficient control concepts.

In this proposal I will achieve unprecedented spatio-temporal measurements of CF instabilities and develop a novel active flow control system that can successfully delay transition on swept wings. To achieve these goals, I bring forth a unique combination of cutting-edge technologies, such as tomographic particle image velocimetry, advanced plasma-based actuators and linear/non-linear stability and control theory.

Spatio-temporal volumetric velocity measurements of CF instabilities will be achieved at three important stages of their life, namely inception, growth and breakdown, providing breakthrough insights into the underlying physics of swept wing transition and turbulence production. The results will be used to postulate and validate linear and non-linear stability and control theory models and provide top benchmarks for high-fidelity CFD. The unprecedented wealth of information, enabled through these advances, will be used to design and demonstrate the first synergetic plasma-based laminar flow control system. This system will feature minimum-thickness plasma actuators, able to suppress the growth of CF instabilities and achieve and sustain considerable transition delay at high Reynolds numbers. These advances will finally enable robust and efficient laminar flow on future air transport.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803213	**HyGate**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. ALBERTO GIACOMELLO**
Host Institution: Universita Degli Studi Di Roma La Sapienza, IT

Hydrophobic Gating in nanochannels: understanding single channel mechanisms for designing better nanoscale sensors

Hydrophobic gating is the phenomenon by which the flux of ions or other molecules through biological ion channels or synthetic nanopores is hindered by the formation of nanoscale bubbles. Recent studies suggest that this is a generic mechanism for the inactivation of a plethora of ion channels, which are all characterized by a strongly hydrophobic interior. The conformation, compliance, and hydrophobicity of the nanochannels – in addition to external parameters such as electric potential, pressure, presence of gases – have a dramatic influence on the probability of opening and closing of the gate. This largely unexplored confined phase transition is known to cause low frequency noise in solid-state nanopores used for DNA sequencing and sensing, limiting their applicability. In biological channels, hydrophobic gating might conspire in determining the high selectivity towards a specific ions or molecules, a characteristic which is sought for in biosensors.
The objective of HyGate is to unravel the fundamental mechanisms of hydrophobic gating in model nanopores and biological ion channels and exploit their understanding in order to design biosensors with lower noise and higher selectivity. In order to achieve this ambitious goal, I will deploy the one-of-a-kind simulation and theoretical tools I developed to study vapor nucleation in extreme confinement, which comprises rare-event molecular dynamics and confined nucleation theory. These quantitative tools will be instrumental in designing better biosensors and nanodevices which avoid the formation of nanobubbles or exploit them to achieve exquisite species selectivity. The novel physical insights into the behavior of water in complex nanoconfined environments are expected to inspire radically innovative strategies for nanopore sensing and nanofluidic circuits and to promote a stepwise advancement in the fundamental understanding of hydrophobic gating mechanisms and their influence on bio-electrical cell response.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803419	**UniEqTURB**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. CLARA VELTE**
Host Institution: Danmarks Tekniske Universitet, DK

Universal Equilibrium and Beyond - Challenging the Richardson-Kolmogorov Paradigm

Turbulence is at a crossroads: The old, established ideas of Richardson and Kolmogorov have with accumulating evidence come under renewed scrutiny, especially in non-stationary and non-equilibrium flows. Many in the community seek new and more accurate ways to describe turbulence. This is a time of re-evaluation and opportunity!

The assumed statistical equilibrium of the smallest and intermediate scales is identified as the main cause of the potentially erroneous deductions. This problem was not previously noticed because experiments that confirmed the previous theories were all in statistical equilibrium. And those experiments and theories which disagreed were labelled ‘anomalous’, no matter how carefully performed or argued.

The proposed theory-intensive approach will therefore specifically use non-equilibrium and statistically non-stationary flows to:
1. Investigate the underlying mechanisms determining the level of dissipation
2. Quantify the resulting effects on the balance equations of central importance
3. Test the results against the established, as well as competing, theories

I will use stationary and accelerating jets well-suited for studying the non-linear interactions and quantifying departures to the assumed equilibrium and the non-stationary dissipation. The feasibility is demonstrated with preliminary results. The databases which will be established should contribute substantially to settling the long-lived ultimate question of turbulence: what are the true underlying mechanisms that set the level of dissipation.

The results will be ground breaking scientifically and economically. The impact for engineering applications is extensive, since Kolmogorov-based turbulence models are routinely used, and since developing flows constitute the rule rather than the exception in the majority of engineering applications. The potential economic consequences for e.g. transportation, climate predictions and power extraction are impossible to underestimate.

Project End Date: **31-MAR-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803553	**SIRIUS**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. TIMM KRUEGER**
Host Institution: The University Of Edinburgh, UK

Simulations for Inertial Particle Microfluidics

Cancer and bacterial infections are projected to kill 18 million people worldwide annually by 2050. Fast and reliable diagnostics are essential for early and targeted treatments. Microfluidics is at the heart of the miniaturisation of diagnostics, enabling novel portable and low-cost point-of-care devices. Inertial particle microfluidics (IPMF) is a novel and competitive method with applications in cancer cell and bacteria separation. Yet, the physics behind IPMF is not well understood, making progress slow and costly. Novel design rules are in urgent need to avoid trial-and-error experiments. I will numerically investigate the underlying physical mechanisms and develop the first predictive toolkit for engineering applications of IPMF.

In particular, I will address five ambitious challenges in SIRIUS:
1. Develop an accurate numerical model for IPMF.
2. Understand the impact of particle softness.
3. Investigate the effect of finite particle concentration.
4. Improve the currently low separation efficiency of small particles.
5. Develop a toolkit to enable simulation-driven design.

These objectives are feasible through novel numerical approaches based on the lattice-Boltzmann method and state-of-the-art high-performance computing. SIRIUS will pursue an innovative simulation campaign, validated with existing experimental data, to generate both physical insight and scaling laws for simulation-driven design.

For the first time, SIRIUS will produce robust numerical methods for IPMF. My pioneering research will uncover the physics behind particle separation and culminate in a design toolkit for IPMF engineers. SIRIUS will fill a critical gap and open up an entirely new research field: “Simulations for inertial particle microfluidics”. Results of SIRIUS will be published as open-source codes, open-access articles, and open data. This will ultimately enable faster, less costly and more innovative research in the field of microfluidics for diagnostics.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803669	**SUPERCOOL**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. JAKA TUŠEK**
Host Institution: Univerza V Ljubljani, SI

Superelastic Porous Structures for Efficient Elastocaloric Cooling

Cooling, refrigeration and air-conditioning are crucial for our modern society. In the last decade, the global demands for cooling are growing exponentially. The standard refrigeration technology, based on vapour compression, is old, inefficient and environmentally harmful. In the SUPERCOOL project we will exploit the potential of elastocaloric cooling, probably the most promising solid-state refrigeration technology, which utilizes the latent heat associated with the martensitic transformation in superelastic shape-memory alloys. We have already demonstrated a novel concept of utilizing the elastocaloric effect (eCE) by introducing a superelastic porous structure in an elastocaloric regenerative thermodynamic cycle. Our preliminary results, recently published in Nature Energy, show the tremendous potential of such a system. However, two fundamental challenges remain. First, we need to create a geometry of the superelastic porous structure (elastocaloric regenerator) to ensure sufficient fatigue life, a large eCE and rapid heat transfer. Second, we must have a driver mechanism that can effectively utilize the work released during the unloading of the elastocaloric regenerator. To succeed I am proposing a unique approach to design advanced elastocaloric regenerators with complex structures together with a driver mechanism with the force-recovery principle. We will employ a systematic characterization and bottom-up linking of all three crucial aspects of the elastocaloric regenerator, i.e., the thermo-hydraulic properties, the stability and the structural fatigue, together with a new solution for force recovery in effective drivers. Based on these theoretical, numerical and experimental results we will combine both key elements of our novel elastocaloric concept into a prototype device, which could be the first major breakthrough in cooling technologies for 100 years, providing greater efficiency and reduced levels of pollution, by applying a solid-state refrigerant.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
805411	**CapBed**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. ROGÉRIO PIRRACO**
Host Institution: Universidade Do Minho, PT

Engineered Capillary Beds for Successful Prevascularization of Tissue Engineering Constructs

The demand for donated organs vastly outnumbers the supply, leading each year to the death of thousands of people and the suffering of millions more. Engineered tissues and organs following Tissue Engineering approaches are a possible solution to this problem. However, a prevascularization solution to irrigate complex engineered tissues and assure their survival after transplantation is currently elusive. In the human body, complex organs and tissues irrigation is achieved by a network of blood vessels termed capillary bed which suggests such a structure is needed in engineered tissues. Previous approaches to engineer capillary beds reached different levels of success but none yielded a fully functional one due to the inability in simultaneously addressing key elements such as correct angiogenic cell populations, a suitable matrix and dynamic conditions that mimic blood flow.
CapBed aims at proposing a new technology to fabricate in vitro capillary beds that include a vascular axis that can be anastomosed with a patient circulation. Such capillary beds could be used as prime tools to prevascularize in vitro engineered tissues and provide fast perfusion of those after transplantation to a patient. Cutting edge techniques will be for the first time integrated in a disruptive approach to address the requirements listed above. Angiogenic cell sheets of human Adipose-derived Stromal Vascular fraction cells will provide the cell populations that integrate the capillaries and manage its intricate formation, as well as the collagen required to build the matrix that will hold the capillary beds. Innovative fabrication technologies such as 3D printing and laser photoablation will be used for the fabrication of the micropatterned matrix that will allow fluid flow through microfluidics. The resulting functional capillary beds can be used with virtually every tissue engineering strategy rendering the proposed strategy with massive economical, scientific and medical potential

Project End Date: **31-OCT-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
816313	**PAIDEIA**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. FRANCESCO SCOTOGNELLA**
Host Institution: Politecnico Di Milano, IT

PlAsmon InduceD hot Electron extraction with doped semiconductors for Infrared solAr energy

Earth is inhabited by an energy hungry human society. The Sun, with a global radiation at the ground level of more than 1 kW/m^2, is our largest source of energy. However, 45% of the total radiation is in the near infrared (NIR) and is not absorbed by most photovoltaic materials.
PAIDEIA focuses on two main advantages aiming to enhance the capacity of solar energy conversion:
i) plasmon assisted hot carriers extraction from NIR plasmonic materials;
ii) linewidth narrowing in plasmonic nanoparticle films that enhances the lifetime of hot carriers and, thus, boosts the efficiency of light driven carrier extraction.
Instead of metals, which operate mostly in the visible region, we will make use of doped semiconductor nanocrystals (DSNCs) as hot electron extraction materials possessing a plasmonic response tunable in the range 800 nm – 4000 nm. Three different innovative architectures will be used for improved device performance: i) improved Schottky junctions (DSNC/wide band gap semiconductor nanocomposites); ii) ultrathin devices (DSNCs/2D quantum materials); iii) maximized interface DSNC/semiconductor bulk hetero-Schottky junctions.
By combining both concepts in advanced architectures we aim to produce a solar cell device that functions in the NIR with efficiencies of up to 10%. A tandem solar cell that combines the conventional power conversion efficiency, up to ~1100 nm, of a commercial Si solar cell (~20%) with the new PAIDEIA based device is expected to reach a total power conversion efficiency of 30% by extending the width of wavelengths that are converted to the full spectral range delivered by the Sun. PAIDEIA has a deeply fundamental character impacting several areas in the field of nanophysics, nanochemistry and materials processing and, at the same time, having a high impact on the study of solar energy conversion. Finally, PAIDEIA will provide answers to the fundamental questions regarding the physical behaviour of plasmonic/semiconductor interfaces.

Project End Date: **31-MAR-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
817190	**CITRES**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. MARCO DELUCA**
Host Institution: Materials Center Leoben Forschung Gmbh, AT

Chemistry and interface tailored lead-free relaxor thin films for energy storage capacitors

The goal of CITRES is to provide new energy storage devices with high power and energy density by developing novel multilayer ceramic capacitors (MLCCs) based on relaxor thin films (RTF).

Energy storage units for energy autonomous sensor systems for the Internet of Things (IoT) must possess high power and energy density to allow quick charge/recharge and long-time energy supply. Current energy storage devices cannot meet those demands: Batteries have large capacity but long charging/discharging times due to slow chemical reactions and ion diffusion. Ceramic dielectric capacitors – being based on ionic and electronic polarisation mechanisms – can deliver and take up power quickly, but store much less energy due to low dielectric breakdown strength (DBS), high losses, and leakage currents.

RTF are ideal candidates: (i) Thin film processing allows obtaining low porosity and defects, thus enhancing the DBS; (ii) slim polarisation hysteresis loops, intrinsic to relaxors, allow reducing the losses. High energy density can be achieved in RTF by maximising the polarisation and minimising the leakage currents. Both aspects are controlled by the amount, type and local distribution of chemical substituents in the RTF lattice, whereas the latter depends also on the chemistry of the electrode metal.

In CITRES, we will identify the influence of substituents on electric polarisation from atomic to macroscopic scale by combining multiscale atomistic modelling with advanced structural, chemical and electrical characterizations on several length scales both in the RTF bulk and at interfaces with various electrodes. This will allow for the first time the design of energy storage properties of RTF by chemical substitution and electrode selection.

The ground-breaking nature of CITRES resides in the design and realisation of RTF-based dielectric MLCCs with better energy storage performances than supercapacitors and batteries, thus enabling energy autonomy for IoT sensor systems.

Project End Date: **31-MAR-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818607	**OPTIMA**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. KEVIN VAN GEEM**
Host Institution: Universiteit Gent, BE

PrOcess intensification and innovation in olefin ProducTIon by Multiscale Analysis and design

New manufacturing techniques such as 3D printing have the potential to drastically transform the chemical industry. Novel, complex, integrated reactor designs can now be created, that will allow to unlock alternative chemical routes, such as for methane activation. Driven by process intensification and the power of high performance computing, this project will enhance heat and mass transfer in advanced chemical reactors by multiscale modelling and experimentation. OPTIMA aims to:

(1) develop in silico novel 3D reactor technologies and concepts with significantly improved selectivity and heat transfer by the use of additive manufacturing;
(2) generate new fundamental understanding of kinetics, heat transfer and mass transfer by using advanced measuring techniques for processes of both current and future importance;
(3) demonstrate the practical applicability of an open-source multiscale large eddy simulation (LES) platform in combination with finite rate chemistry for turbulent reacting flows;
(4) transform the chemical industry by valorising methane and converting it to a platform molecule through oxidative coupling of methane.

OPTIMA will focus on two olefin production processes of industrial and social importance in Europe, the exothermal oxidative coupling of methane and the endothermic steam cracking, demonstrating the universality of the proposed new paradigm. Starting from fundamental experiments and kinetic modelling (WP1), detailed chemistry will be implemented in an open-source LES multiscale modelling framework (WP2) generating in silico novel 3D reactor technologies with significantly improved selectivity (WP3). The power of the approach will be ultimately demonstrated in a novel, 3D integrated reactor, in which the studied exothermic and endothermic processes are cleverly combined (WP4).

OPTIMA will pave the way for designing the 3D reactors of tomorrow and promote the new techniques and tools that will be driving innovation in the next decades.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818941	**LINCHPIN**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. DOROTA KOZIEJ**
Host Institution: Universitaet Hamburg, DE

A platform to LINk between CHemistry and PhysIcs of colloidal Nanomaterials

The recent successful applications of photon-in-photon-out spectroscopy in condense matter physics, bio-inorganic chemistry and catalysis build upon the high brilliance of modern X-ray sources and realization of dedicated emission spectrometers. However, probing with highly energetic X-ray beam puts many constraints on the sample environment and requires probing faster than the X-ray radiation damage occurs. This strongly limits the applicability of the method in studying the chemistry of colloidal nanomaterials.

The objective of LINCHPIN is to investigate the emergence of electronic structure of nanomaterials in solution by hard X-ray photon-in-photon-out spectroscopy. To reach this very ambitious target, LINCHPIN consolidates an interdisciplinary engineering, spectroscopic and chemically driven effort. My group aim for developing micro-reactors, which will enable new fundamental insights related to the chemistry and electronic properties of the transition metal nitrides and sulfides.

The main scientific goals are to study at the relevant time scales the kinetics and dynamics of: (a) short-lived molecular intermediate states and pre-nucleation clusters, (b) metal-sulfur and metal-nitrogen bond formation and their condensation in solution, (c) electronic structure changes during growth of nanostructures, and (d) concurrently interdependent electronic and chemical processes. The ultimate goal is to have a handle on designing and selecting, still in the reaction solution, the nanomaterials with the most promising electronic properties relevant for energy conversion and storage. Moreover, the proposed micro-reactors along with experimental spectroscopic protocols and the concurrent fundamental knowledge create a paradigm shift for in situ time-resolved experiments with an impact in many other fields ranging from catalysis, sustainable flow chemistry to biomedical applications.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
832460	**ElectroThermo**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. GEORGIOS KONTOGEORGIS**
Host Institution: Danmarks Tekniske Universitet, DK

New Paradigm in Electrolyte Thermodynamics

The project's overall target is to arrive at a fundamental understanding of electrolyte thermodynamics and thus enable the engineering of a new generation of useful, physically sound models for electrolyte solutions. These models should be general and applicable to a very wide range of conditions so that they can be potentially used for a wide range of applications.

Electrolyte solutions are present almost anywhere and find numerous applications in physical sciences including chemistry, geology, material science, medicine, biochemistry and physiology as well as in many engineering fields especially chemical & biochemical, electrical and petroleum engineering. In all these applications the thermodynamics plays a crucial role over wide ranges of temperature, pressure and composition. As the subject is important, a relatively large body of knowledge has been accumulated with lots of data and models. However, disappointingly the state-of-the art thermodynamic models used today in engineering practice are semi-empirical and require numerous experimental data. They lack generality and have not enhanced our understanding of electrolyte thermodynamics. Going beyond the current state of the art, we will create the scientific foundation for studying, at their extremes, both "primitive" and "non-primitive" approaches for electrolyte solutions and identify strengths and limitations. The project is based on the PI's many years of experience in thermodynamics. The ambition is to make new advances to clarify major questions and misunderstandings in electrolyte thermodynamics, some remaining for over 100 years, which currently prevent real progress from being made, and create a new paradigm which will ultimately pave the way for the development of new engineering models for electrolyte solutions. This is a risky, ambitious and crucial task, but a successful completion will have significant benefits in many industrial sectors as well as in environmental studies and biotechnology.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833123	**STAND4HERITAGE**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. PAULO B. LOURENCO**
Host Institution: Universidade Do Minho, PT

New STANDards for seismic assessment of built cultural HERITAGE

STAND4HERITAGE ambitiously engages in introducing new standards for safeguarding built cultural heritage for the next generations, which is a major societal demand. Due to its large diversity, the accurate description of the structural behaviour of heritage buildings is still an open issue, particularly when subjected to earthquake ground motions. Among the most frequently observed seismic damage mechanisms in these buildings, the out-of-plane of masonry walls is acknowledged as the main cause for building loss and injuries to people. There are many unresolved challenges to effectively assess the out-of-plane seismic behaviour of masonry structures. First, it is necessary to understand less known phenomena in masonry dynamics, which largely influence the out-of-plane behaviour and capacity of heritage buildings. A recent blind exercise to predict the capacity of a benchmark masonry structure to resist a dynamic excitation demonstrated that, although advanced simulation tools are available, leading international researchers are still unable to consistently provide a collapse estimate. STAND4HERITAGE will address the aspects for successful development of approaches for seismic response prediction of masonry structures, integrating the necessary stages for out-of-plane assessment. It will generate novel: integrated stochastic-based models to consider the seismic signal in the dynamic response and capacity; datasets of the dynamic response evaluated after an extensive shake table testing program; numerical approaches for simulation of the out-of-plane seismic behaviour; an integrated analytical approach for out-of-plane seismic assessment of heritage buildings. STAND4HERITAGE objectives are in line with the UN 2030 agenda for sustainable cities and communities. The project will be founded on the experience of the PI in the topic, and on the interdisciplinary expertise of his team in facing the challenges to provide optimal intervention solutions for heritage buildings.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833125	**HIGHWAVE**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. FREDERIC DIAS**
Host Institution: University College Dublin, National University Of Ireland, Dublin, IE

Breaking of highly energetic waves

HIGHWAVE is an interdisciplinary project at the frontiers of coastal/ocean engineering, earth system science, statistics and fluid mechanics that will explore fundamental open questions in wave breaking. Why do waves break, how do they dissipate energy and why is this important? A central element of the work builds on recent international developments in the field of wave breaking and wave run-up led by the PI that have provided the first universal criterion for predicting the onset of breaking of water waves in uniform water depths from deep to intermediate. This work has also shown that the run-up of nonlinear waves impinging on a vertical wall can exceed up to 12 times the far-field amplitude of the incoming waves. These results have now opened up the possibility for more accurate operational wave models. They have practical and economic benefits in determining structural loads on ships and coastal/offshore infrastructure, evaluating seabed response to extreme waves, and optimizing operational strategies for maritime and marine renewable energy enterprises. This is a tremendous advance comparable to the introduction of wave prediction during World War II, and the PI aims to be at the forefront of this research effort to take research in wave breaking into fundamentally new directions. The objectives of the project are: (i) to develop an innovative approach to include accurate wave breaking physics into coupled sea state and ocean weather forecasting models; (ii) to obtain improved criteria for the design of ships and coastal/offshore infrastructure; (iii) to quantify erosion by powerful breaking waves, and (iv) to develop new concepts in wave measurement with improved characterization of wave breaking using real-time instrumentation. This highly interdisciplinary project will involve an ambitious and unconventional combination of computational simulation/theory, laboratory experiments, and field measurements of sea waves, closely informed by application needs.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834238	**C0PEP0D**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. CHRISTOPHE ELOY**
Host Institution: Ecole Centrale De Marseille Egim, FR

Life and death of a virtual copepod in turbulence

Life is tough for planktonic copepods, constantly washed by turbulent flows. Yet, these millimetric crustaceans dominate the oceans in numbers. What have made them so successful? Copepod antennae are covered with hydrodynamic and chemical sensing hairs that allow copepods to detect preys, predators and mates, although they are blind. How do copepods process this sensing information? How do they extract a meaningful signal from turbulence noise? Today, we do not know.

C0PEP0D hypothesises that reinforcement learning tools can decipher how copepod process hydrodynamic and chemical sensing. Copepods face a problem similar to speech recognition or object detection, two common applications of reinforcement learning. However, copepods only have 1000 neurons, much less than in most artificial neural networks. To approach the simple brain of copepods, we will use Darwinian evolution together with reinforcement learning, with the goal of finding minimal neural networks able to learn.

If we are to build a learning virtual copepod, challenging problems are ahead: we need fast methods to simulate turbulence and animal-flow interactions, new models of hydrodynamic signalling at finite Reynolds number, innovative reinforcement learning algorithms that embrace evolution and experiments with real copepods in turbulence. With these theoretical, numerical and experimental tools, we will address three questions:

Q1: Mating. How do male copepods follow the pheromone trail left by females?

Q2: Finding. How do copepods use hydrodynamic signals to ‘see’?

Q3: Feeding. What are the best feeding strategies in turbulent flow?

C0PEP0D will decipher how copepods process sensing information, but not only that. Because evolution is explicitly considered, it will offer a new perspective on marine ecology and evolution that could inspire artificial sensors. The evolutionary approach of reinforcement learning also offers a promising tool to tackle complex problems in biology and engineering.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834742	**ATOP**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. ZHIPEI SUN**
Host Institution: Aalto-Korkeakoulusaatio, FI

Atomically-engineered nonlinear photonics with two-dimensional layered material superlattices

The project aims at introducing a paradigm shift in the development of nonlinear photonics with atomically-engineered two-dimensional (2D) van der Waals superlattices (2DSs). Monolayer 2D materials have large optical nonlinear susceptibilities, a few orders of magnitude larger than typical traditional bulk materials. However, nonlinear frequency conversion efficiency of monolayer 2D materials is typically weak mainly due to their extremely short interaction length (~atomic scale) and relatively large absorption coefficient (e.g.,>5×10^7 m^-1 in the visible range for graphene and MoS2 after thickness normalization). In this context, I will construct atomically-engineered heterojunctions based 2DSs to significantly enhance the nonlinear optical responses of 2D materials by coherently increasing light-matter interaction length and efficiently creating fundamentally new physical properties (e.g., reducing optical loss and increasing nonlinear susceptibilities).
The concrete project objectives are to theoretically calculate, experimentally fabricate and study optical nonlinearities of 2DSs for next-generation nonlinear photonics at the nanoscale. More specifically, I will use 2DSs as new building blocks to develop three of the most disruptive nonlinear photonic devices: (1) on-chip optical parametric generation sources; (2) broadband Terahertz sources; (3) high-purity photon-pair emitters. These devices will lead to a breakthrough technology to enable highly-integrated, high-efficient and wideband lab-on-chip photonic systems with unprecedented performance in system size, power consumption, flexibility and reliability, ideally fitting numerous growing and emerging applications, e.g. metrology, portable sensing/imaging, and quantum-communications. Based on my proven track record and my pioneering work on 2D materials based photonics and optoelectronics, I believe I will accomplish this ambitious frontier research program with a strong interdisciplinary nature.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
848590	**MULTIMAG**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. PAAVO RASILO**
Host Institution: Tampereen Korkeakoulusaatio Sr, FI

Multiscale Magnetic Models for Emerging Energy Conversion Applications

About 30 % of all the electrical power generated passes through a power electronic converter, and the proportion is expected to rise to 80 % in 10-15 years. The amount of electricity annually wasted due to the losses in such systems in the EU corresponds to at least billions of euros. A major part of these losses arises in passive magnetic components, such as inductors and transformers, which are also the largest and heaviest components of a power electronic device. The physical phenomena related to the power losses in the magnetic cores of these components are not properly understood at the moment. In addition, the engineering community is currently lacking efficient modeling tools for analyzing the losses in the windings of such components at high frequencies.

Improvement of high-frequency magnetic components would require accurate understanding of the power loss mechanisms. However, the device-level losses are affected by physical effects taking place in the microscopic grain and domain structures and very thin conductors, which are often subject to geometrical uncertainties. Accurate geometrical models cannot be used for analyzing the devices due to the impossibly large computational burden.

In MULTIMAG, we will address these challenges by establishing a set of new multiscale numerical modeling tools, which will provide insight into the origin of the power losses and make it possible to perform statistical analysis of the electromagnetic behaviour of such components. The application potential of these new numerical tools will be demonstrated by designing working prototypes of emerging power electronic devices, such as a solid-state transformer and a wireless power transfer system. We will also develop inverse problem approaches for identifying the models from available catalog data, lowering the threshold for adopting the models into use.

As the outcome, new means for improving the energy efficiency and power density of power electronic devices will arise.

Project End Date: **28-FEB-25**

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Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
850437	**PRE-ECO**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. ALFONSO PAGANI**
Host Institution: Politecnico Di Torino, IT

A new paradigm to re-engineering printed composites

Additive manufacturing and Automated Fibre Placement (AFP) processes brought to the emergence of a new class of fibre-reinforced materials; namely, the Variable Angle Tow (VAT) composites. AFP machines allow the fibres to be relaxed along curvilinear paths within the lamina, thus implying a point-wise variation of the material properties. In theory, the designer can conceive VAT structures with unexplored capabilities and tailor materials with optimized stiffness-to-weight ratios. In practise, steering brittle fibres, generally made of glass or carbon, is not trivial. Printing must be performed at the right combination of temperature, velocity, curvature radii and pressure to preserve the integrity of fibres. The lack of information on how the effect of these parameters propagates through the scales, from fibres to the final structure, represents the missing piece in the puzzle of VAT composites, which today are either costly or difficult to design because affected by unpredictable failure mechanisms and unwanted defects (gaps, overlaps, and fibre kinking).

This proposal is for an exploratory study into a radical new approach to the problem of design, manufacturing and analysis of tow-steered printed composite materials. The program will act as a pre-echo, a precursor, to: 1) implement global/local models for the simulation and analysis of VATs with unprecedented accuracy from fibre-matrix to component scales; 2) develop a (hybrid) metamodeling platform based on machine learning for defect sensitivity and optimization; and 3) set new rules and best-practices to design for manufacturing. A 5-year, highly inter-disciplinary programme is planned, encompassing structural mechanics, numerical calculus, 3D printing and AFP, measurements and testing of advanced composites, data science and artificial intelligence, and constrained optimization problems to finally fill the gap between the design and the digital manufacturing chain of advanced printed materials.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851272	**NanoMMES**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. QILEI SONG**
Host Institution: Imperial College Of Science, Technology And Medicine, UK

Design and NanoEngineering of Microporous Membranes for Energy Storage

With the rapid development of renewable energy such as solar and wind power, energy storage technologies are in urgent need to integrate the low carbon energy into the power grid. Redox flow batteries are promising for grid scale energy storage owing to their scalable storage capacity, decoupled power and energy, long-term cycle performance, and quick response time. Membrane separators play a crucial role in flow batteries by selectively transporting ions while preventing the crossover of redox-active materials. Commercial Nafion membranes are being widely used for flow batteries, however, their high costs limit the large-scale application of this promising technology. Next-generation low-cost membranes with high ionic conductivity and selectivity, and durability are desirable for flow battery energy storage. This proposal NanoMMES aims at designing and nanoengineering low-cost, high-performance, ion-selective microporous membranes for redox flow battery energy storage applications. The objectives of NanoMMES will be achieved through curiosity-driven research into (1) designing the structures of microporous polymers to precisely tune the pore size and ion-conducting functionality required for batteries with different redox chemistries; (2) processing and nanoengineering polymers into highly conductive and selective membranes, and understanding the mechanisms of transport of ions and redox materials; (3) combining the designer membranes with redox flow battery chemistries to achieve efficient and stable energy storage. NanoMMES will undertake interdisciplinary research combining the molecular design of microporous polymers, membrane science and engineering, and redox flow battery chemistry and technology. The ultimate goal of the project is to generate design principles for next-generation ion-selective membranes that will have broad implications on advanced batteries for energy storage, helping the EU develop renewable energy and reduce greenhouse gas emissions.

Project End Date: **31-OCT-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851630	**BuBble Gun**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. DAVID FERNANDEZ RIVAS**
Host Institution: Universiteit Twente, NL

Penetrating microjets in soft substrates: towards controlled needle-free injections

The needle-free delivery of liquid jets into soft and heterogeneous substrates, e.g. human tissue, has been hindered by (1) the need to reach specific penetration depths with energy efficient means, (2) the break-up of jets that impedes control over the dose delivery, and (3) liquid splash-back after impacting the substrate that cause cross-contamination between injections. BuBble Gun is aimed at overcoming these challenges. My team and I have recently uncovered new operational regimes of cavitation with continuous-wave lasers. My next goal is to study the energy partition between the creation of bubbles, the formation of liquid jets, and the penetration of these jets into soft substrates. Fundamental insights on energy partitioning will then be applied to achieve major breakthroughs in jet injection, by (1) controlling cavitation within microfluidic confinement, (2) tuning the rheology of jets emerging from confined cavitation, and (3) deriving the relationships between fluid dynamics and material properties governing jet injection into soft substrates. I expect to advance the knowledge at the intersection of microfluidics, physics, and bioengineering, to enable unprecedented control over cavitation, jetting, and injection phenomena. We will develop a portable energy- efficient injection platform by using ultra-high-speed imaging, and quantifying injections with experimental resolutions below the microsecond and micrometer scales. The rheological properties of the jets will be tuned with biocompatible additives to ensure cohesion, before injecting them into in-vitro targets and ex-vivo skin. Numerical models will assist untangling the influence of microfluidic configuration and material properties on the injection outcomes. The ultimate result will be the predictable, reproducible, and efficient injection of liquids that will enable a wide-range of technologies, such as additive manufacturing, coating modifications, the delivery of drugs and vaccinations.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851794	**NANOLED**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. FRANCESCO DI STASIO**
Host Institution: Fondazione Istituto Italiano Di Tecnologia, IT

Toward single colloidal nanocrystal light-emitting diodes

Nanomaterials are a promising technology that includes a variety of applications ranging from electronics to medicine. Within the family of nanomaterials, colloidal semiconductor nanocrystal (NCs) are among the most investigated, thanks to their desirable optoelectronic properties.
Up until now, NCs have been employed in light-emitting diodes (LEDs) and lasers of relatively large size (devices of at least few hundred microns in area), therefore exploiting the properties of the ensemble (i.e., a NC film). LEDs based on ensemble of NCs show good performance in terms of efficiency and luminance but their applicability is still limited to standard consumer electronics products such as displays and illumination. Interestingly, thanks to quantum confinement a single isolated NC displays single photon emission, a desirable property for application in quantum technologies. Such property has been studied in detail using optical excitation. Yet, the challenge is to exploit single photon emission from a NC under electrical excitation but this requires the development of complex fabrication tools and methods for device preparation.
NANOLED aims at developing light-emitting diodes based on individual colloidal NCs, thus paving the way to novel electrically driven single-photon sources with small footprint that are embeddable in photonic quantum networks. Further development of quantum technologies requires the investigation of devices based on novel materials for single photon generation.
The project identifies 3 objectives to reach the final goal of fabricating a light-emitting diode based on a single nanocrystal: i) Identification and synthesis of semiconductor NCs with the necessary properties. ii) Development of methods for precise spatial positioning of a single semiconductor NC within electrodes able to inject a current into it; iii) Study of the electroluminescence of a single NC and investigation of its applicability toward single-photon and classical light sources.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851929	**3DScavengers**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. ANA ISABEL BORRAS MARTOS**
Host Institution: Agencia Estatal Consejo Superior De Investigaciones Cientificas, ES

Three-dimensional nanoscale design for the all-in-one solution to environmental multisource energy scavenging

Imagine a technology for powering your smart devices by recovering energy from lights in your office, the random movements of your body while reading these lines or from small changes in temperature when you breathe or go out for a walk. This very technology will provide energy for wireless sensor networks monitoring the air in your city or the structural stability of buildings and large constructions remotely and sustainably, avoiding battery recharging or even replacing them. These are the challenges in micro energy harvesting from (local) ambient sources.

Kinetic, thermal and solar energies are ubiquitous at our surroundings under diverse forms, but their relatively low intensity and intermittent availability limit their potential recovery by microscale devices. These restrictions call for multi-source energy harvesters working under two principles: 1) combining different single-source harvesters in one device, or 2) using multifunctional materials capable of simultaneously converting various energy sources into electricity. In 1), efficiency per unit volume can decrease compared to the individual counterparts; in 2), materials as semiconductors, polymeric and oxide ferroelectrics and hybrid perovskites may act as multisource harvesters but huge advances are required to optimize their functionalities and sustainable fabrication at large scale.

I propose to fill the gap between these approaches offering an all-in-one solution to multisource energy scavenging, based on the nanoscale design of multifunctional three-dimensional materials. The demonstration of an industrially scalable one-reactor plasma/vacuum method will be crucial to integrate hybrid-scavenging components and to provide 3DScavengers materials with tailored microstructure-enhanced performance.

My ultimate goal is to build nanoarchitectures for simultaneous and enhanced individual scavenging applying photovoltaic, piezo- and pyro-electric effects, minimizing the environmental cost of their synthesis

Project End Date: **28-FEB-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852065	**3DPartForm**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. JULIAN THIELE**
Host Institution: Leibniz-Institut Fur Polymerforschung Dresden Ev, PL

3D-printing of PARTiculate FORMulations utilizing polymer microparticle-based voxels

Topological complexity, multifunctionality and stimuli responsiveness in polymer materials is conventionally achieved by merging individual technological solutions, which limits material combinations and their interplay. This proposal aims at establishing a radically new approach for polymer material design. Here, functionality is already embedded at the building block level to emerge into larger scales. The exact methodology relies on polymer microparticles, which will be assembled into hierarchical, reprogrammable and adaptive materials by additive manufacturing.

To reach such polymer systems, which clearly gostructural and functional complexity in material design is conventionally achieved by combining individual technological solutions which leads to subpar size, and limitations concerning both material combinations and their interplay. We propose a design concept based on 3D printing to assemble predefined material voxels with any arbitrary geometry, function and responsiveness into hierarchical materials. With that, freely reprogrammable, adaptive systems will be realized going far beyond existing classes of functional materials.

This proposal aims at establishing a radically different approach for polymer material design by additive manufacturing. The methodology relies on formulations based on polymer microparticles. These serve as voxel-like building blocks, which will be assembled into hierarchical structures with micrometer precision. Most importantly, each microgel voxel will not only exhibit a defined set of mechanical and physicochemical properties, but its position within the resulting material will be defined individually. With this innovative technology, we target hierarchical assemblies and polymer materials, respectively that allow for spatiotemporal manipulation of light (anisotropic optical materials in information technology), electric current (sensors), and (bio-)chemical reagents (bio-reactors) at an unprecedented level of system integration.

Project End Date: **31-MAR-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852560	**SYNBIO.ECM**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. FRANCESCO PASQUALINI**
Host Institution: Universita Degli Studi Di Pavia, IT

SYNBIO.ECM: Designer extracellular matrices to program healthy and diseased cardiac morphogenesis

To meet medical needs worldwide, tissue engineering must move from successful pre/clinical products towards an effective process to meet Worldwide medical needs, but this is challenging since a quantitative design framework has not emerged, yet. Synthetic biology (SYNBIO) was the solution that genetic engineers found to the same problem: “Despite tremendous individual successes in genetic engineering and biotechnology […], why is the engineering of useful synthetic biological systems still an expensive, unreliable and ad hoc research process?” asked Dr. Endy in a 2005 letter to Nature. The SYNBIO solution included: i) libraries of DNA parts with well-characterized effect on cells; ii) tools to computationally design system-level assemblies, or designer-DNA; and, iii) bottom-up engineering of cell functions using progressively more complex designer-DNA. Effectively, SYNBIO introduced a computer-aided design and manufacturing (CAD/M) platform that transformed the process of engineering cells. However, since inputs from the extracellular matrix (ECM) have largely been ignored, progress towards programmable tissue-level behavior have been more modest. Here, we will build on my experience with computational and experimental models in cardiac tissue engineering to develop a CAD/M framework for engineering cardiac tissues with computationally predictable properties, or designer-ECM. To characterize ECM-cell interactions, we will use traction force and super-resolution microscopy with fluorescence in-situ sequencing. To model multiscale ECM-cell interactions, we will use ordinary differential equations and subcellular element models. Finally, we will leverage ECM parts and human induced pluripotent stem cells to bioprint designer-ECM that recapitulate three phases of heart development: trabeculation, compaction, and maturation.
With synthetic matrix biology (SYNBIO.ECM), we will develop a CAD/M-based process and a new class of products for cardiac
tissue engineering.

Project End Date: **30-JUN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852722	**CREATE**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. MONICA MORALES-MASIS**
Host Institution: Universiteit Twente, NL

Crafting Complex Hybrid Materials for Sustainable Energy Conversion

With an unprecedented rise in solar cell efficiencies and ease of fabrication, hybrid lead halide perovskites (PbHP) have gained worldwide popularity. However, these materials still rely on the use of toxic Pb and lack of long-term stability. Moreover, distracted by a race for higher conversion efficiencies, the development of in-vacuum deposition techniques to reproducibly and controllably grow these hybrid films has been highly overlooked. This is now the main hurdle for the full exploration of Pb-free and stable hybrid halides, which might not be as defect tolerant or easily produced by solution process as PbHP. Therefore, a revolutionary method allowing the discovery of new sustainable complex hybrid materials is now, more than ever, of paramount importance. Here I describe a completely new approach that allows stoichiometric and layer-by-layer in-vacuum deposition of wide families of organic-inorganic materials, and their mixture in any pre-determined ratio. To overcome the specific challenges of hybrid film growth (incompatible volatility and solubility) I propose Pulsed Dual-Laser Deposition (PDLD) to decouple the deposition of the inorganic and organic sources with two distinct laser sources, a high energy (UV) and a low energy (IR), all in one vacuum system. Only this decoupling will allow the control and versatility to bridge the hybrid materials discovery gap and to tackle open scientific questions regarding the interplay between the organic and inorganic components, defect nature and their influence on optical properties, carrier scattering and recombination phenomena. Combining these fundamental insights with controlled growth, will enable the design of a new generation of stable and non-toxic hybrid films. My extensive experience in in-vacuum materials synthesis for solar cells, supported by the unique PLD expertise at the host institution will enable a leap in the discovery and understanding of hybrid materials for solar energy conversion and beyond.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852751	**NanoMMs**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. MAKSYM YAREMA**
Host Institution: Eidgenoessische Technische Hochschule Zurich, CH

Solution-Based Engineering of Nanodimensional Phase-Change Materials and Memory Devices

Phase-change memory (PCM) is a recently-commercialized next-generation memory storage technology that provides a sustainable solution to exponentially-growing memory storage demands of modern society. It is based on resistively switched structural changes of memory cell upon local crystallization and melting phase transitions, resulting in amorphous or crystalline atomic structures with distinctly different “0” and “1” resistance states. PCM is faster and more durable than state-of-the-art non-volatile memory devices like silicon-based solid-state drives (SSD), and it can furthermore be scaled in all three dimensions. However, there are open challenges for PCM technology, such as large power consumption and high price of PCM devices, which stem from large dimensions of memory cells, complex fabrication process, and from use of material-inefficient sputtering and etching fabrication steps for the expensive PCM layer.

This proposal addresses the open challenges and enables further development of PCM technology by applying solution-based engineering. Our goals are (i) to develop robust synthetic approaches for PCM materials, such as ternary tellurides and antimony-rich compositions, in the form of colloidal nanoparticles and molecular ink precursors; (ii) to thoroughly study how PCM properties change at the nanoscale as a function of size, thickness, and composition; and (iii) to employ these phase-change nanomaterials in solution-processed PCM arrays to build new, ultrasmall PCM configurations as well as multilayer PCM cells and to reduce their price and power consumption.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
863808	**PARTIFACE**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. KIRSI MIKKONEN**
Host Institution: Helsingin Yliopisto, FI

Green Route to Wood-Derived Janus Particles for Stabilized Interfaces

Emulsions are elemental to many aspects of every-day life, from food to pharmaceuticals. However, today's emulsion science faces a grand challenge in developing stabilizers with outstanding functionality in a sustainable manner. To enable society's transformation from oil-based economy to bioeconomy, there is an urgent need to develop sophisticated biocompatible materials, such as stabilizers of food and non-food emulsions, from biomass-derived precursors through sustainable conversion routes. Current bio-based stabilizers are poorly defined and not as efficient as the synthetic ones, primarily because key technologies to construct sophisticated hierarchical structures from abundant biopolymers are lacking. I will use my expertise on wood biomass and emulsion stabilizer research to develop a novel approach for asymmetric, bi-facial "Janus" nanoparticles from two of the most abundant, but underused biopolymers: lignin and hemicelluloses. I will develop a green conversion route using enzymatic crosslinking to build a novel concept: tailored wood-based Janus particles with superior capacity to stabilize emulsion interfaces. I will further tailor the particles to control their cooling rate through reversible bond formation, which will revolutionize the materials science. To achieve this ambitious goal, it is crucial to carefully characterize the particles and formed interfaces. I will develop a novel method to characterize real emulsion systems with high precision, which existing methods cannot achieve. PARTIFACE will establish a green route to sophisticated hierarchical architectures—bi-facial Janus-particle-stabilized interfaces—and thermal control systems utilizing abundant bioresources. The project will lead to a breakthrough in colloid and interface science and contribute to more sustainable use of Earth's resources.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864104	**INTEGRATE**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. CONOR BUCKLEY**
Host Institution: The Provost, Fellows, Foundation Scholars & The Other Members Of Board Of The College Of The Holy & Undivided Trinity Of Queen Elizabeth Near Dublin, IE

Personalised Medicine for Intervertebral Disc Regeneration- Integrating Profiling, Predictive Modelling and Gene Activated Biomaterials

Lower back pain is a global epidemiological and socioeconomic problem. Biomaterial and cell-based therapies have been pursued for the treatment of degenerated intervertebral disc (IVD), with a number of clinical trials underway. However, the degenerated intervertebral disc has a distinct environment (e.g. altered oxygen, glucose, acidity, inflammatory cytokine levels) that is unique to an individual (i.e. patient-specific) and will ultimately determine the likelihood and rate at which regeneration can occur. A “one size fits all” approach will lead to the failure to demonstrate efficacy of advanced therapies, as they are not being designed or personalised for individual patients. This proposal envisions a future whereby advanced gene activated cell therapies are personalised (targeting regeneration or modulating inflammation) to treat back pain based on knowing the individuals unique disc microenvironment. This will be achieved through profiling of individual patient disc microenvironmental factors, with in vitro screening and in silico modelling to design cell therapies and predict regeneration outcomes (Aim 1) combined with the development of tailored functionalised gene activated biomaterials (Aim 2), to enhance matrix formation and modulate the inflammatory processes (Aim 3). Gene-based therapy offers several advantages over direct delivery of proteins or small molecules, among them the possibility of sustained efficacy and endogenous synthesis of growth factors or suppression of inflammatory factors and pathways. The platform technology (personalised gene activated biomaterials to regulate regeneration and inflammation) and knowledge (tailoring cell therapies to suit patient-specific microenvironments) generated through this research are beyond the current state-of-the-art and will provide a significant transformative scientific and clinical step change opening new horizons in minimally-invasive therapeutic strategies.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864697	**EXTREMA**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. FRANCESCO TOPPUTO**
Host Institution: Politecnico Di Milano, IT

Engineering Extremely Rare Events in Astrodynamics for Deep-Space Missions in Autonomy

A new space era is fast approaching. A multitude of miniaturised probes will soon permeate the inner solar system. The abundantly variegated minor bodies will be the destinations of numerous missions driven by exploration and exploitation needs. Missions to rocky planets will feature networks of artificial satellites to support science and operations. Yet, the state-of-the-art is to pilot deep-space probes from ground. Although this is reliable, ground control slots will saturate soon, thus hampering the current momentum in space exploration.

EXTREMA enables self-driving spacecraft: machines able to travel in the deep space free of human-driven instructions. We take the challenge to make these systems a reality, and fundamental research is conducted to lay down their foundations. The ambition of EXTREMA is to prove that minor bodies and inner planets can be reached in a totally autonomous fashion with highly constrained platforms. These systems are used to engineer ballistic capture, an extremely rare event observed in highly sensitive regimes. To reinforce this logic, a new approach in orbit validation is introduced, which excels pure computer simulations.

Erected over three pillars, the project forges a Simulation Hub, which reproduces on ground the spacecraft-environment interaction. While the pillars enable intermediate milestones, such as inferring the spacecraft position by exploiting the surrounding environment (autonomous navigation), self-determining a nominal plan without a-priori knowledge (autonomous guidance), and targeting the corridors that conduce to ballistic capture, it is the activity performed in the Simulation Hub that allows achieving the objectives via dedicated case studies.

A successful outcome will boost access to outer space. The impact is to favour settlements in the inner solar system on a large-scale basis. Located at the fringe of research, EXTREMA can determine a paradigm shift in the way we conceive and conduct deep-space mission.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865985	**CLEANH2**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. NICOLAS BOSCHER**
Host Institution: Luxembourg Institute Of Science And Technology, LU

Chemical Engineering of Fused MetalloPorphyrins Thin Films for the Clean Production of Hydrogen

This project stands in the general context of the current worldwide energy and environmental crisis. It aims to engineer a new generation of conjugated microporous polymers based on fused metalloporphyrins for the low-cost, clean and efficient production of hydrogen from solar water splitting. The CLEANH2 concept relies on the gas phase reaction of metalloporphyrins to engineer new heterogeneous catalysts with remarkable hydrogen production yields. Metalloporphyrins, selected by Nature to fulfil the main catalytic phenomena allowing life, are attractive molecules for water splitting owing to their highly conjugated structure and central metal ion, which can readily interconvert between different oxidation states to accomplish oxidation and reduction reactions. For efficiency and sustainability considerations, it is highly desirable to employ metalloporphyrins in conductive assemblies for heterogeneous catalysis. Nevertheless, due to the lack of synthetic approach, the design and application of conjugated porphyrin assemblies is a largely unexplored topic in view of the plethora of available porphyrin patterns.

The central idea of CLEANH2 builds upon our recent advance in the gas phase synthesis and deposition of directly fused metalloporphyrins coatings. Progress in our approach is expected to open the way for the construction of powerful catalytic and photocatalytic materials. To achieve this, the key challenging goals of this project are: 1) the engineering of the microstructure and electronic structure of directly fused metalloporphyrins thin films; 2) the use of the full potential of directly fused metalloporphyrins thin films for the unmet, clean and high quantum yield overall water splitting for hydrogen production. The outcomes of CLEANH2 will be foundational for the engineering of directly fused metalloporphyrins systems and their implementation in advanced technological applications related to catalysis and solar energy.

Project End Date: **30-APR-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866005	**MIGHTY**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. MICHAEL DE VOLDER**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

Roll-to-Roll Manufacturing of Hierarchical Li-Ion Battery Electrodes

Research in the field of micro and nanotechnology has led to the development of materials with fundamentally new or improved functionality, which have the potential to revolutionise electronics, drug delivery, water purification, and energy storage. These scientific discoveries can help address many of the grand challenges our society is facing, but unfortunately, too few of these new materials are implemented in real commercial devices. This is not because of a lack of interest or commercial potential, but often because there are no manufacturing methods available that allow for controlled processing of these materials at scale.

This project aims to address this challenge by developing advanced nano and microstructures directly on a scalable Roll-to-Roll manufacturing platform, rather than considering manufacturing as an after-thought. This will be achieved by following a methodical approach, where material organisation is optimised from the bottom-up, starting with the nanoscale chemical material composition, followed by the microscale particle morphology, and finally their large area coating using Roll-to-Roll manufacturing. This hierarchical material build-up will be achieved by taking advantage of emerging scientific insights in robust self-assembly processes, combined with novel coating processes to allow for precise control over the particle flow and assembly on Roll-to-Roll.

Our Roll-to-Roll process will be optimised to manufacture Li-Ion batteries with new form factors that allow the enhancement of their volumetric performance. This project will demonstrate for the first time how complex hierarchical battery electrodes can be manufactured with a continuous process. These batteries are important to support the EU's strong automotive industry as it transitions to electric vehicles, and therefore this project will contribute to the EU economy as well as to the de-carbonisation of our society.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866018	**SENSATE**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. EDGARDO SAUCEDO**
Host Institution: Universitat Politecnica De Catalunya, ES

Low dimensional semiconductors for optically tuneable solar harvesters

SENSATE proposes ground breaking ideas and concepts combining very innovative low dimensional thin film materials and highly asymmetric selective contacts with dipoles, for the development of non-intrusive and universal solar energy harvester. Materials, processes and devices design innovations will be combined in a straightforward manner, in order to develop next generation of cost-efficient and highly-stable/optically-tuneable photovoltaic (PV) devices.
For achieving this, SENSATE proposes exploiting for the first time the full optical and electrical potential of one-dimensional (1D) thin film wide bandgap materials, including chalcogenide, halide and mixed chalcogenide/halide compounds. The use of 1D semiconductors as PV absorbers will represent a breakthrough thanks to their unique capability to exhibit excellent electrical properties in very thin layers when correctly oriented, keeping at the same time tuneable optical properties to ensure good transparency (AT > 50%), and very competitive efficiencies (>20%). A wide range of wide bandgap 1D semiconductors will be developed (Eg between 1.50-2.70 eV), including strategies for their 1D texturing using annealing at high pressure and under magnetic fields.
This will be combined with disruptive selective asymmetric contacts based on electron and hole transport metal oxide layers, enhanced with superficial organic and inorganic dipoles, to develop a ubiquitous solar harvester with customized transparency/efficiency. If succeed, SENSATE will have an unprecedented impact in our perception of PV energy, opening the possibility to applications that nowadays are considered marginal. Transparent, semi-transparent and coloured devices for advanced BIPV applications and electronics, as well as top cells for very high efficiency and low cost tandem/multi-junction devices will benefit from this technology, setting the basis required for a massive PV implementation and contributing to change our energy consumption model.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866348	**i-NANOSWARMS**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. SAMUEL SANCHEZ**
Host Institution: Fundacio Institut De Bioenginyeria De Catalunya, ES

Cooperative Intelligence in Swarms of Enzyme-Nanobots

In nature, systems composed of self-propelling agents display complex behaviors such as signal interpretation, propagation, amplification and engage in collective motion mediated by interactions between different agents and their environment. Examples range from swarming bacteria to schooling fish and flocking birds. These self-organized systems have served as an inspiration for researchers seeking to achieve complexity in artificial systems composed of synthetic agents. A class of agents that has recently been demonstrated is of synthetic nanomachines (nanobots) that can self-propel thanks to the conversion of chemical energy, harvested from the environment, into motion. While most of the artificial nanobots have been explored at individual level, their collective emergent behavior, arising from inter-particle interactions through chemical and hydrodynamic fields, and through environment mediated interactions is yet to be properly studied. Understanding collective effects will be especially useful in biologically relevant environments, where a number of applications for these nanobot systems have been envisioned.
i-NANOSWARMS aims to realize enzyme-powered nanobot swarms capable to self-propel using biocompatible and bioavailable fuels and display collective and cooperative behaviours through communication among them as well as with the host environment. The proposal is divided in three working packages. In WP1, I will create a toolbox of nanobots based on a library of enzymes and nanoparticle architectures to study communication and long-range signal propagation using enzyme cascades. WP2 will be devoted to the collective behavior of nanobot swarms, exploiting biomimetic strategies such as chemotaxis and stigmergy to guide and recruit other nanobots. WP3 aims at studying, as a proof-of-concept of the applicability of intelligent nanoswarms for biomedical applications, cooperative behavior among nanoswarms for enhanced drug delivery and medical imaging.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
882340	**Smart-TURB**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. LUCA BIFERALE**
Host Institution: Universita Degli Studi Di Roma Tor Vergata, IT

A Physics-Informed Machine-Learning Platform for Smart Lagrangian Harness and Control of TURBulence

Where is it difficult to control, predict and model a flowing system? to search and navigate inside it? to be prepared against extreme events? to tame them? It is in turbulent flows.
Turbulence is ubiquitous and unsolved from the point of view of out-of-equilibrium fundamental physics, uncontrollable from the engineering aspects, and a deadlock for brute-force numerical and experimental investigations. Indeed, progress by using conventional methods has been slow.
In this project, I propose to explore new avenues crossing the boundaries between Theoretical Engineering and Applied Physics using algorithms from Artificial Intelligence (AI) to study and control turbulence in an innovative way using smart Lagrangian objects in a vast array of flows. I am committed to: (i) develop original applications of AI algorithms to track and harness moving coherent structures and/or statistical turbulent fluctuations, (ii) optimise flow navigation of buoyant objects and active surface drifter, (iii) invent collective search protocols to locate emissions from fixed or floating sources, (iv) minimise turbulent dispersion of a swarm of autonomous underwater explorer and (v) perform new in-silico experiments for data-assimilation, to predict extreme-events, or to control turbulent fluctuations by novel Lagrangian injection/adsorption mechanisms.
The unifying fil-rouge of my project is to gain a Deep Understanding of turbulence by performing cutting-edge Lagrangian numerical studies. The project is both methodology oriented, with the grand challenge of developing fully unconventional applications of (Deep) Reinforcement Learning for fluid dynamics, and problem driven, delivering a series of specific optimal control strategies for important realistic flow set-ups and applications to the geophysical fields. With my experience and the impact of my contributions in the discipline, I am confident that I offer the highest chances to carry out this ambitious project with success.

Project End Date: **30-APR-26**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
882929	**EROS**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. JUDITH DRISCOLL**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

Efficient and Robust Oxide Switching

We are at the beginning of a Data Age. Data is exploding. In 2016, 90% of the world's data ever created was in the two previous years. AI and data analytics are further increasing the growth. The power demand is huge and growing. Within a few years some developed countries will not have sufficient power to sustain the growth. The negative effects on the planet are serious. Non-volatile memory (NVM) technology (including memory and neuromorphic computing elements in a single device) could strongly help to solve the problem, giving two orders of magnitude power reduction and, by removing the data transfer bottleneck, increased speed. Oxide memristors have significant advantages over competing NVM technologies, particularly in terms of speed, cost and temperature stability. However, after more than a decade of intense effort, serious challenges remain in terms of scaling, uniformity and robustness. The challenges all relate to a lack of precise control of the materials. Completely new thinking in thin film materials engineering is needed.

EROS provides this new thinking by designing and engineering new forms of nanostructured oxide films to give highly Efficient, Robust Oxide Switching in an ultra-dense, ultra-low power, reliable oxide memristor system, with potential to change the technology landscape in AI, IoT, and security. 'Ideal' films will first be designed, fabricated, and understood. These will direct the way to simple industry-platform devices. Stochastic effects will be eliminated by creating films with separate vertical nanoscale ionic and electron channels with highly controlled vacancy and electronic concentrations, allowing scaling to a few nm, in a forming-free system. Also, multifunctional hybrid structures will be developed to give robustness. Furthermore, ferroelectricity will be induced, allowing simpler and smaller devices. Confidence in the proposed approach comes from proof-of-concept model systems shown by the PI.

Project End Date: **31-DEC-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
884114	**NaCRe**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. FRANCESCO STELLACCI**
Host Institution: Ecole Polytechnique Federale De Lausanne, CH

Nature-inspired Circular Recycling for Polymers

In 2070, 10^12 Kg of plastics (polymers) could be produced yearly in a world inhabited by 11 billion people. Hence, we have ~50 years to address this sustainability challenge. The sourcing and disposing of such quantities without a significant environmental impact will not be possible, even if everything is bio-sourced and bio-degraded. Yet, on earth, there are >10^12 Kg of proteins (one of Nature's polymers). They are sustainable because they are recycled in a circular way. If we exemplify their metabolism, proteins are decomposed by living organisms into their monomeric constituents (the amino acids, AAs); the cell machinery uses such AAs to synthesize new proteins that have little in common with the original ones. This is only possible because a protein is a specific sequence of AAs bound together by cleavable peptide bonds, i.e. proteins are sequence-defined polymers, SDPs. Nature reuses and does not degrade AAs, thus assuring protein sustainability. This project aims at showing that such a circular approach to recycle SDPs is possible for technologically-relevant polymers using engineering-sound laboratory processes. One aim is to show that b-Lactoglobulin, a milk protein used as a component for water filtration membranes, can be digested into its AAs, that, in turn, can be used to form Fibroin, a silk protein used in resistive switching memory devices. Fibroin will be converted into Keratin, a wool protein, that will be converted back into b-Lactoglobulin. Another aim is to perform the whole process within an automated and scalable robotic platform. The final aim is to expand this concept from natural proteins to DNA and non-natural SDPs. There would be a paradigm shift in plastic recycling, if a random mixture of any polymers could be used to produce any other polymer on earth, without taxing the planet with degradation products. Scope of this project is to show that such a vision in the circular use of polymers is scientifically and technologically possible.

Project End Date: **31-DEC-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
885022	**PMP**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. HENNING FRIIS POULSEN**
Host Institution: Danmarks Tekniske Universitet, DK

The Physics of Metal Plasticity

The societal need to conserve materials and energy calls for lighter and stronger metal components. The advantage of metals is their unique combination of plasticity (i.e. formability) and strength, which is governed by their complex structure. This structure is organized hierarchically on several length scales. In contrast to functional materials and polymers, this complexity has led to the common theoretical framework being not physics, but an engineering science: metallurgy. As a result, phenomenological models prevail.

The big obstacle to understand the underlying physics is the lack of visualization of the dynamics of the structure. From 2012 to 2019 I have developed a hard x-ray microscope for high-resolution 3D studies. Uniquely, this now allows us to zoom into the material and map grains and dislocations. This will enable 3D movies on all relevant length scales. No competing group will have anything similar within the next 5 years.

PMP will exploit this to unravel the physics of plasticity. For the first time, we can directly see the processes involved: the creation of dislocations, their self-organization, and subsequent creation of ever more complex patterns. At the same time, we can deduce the local stress. This will provide answers to longstanding core questions of metal science.

Current multiscale models of plasticity are not capable of predicting realistic patterns. The new data will guide theory and allow for direct comparison of models and experiment at all scales. PMP will develop a physics-based multiscale model of plasticity that for the first time can predict which patterns evolve when and where in the metal, and as a result greatly improve predictions of the macroscopic plasticity and strength.

If successful, we have created the instrumental and modelling foundation for a new paradigm in structural materials. This will support the ultimate vision of materials and process design in computer models rather than trial and error in the lab.

Project End Date: **31-JUL-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716155	**SACCRED**	**PE9** Universe Sciences

Principal Investigator: **Dr. ÁGNES KÓSPÁL**
Host Institution: Csillagaszati Es Foldtudomanyi Kutatokozpont, HU

Structured ACCREtion Disks: initial conditions for planet formation in the time domain

In this ERC Starting Grant, I propose an ambitious research program to target important challenges in predicting realistic initial conditions for the planet formation process. I will perform a large systematic study of the accretion-driven eruptions of newborn stars, and evaluate their influence on the structure, composition, and chemistry of the terrestrial planet forming zone in the circumstellar disk. The research will focus on three main questions:

- How does the mass accretion proceed in realistic, structured, non-axisymmetric disks?
- What physical mechanisms explain the accretion-driven eruptions?
- What is the effect of the eruptions on the disk?

My new research group will study young eruptive stars, pre-main sequence objects prone to episodes of extremely powerful accretion-driven outbursts, and combine new observations, state-of-the-art numerical modelling, and information from the literature. With a novel concept, we will first model the time-dependence of mass accretion in circumstellar disks, taking into account the latest observational results on inhomogeneous disk structure, and determine what fraction of young stellar objects is susceptible to high mass accretion peaks. Next, we will revise the paradigm of the eruptive phenomenon, compelled by recently discovered young eruptive stars whose outbursts are inconsistent with current outburst theories. Finally, we will determine the impact of accretion-driven eruptions on the disk, by considering the increased external irradiation, internal accretion heating, and stellar winds. With my experience and track record, I am in a position to comprehensively synthesize existing and newly acquired information to reach the proposed goals. The expected outcome of the ERC project is a conclusive demonstration of the ubiquity and profound impact of episodic accretion on disk structure, providing the initial physical conditions for disk evolution and planet formation models.

Project End Date: **30-JUN-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
717001	**DELPHI**	**PE9** Universe Sciences

Principal Investigator: **Dr. PRATIKA DAYAL**
Host Institution: Rijksuniversiteit Groningen, NL

DELPHI: a framework to study Dark Matter and the emergence of galaxies in the epoch of reionization

Our Universe started as a dark featureless sea of hydrogen, helium, and dark matter of unknown composition about 13 and a half billion years ago. The earliest galaxies lit up the Universe with pinpricks of light, ushering in the era of 'cosmic dawn'. These galaxies represent the primary building blocks of all subsequent galaxies and the sources of the first (hydrogen ionizing) photons that could break apart the hydrogen atoms suffusing all of space starting the process of 'cosmic reionization'. By virtue of being the smallest bound structures in the early Universe, these galaxies also provide an excellent testbed for models wherein Dark Matter is composed of warm, fast moving particles as opposed to the sluggish heavy particles used in the standard Cold Dark Matter paradigm.

Exploiting the power of the latest cosmological simulations as well as semi-analytic modelling rooted in first principles, DELPHI will build a coherent and predictive model to answer three of the key outstanding questions in physical cosmology:
- how did the interlinked processes of galaxy formation and reionization drive each other?
- what were the physical properties of early galaxies and how have they evolved through time to give rise to the galaxy properties we see today?
- what is the nature (mass) of the mysterious Dark Matter that makes up 80% of the matter content in the Universe?

The timescale of the ERC represents an excellent opportunity for progress on these fundamental questions: observations with cutting-edge instruments (e.g. the Hubble and Subaru telescopes) are providing the first tantalising glimpses of early galaxies assembling in an infant Universe, required to pin down theoretical models. The realistic results obtained by DELPHI will also be vital in determining survey strategies and exploiting synergies between forthcoming key state-of-the-art instruments such as the European-Extremely Large Telescope, the James Webb Space Telescope and the Square Kilometre Array.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724326	**BOSS-WAVES**	**PE9** Universe Sciences

Principal Investigator: **Dr. TOM VAN DOORSSELAERE**
Host Institution: Katholieke Universiteit Leuven, BE

Back-reaction Of Solar plaSma to WAVES

The solar coronal heating problem is a long-standing astrophysical problem. The slow DC (reconnection) heating models are well developed in detailed 3D numerical simulations. The fast AC (wave) heating mechanisms have traditionally been neglected since there were no wave observations.
Since 2007, we know that the solar atmosphere is filled with transverse waves, but still we have no adequate models (except for my own 1D analytical models) for their dissipation and plasma heating by these waves. We urgently need to know the contribution of these waves to the coronal heating problem.

In BOSS-WAVES, I will innovate the AC wave heating models by utilising novel 3D numerical simulations of propagating transverse waves. From previous results in my team, I know that the inclusion of the back-reaction of the solar plasma is crucial in understanding the energy dissipation: the wave heating leads to chromospheric evaporation and plasma mixing (by the Kelvin-Helmholtz instability).

BOSS-WAVES will bring the AC heating models to the same level of state-of-the-art DC heating models.

The high-risk, high-gain goals are (1) to create a coronal loop heated by waves, starting from an "empty" corona, by evaporating chromospheric material, and (2) to pioneer models for whole active regions heated by transverse waves.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724857	**ArcheoDyn**	**PE9** Universe Sciences

Principal Investigator: **Dr. GLENN VAN DE VEN**
Host Institution: Universitaet Wien, AT

Globular clusters as living fossils of the past of galaxies

Globular clusters (GCs) are enigmatic objects that hide a wealth of information. They are the living fossils of the history of their native galaxies and the record keepers of the violent events that made them change their domicile. This proposal aims to mine GCs as living fossils of galaxy evolution to address fundamental questions in astrophysics: (1) Do satellite galaxies merge as predicted by the hierarchical build-up of galaxies? (2) Which are the seeds of supermassive black holes in the centres of galaxies? (3) How did star formation originate in the earliest phases of galaxy formation? To answer these questions, novel population-dependent dynamical modelling techniques are required, whose development the PI has led over the past years. This uniquely positions him to take full advantage of the emerging wealth of chemical and kinematical data on GCs.

Following the tidal disruption of satellite galaxies, their dense GCs, and maybe even their nuclei, are left as the most visible remnants in the main galaxy. The hierarchical build-up of their new host galaxy can thus be unearthed by recovering the GCs' orbits. However, currently it is unclear which of the GCs are accretion survivors. Actually, the existence of a central intermediate mass black hole (IMBH) or of multiple stellar populations in GCs might tell which ones are accreted. At the same time, detection of IMBHs is important as they are predicted seeds for supermassive black holes in galaxies; while the multiple stellar populations in GCs are vital witnesses to the extreme modes of star formation in the early Universe. However, for every putative dynamical IMBH detection so far there is a corresponding non-detection; also the origin of multiple stellar populations in GCs still lacks any uncontrived explanation. The synergy of novel techniques and exquisite data proposed here promises a breakthrough in this emerging field of dynamical archeology with GCs as living fossils of the past of galaxies.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
726384	**EMPIRE**	**PE9** Universe Sciences

Principal Investigator: **Dr. FRANK BIGIEL**
Host Institution: Rheinische Friedrich-Wilhelms-Universitat Bonn, DE

Galaxy Evolution in the ALMA Era - The Baryon Cycle and Star Formation in Nearby Galaxies

A thorough understanding of the processes regulating the conversion of gas into stars is key to understand structure formation in the universe and the evolution of galaxies through cosmic time. Despite significant progress over the past years, the properties of the actual dense, star forming gas across normal disk galaxies remain largely unknown. This will be changed with EMPIRE, a comprehensive 500hr large program led by the PI at the IRAM 30m mm-wave telescope. EMPIRE will provide for the first time extended maps of a suite of dense gas tracers (e.g., HCN, HCO+, HNC) for a sample of nearby, star-forming, disk galaxies.

By means of detailed analysis, including radiative transfer and chemical modelling, we will constrain a variety of physical quantities (in particular gas densities). We will relate these directly to the local star formation efficiency and to a variety of other dynamical, stellar and local ISM properties from existing pan-chromatic mapping of these galaxies (HI, IR, CO, UV, optical) to answer the question: ``how is star formation regulated across galaxy disks?''. By determining true abundance variations, we will contribute key constraints to the nascent field of galaxy-scale astrochemistry. Detailed comparisons to data for star forming regions in the Milky Way will link core, cloud and galactic scales towards a coherent view of dense gas and star formation. These results will provide an essential anchor point to Milky Way and high redshift observations alike.

Analysis, interpretation and modelling of this complex data set requires a team of two postdocs and two PhD students. The PI has demonstrated his ability to successfully lead a research group through his current position as a DFG funded Emmy-Noether group leader. In combination with his widely recognized previous work and his expertise in mm-wave astronomy and ISM/star formation studies, the PI and the proposed group are uniquely positioned to make significant impact during this ERC grant.

Project End Date: **30-JUN-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
740021	**ARTHUS**	**PE9** Universe Sciences

Principal Investigator: **Dr. THOMAS BUCHERT**
Host Institution: Universite Lyon 1 Claude Bernard, FR

Advances in Research on Theories of the Dark Universe - Inhomogeneity Effects in Relativistic Cosmology

The project ARTHUS aims at determining the physical origin of Dark Energy: in addition to the energy sources of the standard model of cosmology, effective terms arise through spatially averaging inhomogeneous cosmological models in General Relativity. It has been demonstrated that these additional terms can play the role of Dark Energy on large scales (but they can also mimic Dark Matter on scales of mass accumulations). The underlying rationale is that fluctuations in the Universe generically couple to spatially averaged intrinsic properties of space, such as its averaged scalar curvature, thus changing the global evolution of the effective (spatially averaged) cosmological model. At present, we understand these so- called backreaction effects only qualitatively. The project ARTHUS is directed towards a conclusive quantitative evaluation of these effects by developing generic and non-perturbative relativistic models of structure formation, by statistically measuring the key-variables of the models in observations and in simulation data, and by reinterpreting observational results in light of the new models. It is to be emphasized that there is no doubt about the existence of backreaction effects; the question is whether they are even capable of getting rid of the dark sources (as some models discussed in the literature suggest), or whether their impact is substantially smaller. The project thus addresses an essential issue of current cosmological research: to find pertinent answers concerning the quantitative impact of inhomogeneity effects, a necessary, worldwide recognized step toward high-precision cosmology. If the project objectives are attained, the results will have a far-reaching impact on theoretical and observational cosmology, on the interpretation of astronomical experiments such as Planck and Euclid, as well as on a wide spectrum of particle physics theories and experiments.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
740120	**INTERSTELLAR**	**PE9** Universe Sciences

Principal Investigator: **Dr. ANDREA FERRARA**
Host Institution: Scuola Normale Superiore, IT

The Interstellar Medium of High Redshift Galaxies

When and how did the first galaxies form across cosmic history? Were they different from present-day ones? This is only a small subset of key cosmological questions that the combination of deep galaxy observations, theoretical modeling, and powerful simulations envisaged here will allow us to answer for the first time.

Deep galaxy surveys have provided a first valuable characterization of early galaxies in the Epoch of Reionization (redshift $z > 6$), mostly in terms of their stellar content. However, almost nothing is known about their internal structure and Interstellar Medium (ISM). This is in striking contrast with galaxies at $z < 2$, for which ISM observations have enabled a much more complete physical description. Hence, a substantial progress in the study of early galaxies must be based on techniques able to probe their ISM. Conversely, ISM studies will help completing the “stellar” picture.

Interstellar will bridge this gap. Its main aim is to understand the internal structure and interstellar medium of galaxies in the Epoch of Reionization by performing theoretical modeling and high fidelity simulations. By post-processing the simulations and calibrating them with local analogs, we will produce mock images/spectra used to (i) interpret available high-redshift observations, and (ii) plan breakthrough experiments with ALMA, JWST and E-ELT.

The advent of ALMA, JWST, E-ELT and advances in computational cosmology make the study of high-z ISM one of the most promising areas of development in cosmology.

The aim will be achieved through 5 objectives distributed among 3 Work Packages (WPs). WP1 is concerned with theoretical work, a preparatory phase for the cosmological simulations performed in WP2. WP2 represents the production phase of the project and will deliver cutting-edge zoom simulations of a sample of high-z galaxies and their ISM. Finally, WP3 is concerned with the exploitation of the numerical results and their integration with observations.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
741002	**DOC**	**PE9** Universe Sciences

Principal Investigator: **Dr. CECILIA CECCARELLI**
Host Institution: Universite Grenoble Alpes, FR

The Dawn of Organic Chemistry

Terrestrial life is based on organic chemistry, on the complex combination of relatively small molecules containing less than 50 atoms of carbon and other elements in smaller quantities. Some of these bricks, notably amino acids, are found in meteoritic and cometary material, a fact (among others) which led the Nobel laureate C. de Duve to conclude that “the seeds of life are universal” and “life is an obligatory manifestation of matter, written into the fabric of the Universe”.

The objective of the DOC project is to understand the dawn of organic chemistry, namely the start of organic chemistry in systems similar to the progenitor of the Solar System, with the ultimate goal to understand how organic chemistry builds up and evolves in these systems and, consequently, to understand how universal the chemical seeds of life are.

To achieve this objective, I propose to build a reliable theory for the organic chemistry in nascent Solar type systems, by combining in a tightly coordinated way new ground-breaking astronomical observations, quantum chemistry computations, astrochemical/chemi-physical models and sophisticated analysis tools. The DOC project is based on (i) a mine of first-class data from already awarded Large Programs at IRAM and from a plethora of smaller proposals at IRAM, ALMA and APEX, (ii) new state-of-the-art quantum chemistry computations to understand astrochemistry reactions at the molecular level, and (iii) models and tools to fully exploit the new data and computations.

My ambition is to provide a reliable theory not only for the astrochemical and the star and planet formation communities, but also for the extragalactic one. Indeed, the new highly sensitive spectral observations from facilities like IRAM, ALMA and, in the future, SKA will inevitably contain lines from many organic molecules. DOC ambition is to ultimately allow us to understand how organic chemistry unfolds in the Universe.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
742095	**SPIDI**	**PE9** Universe Sciences

Principal Investigator: **Dr. JEROME BOUVIER**
Host Institution: Centre National De La Recherche Scientifique, FR

Star-Planet-Inner Disk Interactions (SPIDI): unveiling the formation and evolution of inner planetary systems

With more than 2,000 confirmed exoplanets discovered to date, and about 4,000 additional candidates, it is now widely accepted that nearly every star in the Galaxy hosts a planetary system. These systems greatly differs from our Solar System: a vast majority of exoplanets revolves at a distance less than the Earth's orbit (1 astronomical unit, 1 AU), and many orbit very close to their parent star indeed (<0.1 AU). These inner planets, with an orbital period less than 100 days, are quite diverse, ranging from Earth-like to Jupiter-like. How do they form or migrate close their star is still an open issue. ALMA and VLT/SPHERE recently released spectacular images of circumstellar disks around young stars, which exhibit large-scale structures (>10 AU), including rings, gaps, and spiral arms that presumably are the signposts of planet formation. Yet, as powerful as they are, imaging techniques are yet unable to probe the inner disk region. The goal of the SPIDI project is to investigate the origin and evolution of inner planetary systems. Specifically, we will develop dynamical models of inner planets embedded in the accretion disk of young stars to investigate the physical processes that govern the star-disk-planet interactions from 1 AU down to the stellar surface. From these models, we will then predict the observational signatures of disk-embedded inner planetary systems, and devise and implement observations that will allow us to detect them. This can only be done indirectly through simultaneous time domain photometry, spectroscopy, spectropolarimetry, and interferometry. Combined with current results obtained on larger scales, the SPIDI project will thus yield a synthetic view of nascent planetary systems, down to the inner edge of protoplanetary disks. It will bring clues to the origin of our own inner Solar System, and more generally, address the formation process and ubiquity of inner planetary systems throughout the Galaxy.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757258	**TRIPLE**	**PE9** Universe Sciences

Principal Investigator: **Dr. ANNE VERHAMME**
Host Institution: Universite De Geneve, CH

Three Indirect Probes of Lyman continuum LEakage from galaxies

Cosmic reionization corresponds to the period in the history of the Universe during which the predominantly neutral intergalactic medium was ionised by the emergence of the first luminous sources. Young stars in primeval galaxies may be the sources of reionization, if the ionising radiation, called Lyman continuum (LyC), that they produce can escape their interstellar medium: the escape fraction of LyC photons from galaxies is one of the main unknowns of reionization studies. This ERC project will contribute to answer this question, by computing from simulated galaxies three indirect diagnostics of LyC leakage that were recently reported in the literature, and comparing the virtual observables with the direct escape of LyC photons from simulated galaxies, and with observations. The first diagnostic for LyC leakage relates the escape of the strongly resonant Lyman-alpha radiation from galaxies to the LyC escape. It was proposed by the PI (Verhamme et al. 2015), and recently validated by observations (Verhamme et al. 2016). The second diagnostic proposes that the strength of Oxygen lines ratios can trace density-bounded interstellar regions. It was the selection criterion for the successful detection of 5 strong Lyman Continuum Emitters from our team (Izotov 2016a,b). The third diagnostic relates the metallic absorption line strengths to the porosity of the absorbing interstellar gas in front of the stars. The increasing opacity of the intergalactic medium with redshift renders direct LyC detections impossible during reionisation. Indirect methods are the only probes of LyC leakage in the distant Universe, and the proposed diagnostics will soon become observables at the redshifts of interest with JWST. They have passed the validation tests, it is now urgent to calibrate these indicators on state-of-the art simulations of galaxy formation. This is the main objective of the proposed project.

Project End Date: **28-FEB-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757448	**PAMDORA**	**PE9** Universe Sciences

Principal Investigator: **Dr. BERTRAM BITSCH**
Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Planetary accretion and migration in discs over all ages

The goal of this ERC proposal is to make significant progress in our understanding how planetary systems form in protoplanetary discs. In this ambitious research programme I will answer these three key questions:

How does the dust size distribution affect the evolution of ice lines and initial formation location of planetesimals?
How do growing planets migrate in protoplanetary discs?
How does the disc evolution affect the formation and composition of planetary systems?

I will tackle these questions using a combination of novel ideas and computer simulations in which I will model the three before mentioned connected key stages of planet formation. The disc evolution model will incorporate grain growth and drift with self-consistent temperature structure calculations. The planet migration simulations will map the migration rates from small planets all the way to giant gap opening planets in these discs. Finally, I will combine these topics and compute the assembly of whole planetary systems from multiple small bodies in gas discs to full grown solar systems.
Additionally, I will track the chemical composition and evolution of the growing bodies.

These self-consistent models of the formation process from planetary embryos all the way to full planetary systems will be the first of their kind and will shed light on the origin of the variety of planetary systems featuring terrestrial planets, super-Earths, ice and/or gas giants. By incorporating the chemical composition of planets during their formation into my model, I can not only compare the orbital elements to observations, but also their compositions, where observations of the atmospheres of hot Jupiters already exist and future observations of super-Earths will reveal their atmospheric and bulk composition (e.g. through the PLATO space mission), further constraining planet formation theories.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757957	**UFOS**	**PE9** Universe Sciences

Principal Investigator: **Dr. MARIO FLOCK**
Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Unveiling Planet Formation by Observations and Simulations

With each newly detected exoplanet system, the planet formation theory is constantly gaining weight in the astrophysical research. The planets origin is a mystery which can only be solved by understanding the protoplanetary disks evolution. Recent disk observations by the new class of interferometer telescopes are challenging the existing theory of planet formation. They reveal astonishing detailed structures of spirals and rings in the dust emission which have never been seen before. Those structures are often claimed to be caused by embedded planets, which is difficult to explain with current models. This growing discrepancy between observation and theory forces us to realize: a novel disk modeling is essential to move on. Separate gas or dust evolution models have reached their limit and the gap between those has to be closed.

With the UFOS project, I propose an unique and ambitious approach to unite gas and dust evolution models for protoplanetary disks. For the first time, a single global model will mutually link self-consistently: a) the transport of gaseous disk material, b) the radiative transfer, c) magnetic fields and their dissipation and d) the transport and growth of the solid material in form of dust grains.

The development, performing and post-analysis of the models will initiate a new age for the planet formation research. The project results will achieve 1) unprecedented self-consistent precision to answer the question if those novel observed structures are caused by embedded planets or by the gas dynamics itself; 2) to find the locations of dust concentration and growth to unveil the birth places of planets and 3) to close the gap and finally unify self-consistent models of the disk evolution with the new class of observations.

Only such advanced models combined with multi-wavelength observations, can show us the process of planet formation, and so explain the origin of the various of planets and exoplanets in our solar neighborhood and beyond.

Project End Date: **31-MAY-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772086	**ASSESS**	**PE9** Universe Sciences

Principal Investigator: **Dr. ALCESTE BONANOS**
Host Institution: Ethniko Asteroskopeio Athinon, GR

Episodic Mass Loss in the Most Massive Stars: Key to Understanding the Explosive Early Universe

Massive stars dominate their surroundings during their short lifetimes, while their explosive deaths impact the chemical evolution and spatial cohesion of their hosts. After birth, their evolution is largely dictated by their ability to remove layers of hydrogen from their envelopes. Multiple lines of evidence are pointing to violent, episodic mass-loss events being responsible for removing a large part of the massive stellar envelope, especially in low-metallicity galaxies. Episodic mass loss, however, is not understood theoretically, neither accounted for in state-of-the-art models of stellar evolution, which has far-reaching consequences for many areas of astronomy. We aim to determine whether episodic mass loss is a dominant process in the evolution of the most massive stars by conducting the first extensive, multi-wavelength survey of evolved massive stars in the nearby Universe. The project hinges on the fact that mass-losing stars form dust and are bright in the mid-infrared. We plan to (i) derive physical parameters of a large sample of dusty, evolved targets and estimate the amount of ejected mass, (ii) constrain evolutionary models, (iii) quantify the duration and frequency of episodic mass loss as a function of metallicity. The approach involves applying machine-learning algorithms to existing multi-band and time-series photometry of luminous sources in ~25 nearby galaxies. Dusty, luminous evolved massive stars will thus be automatically classified and follow-up spectroscopy will be obtained for selected targets. Atmospheric and SED modeling will yield parameters and estimates of time-dependent mass loss for ~1000 luminous stars. The emerging trend for the ubiquity of episodic mass loss, if confirmed, will be key to understanding the explosive early Universe and will have profound consequences for low-metallicity stars, reionization, and the chemical evolution of galaxies.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772663	**MAGALOPS**	**PE9** Universe Sciences

Principal Investigator: **Dr. MARIJKE HAVERKORN**
Host Institution: Stichting Katholieke Universiteit, NL

The MAgnetic field in the GALaxy, using Optical Polarization of Stars

What makes our Galaxy's ecosystem so fascinating is the complex interactions between its components: stars, gas, dust, magnetic fields, and cosmic rays. Of these components, the Galactic magnetic field (GMF) may well be the most enigmatic. Only partially observable through indirect means, its study relies heavily on modeling, almost exclusively using line-of-sight integrated radio-polarimetric data. Although much has been learned, many questions are still unanswered especially about the turbulent, small-scale field component and out-of-plane field.

The crucial innovations proposed here are large independent data sets with 3D (distance) information – which can only be provided by stars polarized due to differential absorption by interstellar dust, with known distances – and more advanced Bayesian statistics which allows including prior knowledge and enables quantitative model comparison.

I propose to use 2 new polarization surveys in the V (visual) band, resulting in polarimetry of millions of stars across the southern sky. With distance information provided by the GAIA satellite, this improves the current data situation by 3 orders of magnitude. We will test GMF models against all available data, employing a Bayesian inference software package which we are developing. In the process, we will produce the first 3D all-sky (out to absorption limits) dust distribution consistent with both UV/optical/near IR absorption and optical polarization.

This research will result in a next-generation GMF model that includes all observational GMF tracers and can use informative priors. It will allow mapping out interstellar magnetized turbulence in the Galaxy, instead of providing averaged parameters only, and understanding the interplay between the local GMF, gas and dust. Its legacy is a 1000x increased stellar polarization catalog, an all-sky 3D dust model, a bayesian sampler for GMF models, and a superior GMF model for use in cosmic ray modeling or foreground subtraction.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788829	**MSTAR**	**PE9** Universe Sciences

Principal Investigator:	**Dr. JONATHAN TAN**
Host Institution:	Chalmers Tekniska Hoegskola Ab, SE

Massive Star Formation through the Universe

Massive stars are important throughout astrophysics, yet there remain many open questions about how they form. These include: What is the accretion mechanism of massive star formation? What sets the initial mass function of stars, especially at the highest masses? What is the relation of massive star formation to star cluster formation? How do massive star and star cluster formation vary with galactic environment? What was the nature of the first stars to form in the universe and could these have been the seeds for supermassive black holes? With recent advances in both theoretical/computational techniques and observational facilities, the time is now ripe for progress on answering these questions.

Here we propose an ambitious research program that combines latest theoretical studies of massive star and star cluster formation, including analytic, semi-analytic and full numerical simulations, with state-of-the-art observational programs, including several large surveys. We will: 1) Develop new theoretical models for how individual massive stars form from gas cores, focusing on diagnostics and including study of how the process depends on galactic environment; 2) Test these protostar models against observations, especially with ALMA, SOFIA, JVLA, HST and in the near future with JWST and eventually TMT & E-ELT; 3) Develop theoretical models for star cluster formation, including both magneto-hydrodynamics of the gas and N-body modeling of the young stellar population, with the focus on how massive stars form and evolve in these systems; 4) Test these protocluster models against observational data of young and still-forming star clusters, especially with ALMA, HST, Chandra, JWST and ground-based near-IR facilities; 5) Explore new theoretical models of how the first stars formed, with potential implications for the origins of supermassive black holes - one of the key unsolved problems in astrophysics.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803158	**Cat-In-hAT**	**PE9** Universe Sciences

Principal Investigator: **Dr. ONDREJ PEJCHA**
Host Institution: Univerzita Karlova V Praze, CZ

Catastrophic Interactions of Binary Stars and the Associated Transients

One of the crucial formation channels of compact object binaries, including sources of gravitational waves, critically depends on catastrophic binary interactions accompanied by the loss of mass, angular momentum, and energy ("common envelope" evolution - CEE). Despite its importance, CEE is perhaps the least understood major phase of binary star evolution and progress in this area is urgently needed to interpret observations from the new facilities (gravitational wave detectors, time-domain surveys).

Recently, the dynamical phase of the CEE has been associated with a class of transient brightenings exhibiting slow expansion velocities and copious formation of dust and molecules (red transients - RT). A number of RT features, especially the long timescale of mass loss, challenge the existing CEE paradigm.

Motivated by RT, I will use a new variant of magnetohydrodynamics to comprehensively examine the 3D evolution of CEE from the moment when the mass loss commences to the remnant phase. I expect to resolve the long timescales observed in RT, characterize binary stability in 3D with detailed microphysics, illuminate the fundamental problem of how is orbital energy used to unbind the common envelope in a regime that was inaccessible before, and break new ground on the amplification of magnetic fields during CEE.

I will establish RT as an entirely new probe of the CEE physics by comparing my detailed theoretical predictions of light curves from different viewing angles, spectra, line profiles, and polarimetric signatures with observations of RT. I will accomplish this by coupling multi-dimensional moving mesh hydrodynamics with radiation, dust formation, and chemical reactions. Finally, I will examine the physical processes in RT remnants on timescales of years to centuries after the outburst to connect RT with the proposed merger products and to identify them in time-domain surveys.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803193	**BEBOP**	**PE9** Universe Sciences

Principal Investigator: **Dr. AMAURY TRIAUD**
Host Institution: The University Of Birmingham, UK

Binaries Escorted By Orbiting Planets

Planets orbiting both stars of a binary system -circumbinary planets- are challenging our understanding about how planets assemble, and how their orbits subsequently evolve. Long confined to science-fiction, circumbinary planets were confirmed by the Kepler spacecraft, in one of its most spectacular, and impactful result. Despite Kepler's insights, a lot remains unknown about these planets. Kepler also suffered from intractable biases that the BEBOP project will solve.

BEBOP will revolutionise how we detect and study circumbinary planets. Conducting a Doppler survey, we will vastly improve the efficiency of circumbinary planet detection, and remove Kepler's biases. BEBOP will construct a clearer picture of the circumbinary planet population, and free us from the inherent vagaries, and important costs of space-funding. Thanks to the Doppler method we will study dynamical effects unique to circumbinary planets, estimate their multiplicity, and compute their true occurrence rate.

Circumbinary planets are essential objects. Binaries disturbe planet formation. Any similarity, and any difference between the population of circumbinary planets and planets orbiting single stars, will bring novel information about how planets are produced. In addition, circumbinary planets have unique orbital properties that boost their probability to experience transits. BEBOP's detections will open the door to atmospheric studies of colder worlds than presently available.

Based on already discovered systems, and on two successful proofs-of-concept, the BEBOP team will detect 15 circumbinary gas-giants, three times more than Kepler. BEBOP will provide an unambiguous measure of the efficiency of gas-giant formation in circumbinary environments. In addition the BEBOP project comes with an ambitious programme to combine three detection methods (Doppler, transits, and astrometry) in a holistic approach that will bolster investigations into circumbinary planets, and create a lasting legacy.

Project End Date: **31-OCT-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
815673	**GRAMS**	**PE9** Universe Sciences

Principal Investigator: **Dr. ENRICO BARAUSSE**
Host Institution: Scuola Internazionale Superiore Di Studi Avanzati, IT

GRavity from Astrophysical to Microscopic Scales

General Relativity (GR) describes gravity on a huge range of scales, field strengths and velocities. However, despite its successes, GR has been showing its age. Cosmological data support the existence of a Dark Sector, but may also be interpreted as a breakdown of our understanding of gravity. Also, GR is intrinsically incompatible with quantum field theory, and should be replaced, at high energies, by a (still unknown) quantum theory of gravity.

This deadlock may prelude to a paradigm change in our understanding of gravity, possibly triggered by the direct observations of neutron stars and black holes by gravitational-wave interferometers. The recent LIGO/Virgo observations, and in particular the coincident detection of electromagnetic and gravitational signals from neutron-star binaries, have already made a huge impact on our theoretical understanding of gravity, by severely constraining several extensions of GR.

GRAMS is a high-risk/high-gain project seeking to push the implications of these observations even further, by exploring whether the existing LIGO/Virgo data, and in particular their absence of non-perturbative deviations from GR, are consistent with gravitational theories built to reproduce the large-scale behaviour of the Universe (i.e. the existence of Dark Energy and/or Dark Matter), while at the same time passing local tests of gravity thanks to non-perturbative screening mechanisms. I will prove that the very fact of screening local scales makes gravitational emission in these theories much more involved than in GR, and also intrinsically unlikely to yield results in agreement with existing (and future) gravitational-wave observations. This would be a huge step forward for our understanding of cosmology, as it would rule out a modified gravity origin for the Dark Sector. Even if this conjecture is incorrect, GRAMS will provide the first numerical-relativity simulations of compact binaries ever in gravitational theories of interest for cosmology.

Project End Date: **31-MAR-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818665	**UniSDyn**	**PE9** Universe Sciences

Principal Investigator: **Dr. MAARIT KÄPYLÄ**
Host Institution: Aalto-Korkeakoulusaatio, FI

Building up a Unified Theory of Stellar Dynamos

Magnetic fields are ubiquitous in the universe. The special property of cosmic magnetism is that, in the majority of objects hosting magnetic fields, those fields are organized, such that some meaningful averaging can reveal global structure and systematic behavior. In the Sun, averaging over longitude reveals the equatorward migration of the emergence region of the sunspots, forming the famous butterfly diagram. Further, vigorous turbulence is present in a wide variety of astrophysical systems, and yet they still exhibit organized magnetic fields. These observations prompt the search for a theory to explain how order can arise and sustain itself in such chaos. We claim that the available theories are incomplete, especially in the case of solar-like stars which becomes apparent if we view the Sun as one star among many. We propose a coherent plan of advancement in which each theory shall be tested by requiring it also to explain the cyclic dynamo action seen in more active rapid rotators.

UNISDYN project attacks these very problems with novel simulations and data analysis tools. Our path to resolve them is to enhance the state-of-the-art stellar dynamo models with the relevant descriptions of the turbulent processes. This goal is reached in three steps. (i) We will produce improved convection dynamo simulations to serve as laboratories from which (ii) the turbulent transport coefficients are directly measured with a novel test methods suite. (iii) Finally, global dynamo models incorporating the turbulent effects in full are constructed based on (i) and (ii) results. These results will allow us to unify stellar dynamo theory for solar-like inactive and rapidly rotating active stars. The developed toolbox has direct applications in other fields of astrophysics, such as accretion and galactic disk dynamos, and industry, such as combustion engines and fusion reactors.

Project End Date: **30-APR-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818940	**ICYBOB**	**PE9** Universe Sciences

Principal Investigator: **Dr. CLARE DOBBS**
Host Institution: The University Of Exeter, UK

Initial Conditions of YMCs, Birth of OB associations and long term evolution of stellar clusters

The goal of this proposal is to establish a new era of stellar cluster evolution research by performing numerical simulations on different scales, and of different stages of a cluster's life, from the formation of YMCs, the formation and evolution of OB associations, to the evolution of clusters and associations in galaxies. The PI is one of the pioneers of galactic simulations of GMC and star formation was one of the first numericists to perform galactic scale simulations of molecular cloud formation and evolution, and has produced some of the most realistic and sophisticated isolated simulations of galaxies in this field to date. The next challenge is to follow cluster evolution, something which has not yet been attempted numerically. And, with the GaiaAIA instrument set to transform stellar astronomy in our Galaxy, our work will provide a fundamental theoretical counterpart. Key questions we will address include i) how does gas disperse from new clusters and what happens to that gas, ii) how do YMCs form, iii) how do new clustersGiant Molecular Clouds (GMCs) evolve into OB associations, and ivii) how long can clusters survive for as they orbit a galaxy and what causes their destruction.

Project End Date: **31-MAY-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833251	**PROMINENT**	**PE9** Universe Sciences

Principal Investigator: **Dr. RONY KEPPENS**
Host Institution: Katholieke Universiteit Leuven, BE

Solar prominences: unraveling the ultimate condensation catastrophe

The most spectacular solar eruptions recorded in history - such as the Grand Daddy Prominence eruption on the 4th of June 1946 - invariably involve the violent ejection of a prominence: a giant, cool and dense plasma cloud that formed spontaneously within the million-degree solar corona. The role of the dominant prominence mass in all magnetically mediated coronal mass ejections is poorly understood, and yet a typical prominence easily outweighs our Earth population in mass (and the Earth itself in size). While they pervade the solar corona in all shapes and sizes, surprisingly little is known on their formation and ultimate disappearance. At the advent of two revolutionary space missions to the inner reaches of our heliosphere (Parker Probe and Solar Orbiter), a dedicated effort on ab initio prominence simulations beyond current resolution limits is needed. This must provide conclusive answers to intriguing riddles: How, where and why does the solar corona spontaneously condense to form these gigantic structures? What is the magnetic field topology throughout the prominence body, and how can it support their weight against solar gravity? What causes the fine structure (so-called threads and barbs) throughout the prominence body, and what is the role of the mysterious solar tornadoes often found at their feet? Can we use their natural oscillation frequencies seismologically? Is it feasible to predict their eruption, and can one quantify their role in space weather contexts? Armed with state-of-the-art, grid-adaptive software to efficiently exploit current and next generation supercomputers, we will resolve these mysteries, confront historic and forthcoming observations, and train a new generation of solar physicists. Along the way, we unravel fundamental processes relevant in many astrophysical contexts: how do radiatively driven, thermal instabilities induce catastrophic, non-gravitationally mediated condensations?

Project End Date: **31-AUG-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833925	**STAREX**	**PE9** Universe Sciences

Principal Investigator: **Dr. GEORGES MEYNET**
Host Institution: Universite De Geneve, CH

STARs at the EXtreme

The first stars in the Universe are extreme objects. Extreme in their composition: they are made of material having been processed only by the Big Bang nucleosynthesis, and having a content in dark matter likely very different from the one of the present-day stars. Extreme in their properties: one of the most important properties is their mass that might reach values as high as even 100 000 solar masses (supermassive black-hole seeds). Their properties may differ from the today massive star populations also by their likely fast axial spins, the processes of mass loss, their magnetic fields, multiplicity. Extreme in their physics: born in over densities made mainly by dark matter, the physics of candidate dark matter particles may have a significant effect on their evolution and produce what has been called dark or frozen stars, i.e. stars sustained by dark-matter particle annihilation. The aim of STAREX is to determine which observable features can be used to constrain the composition (baryonic and dark matter), the properties (masses, rotation, magnetic field, multiplicity) and the physics of the first stars in the Universe. These observables will be collected by present-day and future facilities as, for instance, the JWST, ELT, adLigo, VIRGO, LISA and are linked to ionising fluxes, nucleosynthesis, radiation of both stellar populations and transient events, and gravitational waves. STAREX will explore new physical processes, build and use new numerical tools, provide observables that will account together for a sophisticated description of the physics of individual stars, single or in binary systems, and for the dynamics of the stars in the first stellar clusters. STAREX is at the crossroad of topics such as stellar physics, nucleosynthesis, hydrodynamics, evolution of galaxies, and will potentially engender ground-braking consequences for observational cosmology, astrophysics and even fundamental physics (fluid dynamics, dark matter properties).

Project End Date: **31-DEC-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834148	**GREATDIGINTHESKY**	**PE9** Universe Sciences

Principal Investigator: **Dr. RODRIGO IBATA**
Host Institution: Centre National De La Recherche Scientifique, FR

Accelerating Galactic Archaeology

Why most of the matter in the Universe appears to be dark, and constituted of some unknown particles, is one of the most important open questions in physics today. Here we propose to investigate the relative merits of different possibilities for the nature of this dark matter, as well as alternative proposals for the nature of the gravitational interaction, by comparing their predictions to new high spatial resolution measurements of the 3D acceleration field in the Milky Way. These measurements will be achieved primarily by finding and analysing the many stellar streams that criss-cross our Galaxy. We have already built a stream-finding prototype that we have used with the Gaia mission's second data release (DR2) to detect 13 new beautiful phase-space streams in the Milky Way. This project aims to develop analysis techniques that will allow us to combine data from all relevant sky surveys together with future Gaia releases to identify many other Galactic star streams. It is plausible that 100 or more streams may be identified by the end of our project. The conjoint analysis of these interwoven structures will provide us with the means to derive, for the very first time, the three-dimensional acceleration field on scales of 1-100 kpc. The streams will be used to probe the granularity of the dark matter distribution, testing whether their kinematics and sub-structure are consistent with interaction with the expected sub-halos of the standard Λ Cold Dark Matter (ΛCDM) paradigm. We will also simulate star streams in several alternative scenarios, including fuzzy dark matter, dipolar dark matter, superfluid dark matter, and modified Newtonian dynamics, and quantify their relative merits to simulations in ΛCDM. Together, these studies will test theories of gravity and dark matter theories, place the best constraints on the distribution of dark matter in our Galaxy, and probe the substructure of the dark matter, thereby setting the state of the art for the next decade.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851103	**PeVSPACE**	**PE9** Universe Sciences

Principal Investigator: **Dr. ANDRII TYKHONOV**
Host Institution: Universite De Geneve, CH

Direct Detection of TeV--PeV Cosmic Rays in Space

The DArk Matter Particle Explorer (DAMPE) mission has recently marked a new epoch in astroparticle physics, extending the direct measurements of cosmic ray spectra beyond a TeV with unprecedented energy resolution. With this project, based on my leadership position in DAMPE and its unique data, I propose to fundamentally improve the precision of direct cosmic ray measurements at the highest energies – in the TeV–PeV range, using for the first time a state-of-the-art artificial intelligence approach. The project will help to solve the century-long problem of cosmic-ray origin at such high energies and its effects on the Universe composition. It will study the cosmic-ray spectrum close to the region of a mysterious decline, so-called “knee”, and shed light on the nature of Dark Matter through the discovery of characteristic fine structures in cosmic-ray and gamma-ray spectra. To achieve this, based on my expertise I propose: i) to develop the TeV–PeV cosmic-ray track reconstruction and identification techniques, using a deep learning or similar artificial intelligence approach; ii) to set up a unique research programme to iteratively improve the precision of hadronic Monte-Carlo models in this rarely explored energy domain, based on the available DAMPE data and data from future experiments. The developed results will be applied to the processing of DAMPE data at the first stage, and will be then extended to the next generation High Energy Cosmic Radiation Detection (HERD) experiment. The research strategy is designed to reduce drastically the dominant uncertainties of the cosmic-ray measurements in space, related to the particle type/direction identification and modeling of hadronic interactions in the detector. As a result of the project, cosmic ray spectra will be directly measured in space in TeV–PeV energy range with qualitatively higher precision, opening up an unprecedented opportunities for new discoveries.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851622	**DustOrigin**	**PE9** Universe Sciences

Principal Investigator: **Dr. ILSE DE LOOZE**
Host Institution: Universiteit Gent, BE

The origin of cosmic dust in galaxies

Dust pervades the Universe; it is responsible for the obscuration of 50% of starlight, for the formation of molecular hydrogen, for the cooling of clouds collapsing to form stars, and for radiative feedback processes capable of driving massive galactic outflows. Due to the unknown origin of dust, cosmological simulations lack detailed dust physics, which will affect the outcome of galaxy evolution models. Current work by myself and collaborators have delivered observational evidence for the efficient condensation of dust in supernova remnants (SNRs). Up to now, grain growth is assumed to be the dominant dust source, but a viable chemical route for growing grains in the ISM has yet to be found. Current dust destruction efficiencies have been overestimated due to the neglect of inhomogeneous cloud structures. With Herschel's legacy of dust in the nearby Universe and ALMA's capabilities to detect the first infrared light of galaxies, this is an opportune time to re-evaluate the origin of dust. Building upon my expertise in dust in both SNRs and nearby galaxies, I will re-evaluate net SN dust production rates by inferring the composition and grain size of SN dust based on my own dust polarimetric data of Galactic SNRs. With my collaborators from LERMA, I will exploit a new experimental technique to simultaneously infer adsorption and diffusion energies; these laboratory measurements will allow me to assess whether grain growth can provide a viable mechanism for dust formation. My Dust and Element evolUtion modelS (DEUS) will be expanded to include a 3D inhomogeneous ISM structure, and will be exploited to model the destruction of dust by shocks in a realistic multi-phase ISM. Finally, the evolution of dust and metals will be modelled in a statistical sample of low- and high-redshift galaxies to infer the dominant dust sources. The three pillars (observations, modelling and laboratory experiments) of my ERC project are essential to solve the origin of dust problem.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852977	**MULTIDIMSPEC**	**PE9** Universe Sciences

Principal Investigator: **Dr. KARIN LIND**
Host Institution: Stockholms Universitet, SE

Multi-dimensional analysis of the metal-poor Galaxy

The history of the cosmos is written in starlight. The stellar surface contains a fossil fingerprint of the chemical composition of its birth cloud, modulu evolutionary effects. It is therefore possible to extract detailed knowledge about the history of galaxies like the Milky Way by studying stars born at different locations and ages: Galactic archaeology. Deciphering the stellar spectra in terms of stellar properties like temperature and chemical composition, however, requires realistic 3-dimensional models of the stellar atmospheres and non-equilibrium spectral line formation, which is the focus of this ambitious and timely project. Together with unprecedented large stellar spectroscopic surveys of the Milky Way, this project will usher in a new era in stellar astrophysics and Galactic archaeology. We will develop highly realistic 3D hydrodynamical simulations of stellar atmospheres for a very wide range of stellar temperatures, gravities and chemical compositions, which will be used to predict the detailed stellar spectra. I will extend the pioneering work I have done in developing comprehensive 3D non-equilibrium (non-LTE) radiative transfer calculations to a large number of elements of key astrophysical importance, thus removing a major systematic error in current spectroscopic analyses. Our endeavours in this field are unique world-wide and ensure that observations with the new generation of telescopes and instruments will be analysed in an optimal manner. I am spearheading the spectroscopic analyses to determine stellar parameters and chemical compositions for many millions of stars in spectroscopic surveys of the Milky Way, like the 200MEUR 4MOST project. This ERC project will guarantee the success of these major investments by providing the critical manpower for the analysis. I will also exploit these huge surveys to study the very first stars born after the Big Bang and the build-up of the ancient Milky Way halo through accretion of smaller galaxies.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
853022	**PEVAP**	**PE9** Universe Sciences

Principal Investigator: **Dr. JAMES OWEN**
Host Institution: Imperial College Of Science, Technology And Medicine, UK

Planet Evaporation as a Window into Exoplanetary Origins

Modern astronomy has truly entered the exoplanet era. Although our knowledge of what planet formation produces has grown immensely thanks to observational advances, our actual understanding of the physical processes that give rise to planets and planetary systems is limited. We now know most stars are unlike our own Sun, in that they host planets which orbit around their star with periods of months or shorter, yet many have volatile rich atmospheres. These planets must result from a dominant (if not the dominant) mode of planet formation, yet they were completely missing from our planet formation theories a decade ago.

Planets which are close to their parent star are extremely vulnerable to mass-loss through evaporation, where UV/X-ray photons can heat their upper atmospheres to close to the escape temperature, causing them to lose-mass. Recently, I have played a leading role in showing that evaporation drives the evolution of the observed exoplanet population. Thus, the observed exoplanet population is not representative of the one at birth; to use it as a probe of planet formation we must understand evaporation. However, the evaporation of highly-irradiated planetary atmospheres is not well understood. This especially true for terrestrial planets where the atmospheres are dominated by heavy elements.

My team will use a combination of theory, simulations and observations to build the first global and comprehensive models of exoplanet evaporation. In doing this, my team will use evaporation as a window into planet formation by answering the following key questions:

1 What are the mass-loss rates and evaporative flow structures for the full spectrum of observed planets?

2 How can we use observations of evaporating planets to learn about their compositions and histories?

3 How does evaporation affect and control the evolution of planets and their atmospheres?

By understanding how exoplanets evaporate and evolve, my team will unveil the exoplanet population at birth.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
853291	**FutureLSS**	**PE9** Universe Sciences

Principal Investigator: **Dr. FLORIAN BEUTLER**
Host Institution: University Of Portsmouth Higher Education Corporation, UK

Fundamental physics from the large-scale structure of the Universe

The last 30 years have been a golden era of cosmological discoveries, which revolutionized our understanding of the physical concepts, which govern our Universe. New discoveries indicate that the beginning of our Universe might have been dominated by the inflaton field, which decayed during the first second of the Universe's existence, introducing tiny ripples in the matter distribution, which ultimately sourced later galaxy formation. The future of our Universe is dominated by dark energy, which causes the current Universe to accelerate in its expansion. Both inflation and dark energy are theoretical constructs, which help to explain current observational results, but their fundamental role in physics is not yet understood.

The distribution of galaxies in the Universe encodes an enormous amount of information, which holds the key to unravel new fundamental concepts of nature. The main goal of this proposal is to use galaxy surveys to uncover convincing evidence for the inflationary scenario and to reveal clues that will help to determine the nature of dark energy.

My team will make use of data from the DESI and Euclid experiments, a new generation of galaxy surveys, which will provide datasets more than an order of magnitude larger than what is available today, thus allowing a decisive step forward with an exciting discovery potential. Such measurements will face significant challenges in systematics control, non-linear modeling, and computational limitations. In this proposal, I will outline my plan to develop new statistical estimators, apply cutting-edge modeling techniques, and access new observables to constrain cosmological models. This project will produce results going beyond cosmology, impacting particle- as well as high energy physics. With DESI starting in late 2019 and Euclid in 2021 this work is timely and my experience in the clustering analysis with such datasets puts me in a unique position to lead the cosmological exploitation of these experiments.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865624	**GPRV**	**PE9** Universe Sciences

Principal Investigator: **Dr. SUZANNE AIGRAIN**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Overcoming stellar activity in radial velocity planet searches

Radial velocity (RV) planet searches are a key exoplanet detection method, and one of the only ways to measure a planet's mass. The best RV instruments today reach precisions well below 1 m/s, something which would have seemed impossible 30 years ago. The key factor limiting the sensitivity of RV surveys now is stellar activity. Regions of enhanced magnetic flux on the stellar surface alter the shape of absorption lines in the stellar spectrum, and perturb the measured RVs. I have developed physically motivated but flexible, data-driven methods to disentangle planets from activity in RV data, which are critical to the success of future surveys. I now propose to apply these state-of-the-art techniques to the very large sample of multi-epoch spectra collected by HARPS and HARPS-N, the leading RV spectrographs of the past decade, and then to the forthcoming Terra Hunting Experiment (THE), which will use a copy of HARPS on a dedicated telescope to search for Earth-analogues around nearby stars.

The combined HARPS(N) archives are a treasure trove of information on activity-induced perturbations to spectra and RVs, which is currently under-exploited. This project have a transformative effect on our understanding of different types of activity effects, their dependence on stellar properties, and their signatures in the spectra and RVs. It will reveal planets that were missed by previous analyses, particularly around active (young) stars. Finally, it sets out a clear route to the efficient mitigation of activity effects that the THE survey requires to achieve its goals. THE will discover some of the best exoplanet characterisation targets for the next 15-20 years, and my ERC-funded team will be central to its success.

Project End Date: **31-DEC-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865637	**Hot Milk**	**PE9** Universe Sciences

Principal Investigator: **Dr. GABRIELE PONTI**
Host Institution: Istituto Nazionale Di Astrofisica, IT

Flows of hot plasma connecting the Milky Way centre to the corona, halo and beyond

We are less than one year away from the beginning of a revolution in our understanding of the hot, X-ray emitting, plasma of the Milky Way.
The growth of galaxies in the local Universe critically depends on the interplay (via outflows and re-condensation) between the hot plasma with the other phases of the interstellar medium (ISM). As a prototype for typical spiral galaxies, the Milky Way offers the unique opportunity to capture the important details of such feedback all the way from sub-parsec to galactic scales.
In the 90's, the ROSAT all-sky X-ray maps confirmed the existence of a hot component of the ISM, the Galactic corona. However, because of strong obscuration in the soft X-ray energy band, those maps have a limited horizon of ~1 kpc in the Galactic plane. Therefore, despite the fundamental role of the hot ISM phase, its properties are still basically unknown outside the Solar neighbourhood.
My XMM surveys of the Galactic centre (GC) demonstrate that the hot ISM phase can be traced throughout the disc in the harder X-ray band, confirming the feasibility of this ERC project and the strong connection between GC activity and the Galactic corona. Additionally, the hot plasma is a plausible candidate for containing the missing Galactic baryons and a key ingredient for galaxy evolution. However, so far only less than 0.03% of the Milky Way has been covered by the narrow fields of view of current X-ray imaging telescopes.
The eROSITA all-sky survey will rectify this state of affairs. Should this ERC proposal be approved, we will trace the connection and feedback between the Galactic corona and halo with the energetic activity at the GC (e.g., due to cosmic rays, stellar and AGN outflows). This will represent one to two orders of magnitude improvement in sensitivity and/or coverage, compared to current surveys.
Our sensitive X-ray maps will represent an invaluable legacy for future multi-wavelength studies with current and next generation array instruments.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865657	**QUANTUMGRAIN**	**PE9** Universe Sciences

Principal Investigator: **Dr. ALBERT RIMOLA**
Host Institution: Universidad Autonoma De Barcelona, ES

Quantum Chemistry on Interstellar Grains

The Universe is molecularly rich, comprising from the simplest molecule (H2), to complex organic molecules (e.g., NH2CHO) and biomolecules (e.g., amino acids). The physical phases involved in a Solar-type planetary system formation go hand-in-hand with an increase in molecular complexity, which is ultimately connected with the origin of life. Interstellar (IS) grains play a key role in this chemical evolution as they provide surfaces where key chemical reactions occur. The IS grain chemistry is not fully understood yet. Spectroscopic astronomical observations combined with astrochemical modelling and laboratory experiments have dedicated great efforts to this end but they are still severally limited at reproducing, characterizing and, ultimately, understanding truly existing IS surface reactions. The QUANTUMGRAIN project aims to overcome such limitations by adopting a fourth approach: new state-of-the-art quantum chemistry simulations. These simulations will provide unique, unprecedented information at a molecular level (structures, energetics and dynamics) of the physico-chemical processes occurring in IS surface reactions, with the final objective to fully unveil the actual chemistry on IS grains. To achieve this objective QUANTUMGRAIN is based on three pillars: i) construction of realistic atom-based structural models for IS grains to characterize their structural, energetic and spectroscopic features, ii) molecular simulation of crucial “on-grain” reactions (formation of simple molecules, complex organic molecules and biomolecules) to disentangle the most favourable mechanisms, and iii) assessment of the actual role of IS grains in each reaction (catalyst? concentrator? third body?) to know why their presence is fundamental. My ambition is to have a complete, accurate molecular description of the different elementary physico-chemical steps involved in IS surface reactions, with the ultimate goal to definitely unveil in a comprehensive way the IS grain chemistry.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865932	**SNeX**	**PE9** Universe Sciences

Principal Investigator: **Dr. HAGAI PERETS**
Host Institution: Technion - Israel Institute Of Technology, IL

The origins of thermonuclear supernova explosions

Type-Ia supernovae (SNe) are thought to originate from thermonuclear explosions of carbon-oxygen (CO) white-dwarfs (WDs). They play a key role in the evolution of the universe (producing most of the Iron-peak elements); and serve as critical cosmological distance-indicators. The main proposed SNe progenitors are CO-WDs accreting material from stellar companions; and mergers of two CO-WDs. However, all suggested models fail to reproduce the diverse physical characteristics of Ia-SNe; their inferred rates/ages/luminosity distrbution; and their puzzling wide sub-types diversity. Finding the origins and the evolutionary pathways of thermonuclear SNe remains one of the most important “holy grail” open questions in modern astronomy. Here we propose novel directions and potential solutions to this question, and suggest new scenarios for the origin of all sub-types of thermonucelar SNe. Supported by preliminary results, we propose that (1) the little-explored mergers of CO-WDs with hybrid He-CO WDs play a key-role in producing most types of SNe, and may provide a viable model for the origin of the majority of thermonuclear SNe, their diversity and their distrbutions; (2) neutron star-WD mergers may explain the origin of peculiar rapidly evolving SNe; (3) the channel of exploding accretion-grown massive CO-WDs never/rarely gives rise to standard Ia-SNe. We propose an end-to-end open-source-based modelling of SNe (providing easy access and reproducibiliy of our results) including stellar evolution of their progenitors; 3D hydro simulations of WD mergers; 2D (+3D) thermonuclear-hydrodynamical+radiative-transfer models (predicting detailed light-curve/spectra/compostion observables); and population synthesis studies. Our proposed science can potentially transform the field; solve the century-long puzzle of Ia-SNe and explain their origins; and provide critical input for understanding the evolution of the universe and the measurements of its fundamental cosmological parameters.

Project End Date: **31-JUL-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866070	**SCIFY**	**PE9** Universe Sciences

Principal Investigator: **Dr. DENIS DEFRERE**
Host Institution: Universite De Liege, BE

Self-Calibrated Interferometry for Exoplanet Spectroscopy

The spectral characterisation and understanding of terrestrial exoplanets is currently one of the most ambitious and challenging long-term goals of astrophysics. All observing techniques with the potential to tackle this challenge face the same limitations: the overwhelmingly dominant flux of the host star and/or the lack of angular resolution. A very promising technical solution around these issues is nulling interferometry, which combines the advantages of stellar interferometry (high angular resolution) and coronagraphy (starlight rejection). For several years, we have been developing both data acquisition and data processing techniques based on self-calibration of the interferometric observable and demonstrated record-breaking starlight rejection on two American ground-based facilities. With the SCIFY project, I propose to prototype the first nulling interferometric instrument for the European Very Large Telescope Interferometer. By leveraging its state-of-the-art infrastructure, long baselines, and strategic position in the Southern hemisphere, the new VLTI instrument will be able to carry out several high-impact exoplanet programmes to characterise the chemical composition of Jupiter-like exoplanets at the most relevant angular separations (i.e., close to the snow line) and better understand how planets form and evolve. To achieve these goals, we will demonstrate a new observing technique called spectral self-calibration, combining nulling interferometry with high-dispersion spectroscopy, and adapt our advanced post-processing techniques to the VLTI. This will provide a new and more robust open-source general-purpose interferometric data reduction tool to the VLTI community. In the long term, the SCIFY project will be a cornerstone in the roadmap leading to the characterisation of terrestrial exoplanets and the search for life beyond Earth.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677898	**MARCAN**	**PE10** Earth System Science

Principal Investigator: **Dr. AARON MICALLEF**
Host Institution: Helmholtz Zentrum Fur Ozeanforschung Kiel, DE

Topographically-driven meteoric groundwater – An important geomorphic agent

Topographically-driven meteoric (TDM) recharge is a key driver of offshore groundwater systems because sea level has been lower than at present for 80% of the last 2.6 million years. Groundwater has been implicated as an important agent in the geomorphic evolution of passive continental margins and the canyons that incise them. However, the geomorphic efficacy of groundwater remains dubious, and a diagnostic link between landscape form and groundwater processes remains poorly quantified, especially for bedrock and cohesive sediments. Obstacles that prevent going beyond the current state-of-knowledge include: (i) a focus on terrestrial contexts and a lack of mechanistic understanding of groundwater erosion/weathering; (ii) limited information on offshore groundwater architecture, history and dynamics. By addressing the role of TDM offshore groundwater in the geomorphic evolution of the most prevalent types of continental margins, MARCAN is expected to open new scientific horizons in continental margin research and bring about a step-change in our understanding of some of the most widespread and significant landforms on Earth. The project's methodology is rooted in an innovative, multi-scale and multidisciplinary approach that incorporates: (i) the most detailed 3D characterisation of TDM offshore groundwater systems and their evolution during an integral glacial cycle, based on state-of-the-art marine data and hydrogeologic models, and (ii) the development of a comprehensive continental margin geomorphic evolution model, based on realistic laboratory simulations, accurate field measurements and advanced numerical solutions. By placing better constraints on past fluid migration histories, MARCAN will also have strong applied relevance, primarily by improving assessment and exploitation of offshore freshwater as a source of drinking water.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715836	**MICA**	**PE10** Earth System Science

Principal Investigator: **Dr. AKE FAGERENG**
Host Institution: Cardiff University, UK

Mechanics of slow earthquake phenomena: an Integrated perspective from the Composition, geometry, And rheology of plate boundary faults

Major tectonic faults have, until recently, been thought to accommodate displacement by either continuous creep or episodic, damaging earthquakes. High-resolution geophysical networks have now detected 'slow earthquakes', transient modes of displacement that are faster than creep but slower than earthquakes. This project aims to illuminate the unknown mechanism behind slow earthquakes, through an integrated, multi-scale approach. MICA uses the unique natural laboratory of exhumed and active faults, to build numerical models constrained by observed fault geometry and microstructurally defined deformation mechanisms, to determine, for the first time, the rheology of slow slip.

The first objective is to create a model of the slow earthquake source, to constrain the micro- to kilometre-scale internal geometry of plate boundary faults, and the spatial distribution of deformation mechanisms. Fault rocks also retain a deformation sequence, allowing insight to how deformation style evolves with time. Thus, a combination of drill samples from active faults and outcrops of exhumed analogues, from a range of depths, allows for a 4-D model from micro- to plate boundary scale.

By knowing the geometrical distribution of fault rocks, and deciphering their evolution in time, this project will apply geologically constrained numerical models and laboratory constrained stress-strain relationships to determine bulk fault rheology as a function of space. Unique from past models, this project integrates scales from microstructures to plate boundary scale faults, and bases rheological models on deformation mechanisms and fault structures constrained through detailed fieldwork, and also considers the state-of-the-art of geophysical observation. The model focuses on understanding slow earthquakes, but also applies to understanding whether the slow earthquake source can also host fast seismic slip, and what differentiates slowly slipping faults from faults hosting major earthquakes.

Project End Date: **31-JAN-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724602	**RECAP**	**PE10** Earth System Science

Principal Investigator: **Dr. PHILIP STIER**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Oxford, UK

constRaining the EffeCts of Aerosols on Precipitation

Precipitation is of fundamental importance so it is vital to understand its response to anthropogenic perturbations. Aerosols have been proposed to significantly affect precipitation [e.g. Ramanathan et al., 2001]. However, despite major research efforts evidence for a systematic aerosol effect on precipitation remains “ambiguous” [IPCC AR5, Stocker et al., 2013].

The vast majority of prior research [even an entire World Meteorological Organisation assessment report: Levin and Cotton, 2009] has taken a process-driven approach: trying to infer aerosol effects on precipitation through modelling/observing the chain of microphysical processes: from aerosols acting as cloud condensation / ice nuclei via cloud microphysics to precipitation formation of individual clouds. However, this relies on a complete understanding of a very complex and uncertain process chain and there exist no clear strategies to scale the response of individual clouds or cloud systems to larger scales.

RECAP will break this deadlock, introducing a radically different approach to aerosol effects on precipitation: globally, precipitation is energetically controlled, as its release of latent heat has to be balanced by radiative cooling or surface flux changes. However, this constraint breaks down for small scales because divergence of static energy can locally balance excess input of latent heat.

RECAP will systematically constrain the energetic control of aerosol effects on precipitation across scales. This will be achieved through i) a consistent analysis from the process to the global scale building on the latest seamless modelling systems, ii) maximisation of synergies between observations and modelling and iii) use of the latest observations to transition energetic and water budgets and process studies to 4D.

RECAP will deliver the first comprehensive and physically consistent assessment of the effect of aerosols on precipitation across scales, uniting energetic and process-driven approaches.

Project End Date: **30-APR-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725955	**GEOSTICK**	**PE10** Earth System Science

Principal Investigator: **Dr. DANIEL PARSONS**
Host Institution: University Of Hull, UK

Morphodynamic Stickiness: the influence of physical and biological cohesion in sedimentary systems

Our coasts, estuaries, & low-land river environments are some of the most sensitive systems to sea-level rise & environmental change. In order to manage these systems, & adapt to future changes, we desperately need to be able to predict how they will alter under various scenarios. However, our models for these environments are not yet robust enough to predict, with confidence, very far into the future. Moreover, we also need to improve how we use our understanding of modern environments in reconstructing paleo-environments, where significant assumptions have been made in the way in which relationships derived from the modern have been applied to ancient rocks.

One of the main reasons our models, & geological interpretations, of these environments, are not yet good enough is because these models have formulations that are based on assumptions that these systems are composed of only non-cohesive sands. However, mud is the most common sediment on Earth & many of these systems are actually dominated by biologically-active muds & complex sediment mixtures. We need to therefore find ways to incorporate the effect of sticky mud & sticky biological components into our predictions. Recent work my colleagues & I have published show just how important such abiotic-biotic interactions can be: inclusion of only relatively small (<0.1% by mass) quantities of biological material into sediment mixtures can reduce alluvial bedform size by an order of magnitude.

However, this is just a start & there is much to do in order to advance our fundamental understanding & develop robust models that predict the combined effects of abiotic & biotic processes on morphological evolution of these environments under changing drivers & conditions. GEOSTICK will deliver this advance allowing us to test how sensitive these environments are, assess if there are tipping points in their resilience & examine evidence for the evolution of life in the ancient sediments of early Earth and Mars.

Project End Date: **30-APR-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
726349	**CLIMAHAL**	**PE10** Earth System Science

Principal Investigator:	**Dr. ALFONSO SAIZ LOPEZ**
Host Institution:	Agencia Estatal Consejo Superior De Investigaciones Cientificas, ES

Climate dimension of natural halogens in the Earth system: Past, present, future

Naturally-emitted very short-lived halogens (VSLH) have a profound impact on the chemistry and composition of the atmosphere, destroying greenhouse gases and altering aerosol production, which together can change the Earth´s radiative balance. Therefore, natural halogens possess leverage to influence climate, although their contribution to climate change is not well established and most climate models have yet to consider their effects. Also, there is increasing evidence that natural halogens i) impact on the air quality of coastal cities, ii) accelerates the atmospheric deposition of mercury (a toxic heavy metal) and iii) that their natural ocean and ice emissions are controlled by biological and photochemical mechanisms that may respond to climate changes. Motivated by the above, this project aims to quantify the so far unrecognized natural halogen-climate feedbacks and the impact of these feedbacks on global atmospheric oxidizing capacity (AOC) and radiative forcing (RF) across pre-industrial, present and future climates. Answering these questions is essential to predict if these climate-mediated feedbacks can reduce or amplify future climate change. To this end we will develop a multidisciplinary research approach using laboratory and field observations and models interactively that will allow us to peel apart the detailed physical processes behind the contribution of natural halogens to global climate change. Furthermore, the work plan also involves examining past-future climate impacts of natural halogens within a holistic Earth System model, where we will develop the multidirectional halogen interactions in the land-ocean-ice-biosphere-atmosphere coupled system. This will provide a breakthrough in our understanding of the importance of these natural processes for the composition and oxidation capacity of the Earth´s atmosphere and climate, both in the presence and absence of human influence.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
741120	**COMPASS**	**PE10** Earth System Science

Principal Investigator: **Dr. KAREN HEYWOOD**
Host Institution: University Of East Anglia, UK

COMPASS: Climate-relevant Ocean Measurements and Processes on the Antarctic continental Shelf and Slope

Processes on the Antarctic continental shelf and slope are crucially important for determining the rate of future sea level rise, setting the properties and volume of dense bottom water exported globally, and regulating the carbon cycle. Yet our ability to model and predict these processes over future decades remains rudimentary. This deficiency in understanding originates in a lack of observations in this inaccessible region. The COMPASS project seeks to rectify that by exploiting new technology - autonomous marine vehicles called gliders - to observe, quantify and elucidate processes on the continental shelf and slope of Antarctica that are important for climate.

The COMPASS objective is to make a step-change in our quantitative understanding of:
(i) the ocean front that marks the boundary between the Antarctic continental shelf and the open ocean, and its associated current system;
(ii) the interaction between ocean, atmosphere and sea-ice on the Antarctic continental shelf; and
(iii) the exchange of heat, salt and freshwater with the cavities beneath ice shelves.

These goals will be met by a series of targeted ocean glider campaigns around Antarctica, spanning different flow regimes, including areas where warm water is able to access the continental shelf and influence ice shelves, areas where the continental shelf is cold and fresh, and areas where the continental shelf hosts cold, salty, dense water that eventually spills into the abyss. A unique circumpolar assessment of ocean properties and dynamics, including instabilities and mixing, will be undertaken. COMPASS will develop new technology to deploy a profiling glider into inaccessible environments such as Antarctic polynyas (regions of open water surrounded by sea-ice). As well as scientific breakthroughs that will feed into future climate assessments, improving projections of future sea level rise and global temperatures, COMPASS will deliver enhanced design for future ocean observing systems.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
742206	**ATM-GTP**	**PE10** Earth System Science

Principal Investigator: **Dr. MARKKU KULMALA**
Host Institution: Helsingin Yliopisto, FI

Atmospheric Gas-to-Particle conversion

Atmospheric Gas-to-Particle conversion (ATM-GTP) is a 5-year project focusing on one of the most critical atmospheric processes relevant to global climate and air quality: the first steps of atmospheric aerosol particle formation and growth. The project will concentrate on the currently lacking environmentally-specific knowledge about the interacting, non-linear, physical and chemical atmospheric processes associated with nano-scale gas-to-particle conversion (GTP). The main scientific objective of ATM-GTP is to create a deep understanding on atmospheric GTP taking place at the sub-5 nm size range, particularly in heavily-polluted Chinese mega cities like Beijing and in pristine environments like Siberia and Nordic high-latitude regions. We also aim to find out how nano-GTM is associated with air quality-climate interactions and feedbacks. We are interested in quantifying the effect of nano-GTP on the COBACC (Continental Biosphere-Aerosol-Cloud-Climate) feedback loop that is important in Arctic and boreal regions. Our approach enables to point out the effective reduction mechanisms of the secondary air pollution by a factor of 5-10 and to make reliable estimates of the global and regional aerosol loads, including anthropogenic and biogenic contributions to these loads. We can estimate the future role of Northern Hemispheric biosphere in reducing the global radiative forcing via the quantified feedbacks. The project is carried out by the world-leading scientist in atmospheric aerosol science, being also one of the founders of terrestrial ecosystem meteorology, together with his research team. The project uses novel infrastructures including SMEAR (Stations Measuring Ecosystem Atmospheric Relations) stations, related modelling platforms and regional data from Russia and China. The work will be carried out in synergy with several national, Nordic and EU research-innovation projects: Finnish Center of Excellence-ATM, Nordic CoE-CRAICC and EU-FP7-BACCHUS.

Project End Date: **31-MAY-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
742472	**ECCLES**	**PE10** Earth System Science

Principal Investigator: **Dr. PETER COX**
Host Institution: The University Of Exeter, UK

Emergent Constraints on Climate-Land feedbacks in the Earth System

The Land Biosphere is a critical component of the Earth System, linking to climate through multiple feedback processes. Understanding these feedback processes is a huge intellectual challenge. In part because of the pioneering work of the PI (Cox et al., 2000), many of the climate projections reported in the IPCC 5th Assessment Report (AR5) now include climate-carbon cycle feedbacks. However the latest Earth System Models (ESMs) continue to show a huge range in the projected responses of the land carbon cycle over the 21st century. This uncertainty threatens to undermine the value of these projections to inform climate policy. This project (ECCLES) is designed to produce significant reductions in the uncertainties associated with land-climate interactions, using the novel concept of Emergent Constraints - relationships between future projections and observable variations in the current Earth System that are common across the ensemble of ESMs. Emergent Constraints have many attractive features but chief amongst these is that they can make ensembles of ESMs more than the sum of the parts - allowing the full range of ESM projections to be used collectively, alongside key observations, to reduce uncertainties in the future climate. The project will deliver: (i) a theoretical foundation for Emergent Constraints; (ii) new datasets on the changing function of the land biosphere; (iii) Emergent Constraints on land-climate interactions based on observed temporal and spatial variations; (iv) a new generation of scientists expert in land-climate interactions and Emergent Constraints. ECCLES will benefit from the expertise and experience of the PI, which includes training as a theoretical physicist, an early career developing models of the land biosphere for ESMs, and a current career in a department of mathematics where he is at the forefront of efforts to develop and apply the concept of Emergent Constraints (Cox et al., 2013, Wenzel et al., 2016).

Project End Date: **30-SEP-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
755865	**ISOBOREAL**	**PE10** Earth System Science

Principal Investigator: **Dr. KATJA RINNE-GARMSTON**
Host Institution: Luonnonvarakeskus, FI

Towards Understanding the Impact of Climate Change on Eurasian Boreal Forests: a Novel Stable Isotope Approach

The vast boreal forests play a critical role in the carbon cycle. As a consequence of increasing temperature and atmospheric CO2, forest growth and subsequently carbon sequestration may be strongly affected. It is thus crucial to understand and predict the consequences of climate change on these ecosystems. Stable isotope analysis of tree rings represents a versatile archive where the effects of environmental changes are recorded. The main goal of the project is to obtain a better understanding of δ13C and δ18O in tree rings that can be used to infer the response of forests to climate change. The goal is achieved by a detailed analysis of the incorporation and fractionation of isotopes in trees using four novel methods: (1) We will measure compound-specific δ13C and δ18O of leaf sugars and (2) combine these with intra-annual δ13C and δ18O analysis of tree rings. The approaches are enabled by methodological developments made by me and ISOBOREAL collaborators (Rinne et al. 2012, Lehmann et al. 2016, Loader et al. in prep.). Our aim is to determine δ13C and δ18O dynamics of individual sugars in response to climatic and physiological factors, and to define how these signals are altered before being stored in tree rings. The improved mechanistic understanding will be applied on tree ring isotope chronologies to infer the response of the studied forests to climate change. (3) The fact that δ18O in tree rings is a mixture of source and leaf water signals is a major problem for its application on climate studies. To solve this we aim to separate the two signals using position-specific δ18O analysis on tree ring cellulose for the first time, which we will achieve by developing novel methods. (4) We will for the first time link the climate signal both in leaf sugars and annual rings with measured ecosystem exchange of greenhouse gases CO2 and H2O using eddy-covariance techniques.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758199	**NEWTON**	**PE10** Earth System Science

Principal Investigator: **Dr. MANUELE FACCENDA**
Host Institution: Universita Degli Studi Di Padova, IT

NEw Windown inTO Earth's iNterior

Comprehensive seismic programs undertaken in the past few years, combined with emerging new numerical technologies now provide the potential, for the first time, to explore in detail the Earth's interior. However, such an integrated approach is currently not contemplated, which produces physical inconsistencies among the different studies that strongly bias our understanding of the Earth's internal structure and dynamics. Of particular concern are nowadays apparent thermo-petrological anomalies in tomographic images that are generated by the unaccounted-for anisotropic structure of the mantle and that are commonly confused with real thermo-petrological features. Given the diffuse mantle seismic anisotropy, apparent thermo-petrological anomalies contaminate most tomographic models against which tectono-magmatic models are validated, representing a critical issue for the present-day window.

Here we aim to develop a new methodology that combines state-of-the-art geodynamic modelling and seismological methods. The new methodology will allow building robust anisotropic tomographic models that will exploit anisotropy predictions from petrological-thermomechanical modelling to decompose velocity anomalies into isotropic (true thermo-petrological) and anisotropic (mechanically-induced) components.

As a major outcome, we expect to provide a new, geodynamically and seismologically constrained perspective of the current deep structure and tectono-magmatic evolution of different tectonic settings. This new methodology will be applied to the Mediterranean and the Cascadia subduction zone where, despite the abundant seismological observations, large uncertainties about the subsurface structure and tectono-magmatic evolution persist.

Furthermore, we plan to develop a new inversion technique for seismic anisotropy, and release an open source, sophisticated code for mantle fabric modelling, which will allow coupling geodynamic and seismological modelling in other tectonic settings.

Project End Date: **28-FEB-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771012	**TUVOLU**	**PE10** Earth System Science

Principal Investigator: **Dr. RIIKKA RINNAN**
Host Institution: Kobenhavns Universitet, DK

Tundra biogenic volatile emissions in the 21st century

Biogenic volatile organic compounds (BVOCs) influence atmospheric oxidation causing climate feedback thought to be especially significant in remote areas with low anthropogenic emissions, such as the Arctic. Still, we do not understand the dynamics and impact of climatic and biotic BVOC emission drivers in arctic and alpine tundra, which are highly temperature-sensitive BVOC sources.

TUVOLU will redefine tundra BVOC emission estimates to account for rapid and dramatic climate warming accompanied by effects of vegetation change, permafrost thaw, insect outbreaks and herbivory using multidisciplinary, established and novel methodology.

We will quantify the relationships between leaf and canopy temperatures and BVOC emissions to improve BVOC emission model predictions of emission rates in low-statured tundra vegetation, which efficiently heats up. We will experimentally determine the contribution of induced BVOC emissions from insect herbivory in the warming Arctic by field manipulation experiments addressing basal herbivory and insect outbreaks and by stable isotope labelling to identify sources of the induced emission. Complementary laboratory assessment will determine if permafrost thaw leads to significant BVOC emissions from thawing processes and newly available soil processes, or if released BVOCs are largely taken up by soil microbes. We will also use a global network of existing climate warming experiments in alpine tundra to assess how the BVOC emissions from tundra vegetation world-wide respond to climate change.

Measurement data will help develop and parameterize BVOC emission models to produce holistic enhanced predictions for global tundra emissions. Finally, modelling will be used to estimate emission impact on tropospheric ozone concentrations and secondary organic aerosol levels, producing the first assessment of arctic BVOC-mediated feedback on regional air quality and climate.

Project End Date: **31-MAR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771143	**MAGMA**	**PE10** Earth System Science

Principal Investigator: **Dr. BORIS KAUS**
Host Institution: Johannes Gutenberg Universitaet Mainz, DE

Melting And Geodynamic Models of Ascent

The production and migration of magma through the lithosphere results in spectacular geological processes such as volcanic eruptions, giant ore deposits, large magmatic intrusions, and is responsible for the formation of continents on Earth.

Since magmatic systems develop on timescales of millions of years and are not directly accessible, we have to reconstruct them indirectly, such as by studying exhumed magmatic intrusions, or by using geophysical methods. Interpreting these data is complicated, as geophysical techniques only give a present-day snapshot, whereas the geological record yields an incomplete picture of the underlying processes. As a result, most existing ideas on how magmatic systems work remain conceptual and are not necessarily consistent with the mechanics of the lithosphere, which hampers our understanding of such processes.

Here, we will develop and employ a new generation of 3D computer models to simulate the full magmatic system in arcs in a self-consistent manner, while taking both realistic rock rheologies and evolving melt chemistry into account. We will:

1. Derive mechanically-consistent interpretations of active magmatic plumbing systems by combining geophysical and petrological data with geodynamic inverse models.
2. Obtain insights into the physics of magma migration through arcs on geological timescales, by combining numerical simulations with geological constraints from exhumed arc roots, and by targeting several well-studied magmatic intrusions.
3. Unravel how arcs are built on geological timescales, what the role and the rates of magmatic differentiation processes are in this, and how this may have formed continental crust on Earth.

We can thus, for the first time, interpret the available data in a physically consistent manner. This will give deep insights in how magmatic systems develop over geological timescales and why only some evolve into large super-volcanoes.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771369	**Sea2Cloud**	**PE10** Earth System Science

Principal Investigator: **Dr. KARINE SELLEGRI**
Host Institution: Centre National De La Recherche Scientifique, FR

Are marine living microorganisms influencing clouds?

Earth, as a whole, can be considered as a living organism emitting gases and particles in its atmosphere, in order to regulate its own temperature (Lovelock, 1988). In particular oceans, which cover 70% of the Earth, may respond to climate change by emitting different species under different environmental conditions. At the global scale, a large fraction of the aerosol number concentration is formed by nucleation of low-volatility gas-phase compounds, a process that is expected to ultimately determine the concentrations of Cloud Condensation Nuclei (CCN). Nucleation occurrence over open oceans is still debated, due to scarce observational data sets and instrumental limitations, although our recent findings suggest biologically driven nucleation from seawater emissions. Marine aerosol can also be emitted to the atmosphere as primary particles via bubble bursting, among which living microorganisms are suspected to act as excellent ice nuclei (IN) and impact clouds precipitation capacities. The main goal of this proposal is to investigate how marine emissions from living microorganisms can influence CCN, IN and ultimately cloud properties. We will investigate the whole process chain of gas-phase emissions, nucleation and growth through the atmospheric column, and impact on the CCN population. We will also quantify marine primary bioaerosol emissions and evaluate how they impact IN and cloud precipitation capabilities. Experiments will be performed in the Southern Hemisphere, especially sensitive to the natural aerosol concentration variability. We will use an original approach of field mesocosms enclosing the air-sea interface, to link marine emissions to the biogeochemical properties of natural seawater, combined with ambient aerosol measurements simultaneously at low and high altitude sites. At last, a modelling study will help merging process studies and ambient measurements, and assess the role of biologically driven marine emissions on cloud properties.

Project End Date: **30-JUN-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771859	**INTERACTION**	**PE10** Earth System Science

Principal Investigator: **Dr. JAN HAERTER**
Host Institution: Kobenhavns Universitet, DK

Cloud-cloud interaction in convective precipitation

State-of-the-art simulations and observations highlight the self-organization of convective clouds. Our recent work shows two aspects: these clouds are capable of unexpected increase in extreme precipitation when temperature rises; interactions between clouds produce the extremes. As clouds interact, they organize in space and carry a memory of past interaction and precipitation events. This evidence reveals a severe shortcoming of the conventional separation into "forcing" and "feedback" in climate model parameterizations, namely that the "feedback" develops a dynamics of its own, thus driving the extremes. The major scientific challenge tackled in INTERACTION is to make a ground-breaking departure from the established paradigm of "quasi-equilibrium" and instantaneous convective adjustment, traditionally used for parameterization of "sub-grid-scale processes" in general circulation models. To capture convective self-organization and extremes, the out-of-equilibrium cloud field must be described. In INTERACTION, I will produce a conceptual model for the out-of-equilibrium system of interacting clouds. Once triggered, clouds precipitate on a short timescale, but then relax in a "recovery" state where further precipitation is suppressed. Interaction with the surroundings occurs through cold pool outflow,facilitating the onset of new events in the wake. I will perform tailored numerical experiments using cutting-edge large-eddy simulations and very-high-resolution observational analysis to determine the effective interactions in the cloud system. Going beyond traditional forcing-and-feedback descriptions, I emphasize gradual self-organization with explicit temperature dependence. The list of key variables of atmospheric water vapor, temperature and precipitation must therefore be amended by variables describing organization. Capturing the self-organization of convection is essential for understanding of the risk of precipitation extremes today and in a future climate.

Project End Date: **30-JUN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772751	**RAVEN**	**PE10** Earth System Science

Principal Investigator: **Dr. FRANCESCA PELLICCIOTTI**
Host Institution: Eidgenossichen Forschungsanstalt Fur Wald Schnee Und Landschaft, CH

Rapid mass loss of debris covered glaciers in High Mountain Asia

The research proposed uses an integrated data-modelling approach to elucidate the role that debris-covered glaciers play in the water cycle of High Mountain Asia (HMA) and establish how future HMA glacier and runoff will evolve. Debris-covered glaciers are of great significance for the hydrology of HMA, with large contributions to headwater streamflow. Despite this, their mass balance, hydrological role and future changes are poorly constrained, challenging model predictions of future water resources. Debris mantles insulate the ice and reduce ablation, but large-scale research indicates that HMA debris-covered glaciers are losing mass at rates similar to debris-free glaciers. This anomalous behaviour has profound implications for future glacier mass balance and runoff, but has not been reproduced with models, a fundamental limitation to a global assessment. I aim to establish that: 1) supraglacial cliffs and ponds are responsible for higher than expected mass losses of HMA debris-covered glaciers, because they act as windows of energy transfer through the debris; and that 2) their inclusion into models of glacier evolution will provide essential new estimates of glacier changes and future water availability in HMA. RAVEN will achieve these aims through combination of high-resolution satellite observations, field data and physically-based models in four sites along the Himalayan arc. This unprecedented setup captures the variety of climate and glaciers across HMA. Using satellite images I will investigate the spatial distribution and temporal evolution of cliffs and ponds; the insights will be used to develop physically-based models of cliff and pond ablation, which will be included in a glacio-hydrological model. Future glacier and runoff response will be projected using downscaled climate scenarios, allowing new estimates of glacier changes and future runoff for a data-starved region where millions of people depend on the water resources from glaciers and snow.

Project End Date: **30-APR-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
773245	**ISLAS**	**PE10** Earth System Science

Principal Investigator:	**Dr. HARALD SODEMANN**
Host Institution:	Universitetet I Bergen, NO

Isotopic links to atmopheric water's sources

The hydrological cycle, with its feedbacks related to water vapour and clouds, is the largest source of uncertainty in weather prediction and climate models. Particularly processes that occur on scales smaller than the model grid lead to errors, which can compensate one another, making them difficult to detect and correct for. Undetectable compensating errors critically limit the understanding of hydrological extremes, the response of the water cycle to a changing climate, and the interpretation of paleoclimate records. Stable water isotopes have a unique potential to serve as the needed constraints, as they provide measures of moisture origin and of the phase change history. We have recently spearheaded a revised view of the atmospheric water cycle, which highlights the importance of connections on a regional scale. This implies that in some areas, all relevant processes can be studied on a regional scale. The Nordic Seas are an ideal case of such a natural laboratory, with distinct evaporation events, shallow transport processes, and swift precipitation formation. Together with recent technological advances in isotope measurements and in-situ sample collection, this will allow us to acquire a new kind of observational data set that will follow the history of water vapour from source to sink. The high-resolution, high-precision isotope data will provide a combined view of established and novel natural isotopic source tracers and set new benchmarks for climate models. A unique palette of sophisticated model tools will allow us to decipher, synthesize and exploit these observations, and to identify compensating errors between water cycle processes in models. In ISLAS, my team and I will thus make unprecedented use of stable isotopes to provide the sought-after constraints for an improved understanding of the hydrological cycle in nature and in climate models, leading towards improved predictions of future climate.

Project End Date: **31-JUL-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787576	**IntelliAQ**	**PE10** Earth System Science

Principal Investigator: **Dr. MARTIN SCHULTZ**
Host Institution: Forschungszentrum Juelich Gmbh, DE

Artificial Intelligence for Air Quality

The IntelliAQ project will develop novel approaches for the analysis and synthesis of global air quality data based on deep neural networks. The foundation of this project is the world's largest collection of surface air quality measurements, which was recently assembled by the principal investigator and plays a pivotal role in the ongoing first comprehensive Tropospheric Ozone Assessment Report (TOAR). This database will be complemented with data from the world's leading effort to collect global air pollutant measurements in near realtime and combined with high-resolution geodata, weather information, and satellite retrievals of atmospheric composition in order to characterize individual measurement locations and regional air pollution patterns. State-of-the-art deep learning methods will be applied to this unprecedented dataset in order to 1) fill observation gaps in space and time, 2) provide short-term forecasts of air quality, and 3) assess the quality of air pollutant information from diverse measurements. The combination of diverse data sources is unique, and the project will be the first to apply the full potential of deep neural networks on global air quality data. The achievement of the three IntelliAQ objectives will shift the analysis of global air pollutant observations to a new level and provide a basis for the future development of innovative air quality services with robust scientific underpinning. Due to the heterogeneity of the multivariate data, lack of structure, and generally unknown uncertainty of the input data, the project also poses challenges for existing deep learning methods, and will thus lead to new developments in this field. Direct outcomes of the project will be a substantial improvement of global air quality information including methods to assess the quality of air pollution measurements, and a new data-driven method for forecasting air quality at local scales.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802281	**RISeR**	**PE10** Earth System Science

Principal Investigator: **Dr. NATASHA BARLOW**
Host Institution: University Of Leeds, UK

Rates of Interglacial Sea-level Change, and Responses

Global sea-level rise is one of our greatest environmental challenges and is predicted to continue for hundreds of years, even if global greenhouse-gas emissions are stopped immediately. However, the range, rates and responses to sea-level rise beyond 2100 are poorly understood. Current models that project sea-level rise centuries into the future have large uncertainties because the recent observations upon which they are based, encompass too limited a range of climate variability. Therefore, it is crucial to turn to the geological record where there are large-scale changes in climate. Global temperatures during the Last Interglacial were ~1oC warmer than pre-industrial values and 3-5oC warmer at the poles (a pattern similar to that predicted in the coming centuries), and global sea level was 6-9 m higher, far above that experienced in human memory.

Through the RISeR project, I will lead a step-change advance in our understanding of the magnitude, rates and drivers of sea-level change during the Last Interglacial, to inform both global and regional sea-level projections beyond 2100. Specifically I will:

1. Develop new palaeoenvironmental reconstructions of Last Interglacial sea-level change from northwest Europe;
2. Provide the first ever chronological constraints on the timing, and therefore rates, of relative sea-level change that occurred in northwest Europe during the Last Interglacial;
3. Use state-of-the-art numerical modelling to distinguish the relative contributions of the Greenland and Antarctica ice sheets to global sea-level rise during the Last Interglacial;
4. Provide estimates of the land areas and exposed populations in northwest Europe at risk of inundation by long-term (2100+) sea-level rise, providing high-end scenarios critical for coastal-risk management practice.

These ambitious objectives will result in a state-of-the-art integrated study of the most appropriate analogue for a critical global environmental challenge; future sea-level rise.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802777	**MONIFAULTS**	**PE10** Earth System Science

Principal Investigator: **Dr. PIERO POLI**
Host Institution: Universite Grenoble Alpes, FR

Monitoring real faults towards their critical state

The last seismic sequence in Italy, responsible for 298 fatalities and important economic loss, remind us how urgent it is to improve our knowledge about earthquake physics to advance earthquake forecasting. While direct observations during laboratory earthquakes permit us to derive exhaustive physical models describing the behaviour of rocks and to forecast incoming lab-earthquakes, the complex physics governing the nucleation of earthquakes remain poorly understood in real Earth, and so does our ability to forecast earthquakes. I posit that this 'ignorance' emerges from our limited ability to unravel information about fault physics from geophysical data.The objective of this proposal is to introduce a new and integrated methodology to monitor the spatiotemporal evolution of elastic properties on real faults using seismological and geodetic data. We will apply machine learning and covariance matrix factorization for improved earthquake detection, and to discover 'anomalous' seismological signals, which will reveal unknown physical processes on faults. These novel observations will be integrated with time dependent measurements of rheology and deformation, obtained from cutting-edge techniques applied to continuous seismological and geodetic data. Our integrated monitoring approach will be applied to study how faults respond to known stress perturbations (as Earth tides). In parallel, we will analyse periods preceding significant earthquakes to assess how elastic properties and deformation evolve while a fault is approaching a critical (near rupture) state. Our natural laboratory will be Italy, given its excellent geodetic and seismological instrumentation, deep knowledge about faults geometry and the relevant risk posed by earthquakes. Our research will provide new insights about the complex physics of faults at critical state, necessary to understand how real earthquakes nucleate. This project will also have a major impact on observational earthquake forecast.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818449	**AGENSI**	**PE10** Earth System Science

Principal Investigator: **Dr. STIJN DE SCHEPPER**
Host Institution: Norce Norwegian Research Centre As, NO

A Genetic View into Past Sea Ice Variability in the Arctic

Arctic sea ice decline is the exponent of the rapidly transforming Arctic climate. The ensuing local and global implications can be understood by studying past climate transitions, yet few methods are available to examine past Arctic sea ice cover, severely restricting our understanding of sea ice in the climate system. The decline in Arctic sea ice cover is a 'canary in the coalmine' for the state of our climate, and if greenhouse gas emissions remain unchecked, summer sea ice loss may pass a critical threshold that could drastically transform the Arctic. Because historical observations are limited, it is crucial to have reliable proxies for assessing natural sea ice variability, its stability and sensitivity to climate forcing on different time scales. Current proxies address aspects of sea ice variability, but are limited due to a selective fossil record, preservation effects, regional applicability, or being semi-quantitative. With such restraints on our knowledge about natural variations and drivers, major uncertainties about the future remain.

I propose to develop and apply a novel sea ice proxy that exploits genetic information stored in marine sediments, sedimentary ancient DNA (sedaDNA). This innovation uses the genetic signature of phytoplankton communities from surface waters and sea ice as it gets stored in sediments. This wealth of information has not been explored before for reconstructing sea ice conditions. Preliminary results from my cross-disciplinary team indicate that our unconventional approach can provide a detailed, qualitative account of past sea ice ecosystems and quantitative estimates of sea ice parameters. I will address fundamental questions about past Arctic sea ice variability on different timescales, information essential to provide a framework upon which to assess the ecological and socio-economic consequences of a changing Arctic. This new proxy is not limited to sea ice research and can transform the field of paleoceanography.

Project End Date: **31-JUL-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818450	**MERIR**	**PE10** Earth System Science

Principal Investigator: **Dr. ORIT SIVAN**
Host Institution: Ben-Gurion University Of The Negev, IL

Methane related iron reduction processes in sediments: Hidden couplings and their significance for carbon and iron cycles

About one-third of annual methane (CH4) emissions to the atmosphere originate from natural, nonanthropogenic sources. However, if all the naturally produced methane actually did reach the atmosphere, its levels would increase by an order of magnitude, dwarfing anthropogenic CO2 emissions. Fortunately, natural scavengers of this methane near its production zone limit its release. One of these scavengers, iron (Fe) oxide, can become a major sink for methane when sulfate concentrations are low. Methane-iron couplings in established sediments, however, are poorly understood. Specifically, significant iron oxide reduction has been observed in many aquatic sediments at depths well below its expected redox zone, where methane is produced by methanogenesis, often accompanied by decreases in methane concentrations. These observations challenge our understandings of iron-methane couplings and microbial players in the deep methanogenic zone and their impacts on the carbon, iron and other cycles. I aim in the proposed research to elucidate the unexplored mechanisms of methane-related iron reduction (MERIR) in the methanogenic zone of established sedimentary profiles under various environmental conditions and their impact on global biogeochemical cycles. I will resolve two striking yet unexplained phenomena: (1) the active involvement of aerobic methanotrophs in iron-coupled anaerobic oxidation of methane (AOM), and (2) the unusual reactivity of iron minerals toward reduction that is accompanied by intensive authigenic magnetite precipitation, and the effects of this mineralogy change on sedimentary magnetism. My expertise will enable me to achieve the objectives of this interdisciplinary proposed work using novel approaches from different fields. The project will likely lead to breakthroughs in our understanding of microbial survival strategies, reveal novel pathways for aerobic methanotrophs, and change our perspectives on iron mineral reactivities and sedimentary magnetism.

Project End Date: **31-MAR-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833275	**DEEPTIME**	**PE10** Earth System Science

Principal Investigator: **Dr. MARTIN BIZZARRO**
Host Institution: Kobenhavns Universitet, DK

Probing the history of matter in deep time

The solar system represents the archetype for the formation of rocky planets and habitable worlds. A full understanding of its formation and earliest evolution is thus one of the most fundamental goals in natural sciences. The only tangible record of the formative stages of the solar system comes from ancient meteorites and their components some of which date back to the to the birth of our Sun. The main objective of this proposal is to investigate the timescales and processes leading to the formation of the solar system, including the delivery of volatile elements to the accretion regions of rocky planets, by combining absolute ages, isotopic and trace element compositions as well as atomic and structural analysis of meteorites and their components. We identify nucleosynthetic fingerprinting as a tool allowing us to probe the history of solids parental to our solar system across cosmic times, namely from their parent stars in the Galaxy through their modification and incorporation into disk objects, including asteroidal bodies and planets. Our data will be obtained using state-of-the-art instruments including mass-spectrometers (MC-ICPMS, TIMS, SIMS), atom probe and transmission electron microscopy. These data will allow us to: (1) provide formation timescales for presolar grains and their parent stars as well as understand how these grains may control the solar system's nucleosynthetic variability, (2) track the formation timescales of disk reservoirs and the mass fluxes between and within these regions (3) better our understanding of the timing and flux of volatile elements to the inner protoplanetary disk as well as the timescales and mechanism of primordial crust formation in rocky planets. The novel questions outlined in this proposal, including high-risk high-gain ventures, can only now be tackled using pioneering methods and approaches developed by the PI's group and collaborators. Thus, we are in a unique position to make step-change discoveries.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834934	**PALADYN**	**PE10** Earth System Science

Principal Investigator: **Dr. ANTONI ROSELL-MELE**
Host Institution: Universidad Autonoma De Barcelona, ES

New geochemical approach to reconstruct tropical palaeo-atmospheric dynamics

Tropical climates are changing rapidly in the most populated regions of the planet. The changes largely arise from alterations in the Hadley circulation driven by natural and anthropogenic factors, whose relative roles and temporal variability are unclear. These knowledge gaps are in part due to the shortage of methods to study the atmospheric circulation before the advent of instrumental and satellites observations, and compounded by the contradictions between models and palaeo-data.

The aim of the project is to develop an innovative palaeo-proxy approach to investigate the natural range of variability of the Hadley circulation during past episodes of extreme warmth and cold. The approach relies on the exploitation as climate proxy of an untapped but widespread material in marine sediments: windborne pyrogenic carbon (PyC) derived from savannah and grassland fires in the tropics.

Through the geochemical and isotopic spatial characterization of PyC, along with the analysis of mineral dust in the modern tropical deep ocean, and a PyC biogeochemical model, we will build an interpretative framework of PyC deposition in deep-sea sediments. Its application in Pliocene-Pleistocene sequences from the Atlantic and the Pacific will allow the reconstruction of past meridional and zonal shifts in the Intertropical Convergence Zone and the Southern hemisphere westerlies, and provide new constraints on the natural variability of the Hadley circulation and associated hydroclimates.

PALADYN is possible thanks to the combination of cutting-edge geochemical and satellite data, and GIS methodologies, with in-depth interdisciplinary expertise on the palaeoclimatic study of marine sediments. We will provide new important datasets of windborne deep-sea PyC for testing and refining prediction models of atmospheric circulation, carbon cycle, precipitation and wildfires, issues which are of paramount global importance from scientific as well as societal standpoints.

Project End Date: **30-NOV-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
848698	**GLAD**	**PE10** Earth System Science

Principal Investigator: **Dr. SEBASTIAN SCHEMM**
Host Institution: Eidgenoessische Technische Hochschule Zurich, CH

Global Lagrangian Cloud Dynamics

This project will address fundamental gaps in our understanding of how clouds form, how they interact with the atmospheric flow and how they need to be simulated in weather and climate models. Our inability to improve the representation of clouds and their interactions with the atmospheric flow is the leading cause of the high level of uncertainty associated with projections of future changes in storm tracks, precipitation bands and weather extremes. The representation of clouds in models is poor, largely because clouds are unresolved. Given the potentially significant impacts of projected global warming and the significant benefits of improved weather predictions, it is imperative to improve the representation of cloud-circulation interactions in models. However, how do we acquire the necessary process understanding to close existing knowledge gaps? I propose a fundamentally new perspective on clouds and their control of the large-scale flow leading ultimately to a unique cloud classification system. Instead of studying clouds based on the traditional Eulerian perspective, I suggest analysing cloud-circulation couplings based on the history of air parcels (Lagrangian perspective). A systematic Lagrangian-based investigation of cloud-circulation couplings in ultra-high-resolution simulations is a true novelty and has never been attempted. Based on convection-permitting simulations over a climatological period, which exploit recent advances in supercomputing architectures, the cloud parcels are classified according to their circulation impact and feed into a machine learning algorithm that is trained using the physical processes acting along their pathways. This approach has the potential to drastically improve our mechanistic understanding of how to represent clouds in models and to identify the leading cloud-related processes that control regional to large-scale flow variability, which is one of the Grand Challenges defined by the World Climate Research Programme.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850530	**PROMOTING**	**PE10** Earth System Science

Principal Investigator: **Dr. PIERRE LANARI**
Host Institution: Universitaet Bern, CH

PROgrade metamorphism MOdeling: a new petrochronological and compuTING framework

Prograde metamorphism produces large amounts of fluids that have an important role for earthquake generation, arc magmatism, the growth of continental crust and for global geochemical cycles. Despite recent efforts, it remains challenging to recognize and quantify fluid fluxes in natural rocks and to model fluid pathways. The existing petrological modeling techniques are all based on the thermodynamic analysis of single rock types and neglect the chemical changes caused by fluid expulsion and the possible interactions with other rocks. The next frontier in metamorphic petrology is therefore to move our modeling capabilities from an isolated single rock system to an open and multi rock system, in which fluids can flow in, react and flow out. This concept introduces several challenges from the quantification of fluid-rock interactions in natural samples to the integration of aqueous thermodynamics and fluid dynamics in the petrological models. Based on the developments of high-resolution techniques such as quantitative compositional mapping, I have demonstrated that the petrological models can be inverted to quantify prograde metamorphism based on preserved mineral relics that partially re-equilibrated in the presence of fluids. The primary objective of PROMOTING is to develop a brand-new framework for petrological modeling of fluid-rock interactions in different, coupled rock types during prograde metamorphism. The models will be calibrated on two key tectonic settings that shaped Earth: subduction of oceanic crust and differentiation of the continental crust. A cutting-edge petrochronological strategy is required to identify at which conditions and when fluid-rock interactions occurred in natural rocks. The outcomes of this project will not only form the basis for a new generation of models integrating element mobility from rock scale to crustal sections, but they will also bring new constraints to test the validity of the most advanced subduction models.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850614	**CHAPAs**	**PE10** Earth System Science

Principal Investigator: **Dr. FEDERICO BIANCHI**
Host Institution: Helsingin Yliopisto, FI

Chasing pre-industrial aerosols

Aerosol particles affect the climate by scattering incoming radiation and by acting as cloud condensation nuclei; however, their net effect remains of highest uncertainty, specifically when quantifying their relationship to anthropogenic greenhouse gases. It has been estimated that 45% of the variance of aerosol forcing arises from uncertainties in natural emissions. This highlight the importance of understanding pristine preindustrial-like environments, with natural aerosols only. One of the great challenges in understanding preindustrial aerosols and their sources resides in identifying the processes by which new particles form and grow from oxidized vapours.

We recently presented in Science the ground-breaking observation of purely organic nucleation. The existence of this mechanism was confirmed by laboratory experiments where we show that highly oxygenated molecules are able to form new particles independent of H2SO4. This finding sheds the light into the preindustrial era where the anthropogenic emissions were almost absent and H2SO4 concentration was rather minimal.

The aim of my project is to provide unprecedented data to resolve the preindustrial nucleation mechanism. I will organize intensive long-term measurements in pristine preindustrial-like environments like the Arctic and Siberia. Using state-of-the-art chemical ionization mass spectrometry, I will retrieve the chemical cluster composition and the vapours concentration. Additionally, I am planning short intensive measurements at high altitude above the oceans. Finally, these measurements will be complemented by laboratory experiments needed to probe the observed mechanism and retrieve a parametrization that can be used in global modelling.

The outcome of these field campaigns combined with laboratory experiments will provide extraordinary results in understanding pre-industrial aerosol formation, which will set the baseline for estimations of the impact of present and future aerosol on climate.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851374	**trainABL**	**PE10** Earth System Science

Principal Investigator: **Dr. CEDRICK ANSORGE**
Host Institution: Universitaet Zu Koeln, DE

Turbulence-Resolving Approaches to the Intermittently Turbulent Atmospheric Boundary Layer

Vertical exchange in the atmospheric boundary is primarily due to turbulence, but turbulence may cease locally as a consequence of stable density stratification. This state of turbulence intermittency challenges traditional geophysical approaches to represent turbulent mixing. Field observations of the phenomenon are hard to obtain because of broad-scale interacting processes. Existing numerical approaches based on bulk turbulence closures reach their limits because they neglect the relevance of large-scale intermittency for turbulent mixing. Hence, process-level insight to turbulence intermittency in the atmospheric boundary layer is lacking which has dramatic consequences for the forecast of minimum temperature, of frost and fog situations, and of the potential for wind-power extraction.

trainABL recognizes the geophysical phenomenon of turbulence intermittency in the atmospheric boundary layer as a fluid mechanics problem. A virtual-lab approach based on direct numerical simulation yields an appropriate turbulence-resolving representation of the intermittently turbulent atmospheric boundary layer. The quantitative insight into large-scale intermittency offered by direct numerical simulation in combination with large-eddy simulation and observational data allows to transfer the emerging physical understanding to the geophysical range of parameters. This paves the avenue towards a novel turbulence mixing representation based on factorization of the turbulent flux into a reference flux and pre-factor accounting for large-scale intermittency. trainABL will thus provide a first physically consistent turbulent mixing parametrization that acknowledges the importance of turbulence intermittency, covers the entire vertical range of the atmospheric boundary layer, and is valid for all regimes of stratification.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851614	**ICED**	**PE10** Earth System Science

Principal Investigator:	**Dr. GEORGINA KING**
Host Institution:	Universite De Lausanne, CH

Impact of climate on mountain denudation

Mountain ranges evolve in response to tectonic uplift, erosion and climatic change, but decoupling the feedbacks between these processes remains one of the most active debates in Earth Science. Resolving this debate is fundamental for successful projection of Earth's surface response under a changing climate. The Impact of ClimatE on mountain Denudation remains highly contested because no technique is available to resolve changes in erosion rates over the timescale of glacial-interglacial cycles i.e. 10^3-6 years, a key time range for quantifying the role that silicate weathering and denudation plays in modulating global climatic change. ICED will resolve this debate through establishing time-series of rock erosion over 10^3-6 years, allowing erosion rate changes to be related to specific climatic changes, and specific processes, for the first time. These data will show whether tectonics or climatic feedbacks on surface processes are dominant in determining rates of surface denudation, providing insights into the influence of the lithosphere on global climatic change throughout the Quaternary period (ice age).

The objective of ICED will be achieved through the development and application of recently established thermochronometers based on the luminescence and electron spin resonance of quartz and feldspar minerals. Thermochronometers measure the rate of rock cooling, from which rates of rock exhumation and thus erosion rates can be calculated. Unlike existing methods, the new techniques developed within ICED are capable of resolving changes in erosion over timescales of between 10^3-6 years. Combining these new methods with cosmogenic nuclide data, using numerical models developed within ICED, will allow the generation of high-resolution time-series of erosion. The strategic application of these new techniques to the western European Alps will allow the Impact of ClimatE on mountain Denudation rates to be resolved for the first time.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851854	**UpTrop**	**PE10** Earth System Science

Principal Investigator: **Dr. ELOISE MARAIS**
Host Institution: University Of Leicester, UK

Fundamental understanding of reactive nitrogen in the global upper troposphere

The upper troposphere (UT), a severely under-researched part of the atmosphere, has profound impacts on global climate, air quality, major atmospheric oxidants, and the protective ozone layer. Key to its influence on the Earth system are reactive nitrogen compounds (collectively NOy). Models, since their inception, have grossly misrepresented observations of UT NOy, hindering application of these models to accurately estimate the impact of humans on climate, the ozone layer, and air quality. The reasons proposed for discrepancies between models and observations are unsatisfactory, as past studies have been hampered by observations that are limited in space and time. Only now are there unprecedented global, high-resolution measurements of the UT from instruments on aircraft and satellites that can be combined with detailed and advanced modelling tools to at last tackle this issue on a global scale. The ground-breaking UpTrop work programme will innovatively combine observations from the recently launched ESA Sentinel-5P mission and a long record of aircraft campaigns (most crucially the 2016-2018 NASA ATom campaign) to create the first truly global dataset of UT NOy abundance, interpreted with the state-of-the-art GEOS-Chem model. This pioneering multiplatform approach, the bedrock of my previous highly cited work, will deliver game-changing objectives: (i) novel insights into the processes controlling UT NOy, (ii) an unequivocal account of the role of the upper troposphere in altering climate and the chemical composition of the atmosphere, and (iii) interpretation of the disruptive impact of improved understanding of UT NOy on widespread application of satellite observations to constrain global air quality. UpTrop is ambitious, with bold objectives that will conceptually change fundamental understanding of UT NOy and address a challenge that has plagued atmospheric chemists for decades. A cascade of new avenues of cross-disciplinary research is inevitable.

Project End Date: **30-NOV-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852161	**MAARvEL**	**PE10** Earth System Science

Principal Investigator: **Dr. MATTHIEU RIVA**
Host Institution: Centre National De La Recherche Scientifique, FR

A Missing Key Property in Atmospheric AeRosol ChEmistry: the Laplace Pressure

Fine aerosol particles are ubiquitous in the atmosphere and have important impacts on climate change and air quality. Organic compounds represent the largest mass fraction of fine particulate matter and their formation is believed to occur through the condensation of oxygenated volatile organic compounds. However, a fundamental physicochemical property of atmospheric aerosols – the Laplace pressure – has never been studied. This "missing" property is expected to have major implications for atmospheric chemistry and may explain the current gaps between ambient observations and modelling studies when evaluating the formation rates, ambient concentrations and the spatial distribution of atmospheric nanoparticles. Hence, my project aims at elucidating the key processes driven by the Laplace pressure in atmospheric aerosols and how they impact on the growth, evolution and physicochemical properties of submicron particles. MAARvEL focuses on the smallest particles, where the Laplace pressure is expected to have the greatest impact. By exploiting recent instrumental developments and using state-of-the-art mass spectrometry techniques, MAARvEL will provide an unequalled understanding of the processes occurring within the particles. Innovative laboratory experiments will be performed to discover the central role of the Laplace pressure for; (i) condensed-phase reactions, (ii) photochemical processes, and (iii) physicochemical properties of submicron particles. A strong emphasis will be placed on quantifying the extent to which chemical processes govern the growth and evolution of atmospheric nanometre-sized particles. By revealing how the Laplace pressure controls particle phase chemistry, MAARvEL will provide a major breakthrough to support more accurate predictions of the formation and evolution of atmospheric nanoparticles, thereby decreasing the uncertainties in assessing the magnitude of aerosol effects on climate.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864792	**OXYGEN**	**PE10** Earth System Science

Principal Investigator: **Dr. ZOLTAN ZAJACZ**
Host Institution: Universite De Geneve, CH

The redox evolution of arc magmas: from the oxygenation of the Earth's atmosphere to the genesis of giant hydrothermal ore deposits

Arc magmatism at subduction zones is responsible for much of the mass transfer of chemical elements between the Earth's lower and upper spheres. Arc magmas are significantly more oxidized and richer in volatile elements than other voluminous magma types on Earth. These characteristics promote the genesis of large magmatic-hydrothermal ore deposits and potentially also the build-up of the oxygen budget of the Earth's atmosphere. Despite its great significance, the origin of the higher oxidation state of arc magmas is still one of the most debated questions in petrology. I will combine high-pressure-temperature experiments, field-based studies and computational simulations to obtain quantitative understanding of redox reactions taking place during magma genesis, differentiation and degassing. Subsequently, I will apply this new knowledge to assess if arc magmatism may have been a key to the oxygenation of the Earth's atmosphere, and to pinpoint the most prospective regions for the generation of giant ore deposits. Most experiments will rely on revolutionary new instrumentation and methodologies, which I have recently developed or will develop as a part of the project. For example, we will determine for the first time the speciation of sulfur in aqueous fluids in situ at magmatic temperatures and upper crustal pressures by using a prototype spectroscopic cell, so that its critical role in redox transfer and ore genesis can be quantified. Similarly, the field-based studies will employ a new method to constrain the redox evolution of magmas with unparalleled precision, which will be developed experimentally by using a prototype high-pressure apparatus with a unique capability to control redox conditions. In addition, these will also apply a powerful combination of novel and challenging analytical methods including the analysis of Au, Pt, Pd and Re concentrations and S isotope ratios in silicate melt inclusions in minerals to identify the key agents of magma oxidation.

Project End Date: **31-OCT-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865403	**TroPeaCC**	**PE10** Earth System Science

Principal Investigator: **Dr. ANGELA GALLEGO-SALA**
Host Institution: The University Of Exeter, UK

Tropical Peatlands and the Carbon Cycle

Tropical peatlands are the most carbon-dense ecosystems in the world and they store the equivalent of ~10 years of global anthropogenic CO2 emissions. Despite their importance, crucial questions remain about carbon cycling in tropical peatlands and improving understanding is critical as they are at high risk from climate change and drainage for oil palm cultivation.

TroPeaCC will provide a step-change gain in our understanding of tropical peatland functioning and in projecting their response to climate change. PI Gallego-Sala will use her unique background that bridges peatland modelling and observations to deliver a novel interdisciplinary approach to tackle four outstanding questions about tropical peatlands:

Q1: What controls the geographical distribution of peatlands in the tropics? TASK1: To assess the tropical peatland extent using a combination of models

Q2: How large is the tropical peatland CO2 sink and what are its main climatic drivers? TASK2: To characterize the drivers of carbon accumulation rates in tropical peatlands using the palaeo-archive.

Q3: How large is the methane flux in tropical peatlands? What are the main controls at the intercontinental scale? TASK3: To determine the main controls on methane fluxes in tropical peatlands, using eddy covariance, chamber-based gas flux measurements, and ground penetrating radar.

Q4: What is the overall carbon balance of tropical peatlands and how will this change in the future? TASK4: To forecast future changes of the extent of tropical peatlands, of the carbon sink and of methane emissions, using the results of Tasks 1-3 to parameterise and evaluate a global dynamic vegetation model that includes tropical peatlands for the first time.

The interdisciplinary approach will lead to a comprehensive understanding of the role of tropical peatlands in the global carbon cycle, allowing their inclusion in earth system models, and informing management decisions to optimise provision of multiple ecosystem services.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865411	**PERSISMO**	**PE10** Earth System Science

Principal Investigator:	**Dr. HARSHA BHAT SURESH**
Host Institution:	Centre National De La Recherche Scientifique, FR

Predicting Energy Release in fault Systems: Integrating Simulations, Machine learning, Observations

Quantum leaps in observations have recently upended our classical view of earthquakes & tsunamis and have demonstrated that our understanding of these destructive natural events is not unified and still too limited to perform reliable predictions. Fortunately, catastrophic events remain relatively rare. Yet this scarcity also implies that their fine scale and long-term dynamics can only be studied in detail through numerical simulations.

The goal of PERSISMO is to build a physics based Virtual Earthquake Simulator to make seismic and tsunami hazard estimates on fault networks. Indeed, the modern view emanating from observations is that fault networks continuously release stored energy over a wide range of spatiotemporal scales. With this philosophy in mind, we have been developing simulation tools to capture the behaviour of these fault networks and our recent work has demonstrated that these networks indeed control the dominant portion of the continuous energy release, whatever the time and length scales considered.

Within PERSISMO, we will build a physics-based framework, which will include all known physical contributions to dynamic fracturing. This will unify a never achieved range of spatiotemporal scales, from meters to hundreds of kilometres, seconds to millenniums. Using available data and catalogues, our results will be validated along natural fault networks to capture slow and fast seismic energy release. Building on this, we will develop a Machine Learning based framework to run thousands of ensemble and future hazard scenarios on a given fault network. Only then, we might be able to make reliable predictions about their behaviour in the future.

Our project to build a physics-driven Virtual Earthquake Simulator is interdisciplinary by nature, as it must combine expertise in mechanics, earth sciences and computation. In the long-term, our simulator will have the potential to become key in helping decision makers on possible natural hazard scenarios.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866085	**DEEPVOLC**	**PE10** Earth System Science

Principal Investigator: **Dr. ANDREW HOOPER**
Host Institution: University Of Leeds, UK

Forecasting volcanic activity using deep learning

DEEPVOLC will radically advance the way future activity is forecast at volcanoes by applying advances in artificial intelligence to transformative new geodetic datasets. 200 million people live within 30 km of a volcano. Accurate forecasting of volcanic eruptions is problematic because 1) it relies on human interpretation at individual volcanoes, 2) a volcano can behave in unexpected ways not previously seen at that location, and 3) most volcanoes are not instrumented. DEEPVOLC will address this by i) applying artificial intelligence, ii) using data for all volcanoes worldwide, and iii) exploiting advances in satellite monitoring. A key indicator of potential volcanic activity is deformation of a volcano's surface due to magma migrating beneath. Surface movements as small as a few millimetres can now be measured from space, using satellite-borne radar. A recently-launched European satellite mission, Sentinel-1, has transformed our ability to measure surface deformation at all of the world's volcanoes, acquiring data at least twice every twelve days. However, forecasting how deforming volcanoes will behave in the future remains challenging. In this project I will apply recently developed deep learning approaches to the satellite data. This is an entirely new approach to forecasting volcanic activity, which currently relies on the individual expertise available at each observatory, and which is only now made possible due to the launch of Sentinel-1 and advances in deep learning algorithms. DEEPVOLC will combine knowledge from all volcanoes that have been active in the era of satellite deformation observations, and will continue to improve as it ingests data from new activity. The main deliverable will be a system for volcano observatories that uses knowledge of how volcanoes behave globally to automatically identify deformation at volcanoes locally, and forecast how the deformation will evolve, indicating the probability of eruption.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715940	**EPP**	**SH1** Markets, Individuals and Institutions

Principal Investigator: **Dr. TORU KITAGAWA**
Host Institution: University College London, UK

Econometrics for Public Policy: Sampling, Estimation, Decision, and Applications

One of the ultimate goals of economics is to inform a policy that improves welfare. Despite that the vast amount of empirical works in economics aims to achieve this goal, the current state of the art in econometrics is silent about concrete recommendation for how to estimate the welfare maximizing policy. This project addresses statistically optimal and practically useful ways to learn the welfare-maximizing policy from data by developing novel econometric frameworks, sampling design, and estimation approaches that can be applied to a wide range of policy design problems in reality.

Development of econometric methods for optimal empirical policy design proceeds by answering the following open questions. First, given a sampling process, how do we define optimal estimation for the welfare-maximizing policy? Second, what estimation method achieves this statistical optimality? Third, how do we solve policy decision problem when the sampling process only set-identifies the social welfare criterion? Fourth, how can we integrate the sampling step and estimation step to develop a package of optimal sampling and optimal estimation procedures?

I divide the project into the following four parts. Each part is motivated by important empirical applications and has methodological challenges related to these four questions.

1) Estimation of treatment assignment policy
2) Estimation of optimal policy in other public policy applications
3) Policy design with set-identified social welfare
4) Sampling design for empirical policy design

Project End Date: **31-JAN-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724231	**DIVERSE-EXPECON**	**SH1** Markets, Individuals and Institutions

Principal Investigator: **Dr. SIGRID SUETENS**
Host Institution: Stichting Katholieke Universiteit Brabant, NL

Discriminative preferences and fairness ideals in diverse societies: An 'experimental economics' approach

In economics, a distinction is made between statistical and taste-based discrimination (henceforth, TBD). Statistical discrimination refers to discrimination in a context with strategic uncertainty. Someone who is uncertain about the future behaviour of a person with a different ethnicity may rely on information about the different ethnic group to which this person belongs to form beliefs about the behaviour of that person. This may lead to discrimination. TBD refers to discrimination in a context without strategic uncertainty. It implies suffering a disutility when interacting with 'different' others. This project systematically studies TBD in ethnically diverse societies.

Identifying TBD is important because overcoming it requires different policies than overcoming statistical discrimination: they should deal with changing preferences of people rather than providing information about specific interaction partners. But identifying TBD is tricky. First, it is impossible to identify using uncontrolled empirical data because these data are characterised by strategic uncertainty. Second, people are generally reluctant to identify themselves as a discriminator. In the project, I study TBS using novel economic experiments that circumvent these problems.

The project consists of three main objectives. First, I investigate whether and how preferences of European natives in social interactions depend on others' ethnicity. Are natives as altruistic, reciprocal, envious to immigrants as compared to other natives? Second, I study whether natives have different fairness ideals—what constitutes a fair distribution of resources from the perspective of an impartial spectator—when it comes to natives than when it comes to non-natives. Third, I analyse whether preferences and fairness ideals depend on exposure to diversity: do preferences and fairness ideals of natives change as contact with non-natives increases, and, if so, how?

Project End Date: **31-DEC-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
740272	**lending**	**SH1** Markets, Individuals and Institutions

Principal Investigator: **Dr. STEVEN ONGENA**
Host Institution: Universitaet Zuerich, CH

Drivers of Growth in Bank Lending and Financial Crises

Banking crises are thought to be recurrent phenomena that generally come on the heels of strong credit growth. Their damaging real effects have generated a broad agreement among academics and policymakers that financial regulation needs to tighten and to obtain a macroprudential dimension that aims to lessen the negative externalities from the financial to the macro real sector.

Among the main ingredients that are often mentioned to have played a role in the explosive growth of credit in the run-up to the latest financial crisis are the financial innovations by financial institutions, in particular loan securitization, the boom in mortgage lending and prices of real estate, the lack of information about prospective borrowers, and the high leverage (and corresponding low capital ratios) of financial institutions.

Yet, despite the singling out of these ingredients by policymakers, decisive empirical evidence about their role and relevancy is lacking. However, given the magnitude and complexity of the global banking system and the lack of encompassing micro-level data, it is currently impossible to confidently study the impact of all ingredients jointly. This project therefore analyses pertinent settings where we can empirically identify the correspondence between the aforementioned individual ingredients and the credit granting by financial institutions.

The objective of the project is to advance identification and estimation of the impact of each respective factor on loan growth by combining the appropriate methodology with an exceptional set of micro-level datasets. When missing in the literature a theoretical framework will be provided. The project further aims to assess how potential combinations of these ingredients may have interacted in spurring credit growth. While the identification of the impact of each ingredient on credit growth is paramount, the individual setting of the studied datasets and employed methodologies will ensure maximum external validity.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759424	**SUEE**	**SH1** Markets, Individuals and Institutions

Principal Investigator: **Dr. ANTONIO PENTA**
Host Institution: Universitat Pompeu Fabra, ES

Strategic Uncertainty in Economic Environments

This proposal concerns two sets of projects that tackle theoretical challenges raised by the data broker and online advertisement industry.

1-Strategic Uncertainty (SU) in Economic Environments: By assuming that individuals have correct beliefs about others' behavior, the equilibrium approach in economics assumes away SU. But SU is central to many settings. Testament to this is the existence of a data broker industry, in which data on agents' behavior are traded: this information would have no value without SU. Within game theory, non-equilibrium concepts such as rationalizability and models of level-k reasoning have been developed to study SU. But these models have had a limited impact on broader economics. This is partly due to the weakness and limited tractability of these concepts. Part 1 tackles SU in order to favor a better integration within economics. From a behavioral perspective, I propose axiomatic foundations that justify modeling individuals' reasoning as stemming from a cost-benefit analysis, and investigate (theoretically and experimentally) how these ideas shed light on the occurrence of equilibrium coordination under SU, i.e. as the result of purely subjective reasoning. From a classical perspective, I develop uniqueness and monotone comparative statics results for non-equilibrium concepts, to favor a better integration of SU in standard economics. Applications include problems of information disclosure of strategic datasets and identification in models of social interactions.

2-Online Auctions with Digital Marketing Agencies (DMA): I study the role of DMA in the auctions used to sell advertisement space on the web. I analyze how collusive bidding can emerge from bid delegation to a common DMA and how this undermines both revenues and efficiency of the auctions used by key players in the industry such as Facebook, Google and Microsoft-Yahoo!. Implications and extensions include business, policy and economics methodology.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
770652	**BEHAVFRICTIONS**	**SH1** Markets, Individuals and Institutions

Principal Investigator: **Dr. JAKUB STEINER**
Host Institution: Narodohospodarsky Ustav Akademie Ved Ceske Republiky Verejna Vyzkumna Instituce, CZ

Behavioral Implications of Information-Processing Frictions

BEHAVFRICTIONS will use novel models focussing on information-processing frictions to explain choice patterns described in behavioral economics and psychology. The proposed research will provide microfoundations that are essential for (i) identification of stable preferences, (ii) counterfactual predictions, and (iii) normative conclusions.

(i) Agents who face information-processing costs must trade the precision of choice against information costs. Their behavior thus reflects both their stable preferences and the context-dependent procedures that manage their errors stemming from imperfect information processing. In the absence of micro-founded models, the two drivers of the behavior are difficult to disentangle for outside observers. In some pillars of the proposal, the agents follow choice rules that closely resemble logit rules used in structural estimation. This will allow me to reinterpret the structural estimation fits to choice data and to make a distinction between the stable preferences and frictions.
(ii) Such a distinction is important in counterfactual policy analysis because the second-best decision procedures that manage the errors in choice are affected by the analysed policy. Incorporation of the information-processing frictions into existing empirical methods will improve our ability to predict effects of the policies.
(iii) My preliminary results suggest that when an agent is prone to committing errors, biases--such as overconfidence, confirmatory bias, or perception biases known from prospect theory--arise under second-best strategies. By providing the link between the agent's environment and the second-best distribution of the perception errors, my models will delineate environments in which these biases shield the agents from the most costly mistakes from environments in which the biases turn into maladaptations. The distinction will inform the normative debate on debiasing.

Project End Date: **31-MAY-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772331	**ELECTRIC CHALLENGES**	**SH1** Markets, Individuals and Institutions

Principal Investigator: **Dr. NATALIA FABRA**
Host Institution: Universidad Carlos Iii De Madrid, ES

Current Tools and Policy Challenges in Electricity Markets

The fight against climate change is among Europe's top policy priorities. In this research agenda, I propose to push out the frontier in the area of Energy and Environmental Economics by carrying out policy-relevant research on a pressing issue: how to design optimal regulatory and market-based solutions to achieve a least cost transition towards a low-carbon economy.

The European experience provides unique natural experiments with which to test some of the most contentious issues that arise in the context of electricity markets, including the potential to change households' demand patterns through dynamic pricing, the scope of renewables to mitigate market power and depress wholesale market prices, and the design and performance of the auctions for renewable support. While there is a body of policy work on these issues, it generally does not meet the required research standards.

In this research, I will rely on cutting-edge theoretical, empirical, and simulation tools to disentangle these topics, while providing key economic insights that are relevant beyond electricity markets. On the theory front, I propose to develop new models that incorporate the intermittency of renewables to characterize optimal bidding as a key, broadly omitted ingredient in previous analysis. In turn, these models will provide a rigorous structure for the empirical and simulation analysis, which will rely both on traditional econometrics for casual inference as well as on state-of-the-art machine learning methods to construct counterfactual scenarios for policy analysis.

While my focus is on energy and environmental issues, my research will also provide methodological contributions for other areas - particularly those related to policy design and policy evaluation. The conclusions of this research should prove valuable for academics, as well as to policy makers to assess the impact of environmental and energy policies and redefine them where necessary.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788433	**FAIR**	**SH1** Markets, Individuals and Institutions

Principal Investigator: **Dr. BERTIL TUNGODDEN**
Host Institution: Norges Handelshoyskole, NO

Fairness and the Moral Mind

The project provides a comprehensive and groundbreaking approach to the analysis of the moral mind and inequality acceptance. The first part of the project will provide a novel study of how the moral ideals of personal responsibility and individual freedom, which are fundamental values in most liberal societies, shape inequality acceptance. It will also provide the first experimental study of how people draw the moral circle, which is at the heart of the most pressing policy challenges facing the world today and strongly related to the question of global fairness. The second part will study how social institutions shape inequality acceptance and how it develops in childhood and adolescence, by providing two unique international studies of inequality acceptance in 60 countries across the world. These studies will provide novel insights on the distributive behavior of nationally representative samples of adults and children and on the cultural transmission of moral preferences in society. The project is rooted in behavioral and experimental economics, but will also draw on insights from other social sciences and philosophy. It will develop novel experimental paradigms to study the moral mind and the nature of inequality acceptance, including incentivized experiments on nationally representative populations, and combine structural and non-parametric empirical analysis with theory development. Taken together, the project represents a unique study of inequality acceptance in the social sciences that will address an important knowledge gap in the literature on inequality.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802450	**ABRSEIST**	**SH1** Markets, Individuals and Institutions

Principal Investigator: **Dr. HANNES ULLRICH**
Host Institution: Deutsches Institut Fur Wirtschaftsforschung Diw (Institut Fur Konjunkturforschung) Ev, DE

Antibiotic Resistance: Socio-Economic Determinants and the Role of Information and Salience in Treatment Choice

Antibiotics have contributed to a tremendous increase in human well-being, saving many millions of lives. However, antibiotics become obsolete the more they are used as selection pressure promotes the development of resistant bacteria. The World Health Organization has proclaimed antibiotic resistance as a major global threat to public health. Today, 700,000 deaths per year are due to untreatable infections. To win the battle against antibiotic resistance, new policies affecting the supply and demand of existing and new drugs must be designed. I propose new research to identify and evaluate feasible and effective demand-side policy interventions targeting the relevant decision makers: physicians and patients. ABRSEIST will make use of a broad econometric toolset to identify mechanisms linking antibiotic resistance and consumption exploiting a unique combination of physician-patient-level antibiotic resistance, treatment, and socio-economic data. Using machine learning methods adapted for causal inference, theory-driven structural econometric analysis, and randomization in the field it will provide rigorous evidence on effective intervention designs. This research will improve our understanding of how prescribing, resistance, and the effect of antibiotic use on resistance, are distributed in the general population which has important implications for the design of targeted interventions. It will then estimate a structural model of general practitioners' acquisition and use of information under uncertainty about resistance in prescription choice, allowing counterfactual analysis of information-improving policies such as mandatory diagnostic testing. The large-scale and structural econometric analyses allow flexible identification of physician heterogeneity, which ABRSEIST will exploit to design and evaluate targeted, randomized information nudges in the field. The result will be improved rational use and a toolset applicable in contexts of antibiotic prescribing.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804104	**VALURED**	**SH1** Markets, Individuals and Institutions

Principal Investigator: **Dr. PAOLO GIOVANNI PIACQUADIO**
Host Institution: Universitetet I Oslo, NO

Value Judgments and Redistribution Policies

Heterogeneity and diversity are a pervasive aspect of modern societies. Differences in individuals' preferences, needs, skills, and information are key to explain variation in individuals' behavior and to anticipate individuals' responses to policy changes. There is no consensus, however, about how to take these differences into account when evaluating policies.

Project VALURED will reexamine this ethical challenge by characterizing the mapping between value judgments—i.e. principles of distributive justice—and redistribution policies. This mapping is tremendously important for welfare analysis and policy design. First, it associates the most desirable policy to each set of value judgments, providing an "ethical menu" to policy design. Second, it gives an ethical identity of each policy proposal, that is, it identifies the value judgments a policymaker endorses when proposing a specific policy.

The main objectives of VALURED are to:

1) identify transparent and compelling value judgments that accommodate heterogeneity and diversity;

2) show the implications of these value judgments for the evaluation and design of redistribution policies;

3) characterize welfare criteria that respect individuals' preferences and account for individuals' differences in needs, skills, and information;

4) provide new insights for the design of income, capital, and inheritance taxation;

5) develop simple formulas that express optimal policies as a function of observable heterogeneity and ethical parameters.

Project VALURED combines welfare economics with public economics. The first part deals with income taxation and addresses the ethical challenges related to individuals' heterogeneity in preferences, needs, and skills. The second part focuses on capital taxation and addresses individuals' differences in risk preferences and information. The third part analyses the design of inheritance taxation and addresses the social concerns for intergenerational and intragenerational equity.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818992	**FirmIneq**	**SH1** Markets, Individuals and Institutions

Principal Investigator: **Dr. UTA SCHOENBERG**
Host Institution: University College London, UK

Wage inequality within and across firms: The role of market forces, government and firm policies

Wage inequality in industrialised countries has increased sharply over the past decades, and much of this increase has occurred between rather than within firms. Furthermore, substantial inequality between men and women persists in all industrialised countries, and a large part of the gender gaps observed today is attributable to the arrival of children. In this proposal, we put firms at the centre of the analysis and ask the following questions: First, which market forces can (partly) explain the increasing wage inequality between firms? Second, how do government policies alter the wage structure? And third, how do firm policies and the firm environment impact on gender inequality? All projects draw on four decades of German social security records comprising the near universe of workers and establishments, which we augment with survey and administrative data on firms. In Project A, we investigate how two important market forces, increased product market competition and routine-biased technological change, contributed to the increasing wage inequality between firms, by changing which firms operate in the market (selection) and how employment is distributed across low and high productivity firms (reallocation), and by differentially affecting wage growth across firm types (differential wage growth). In Project B, we study how two prominent government policies, the introduction of a minimum wage and changes in business tax rates, affect wage dispersion between firms through selection, reallocation and differential growth effects. In Project C, we first analyse whether firm provided family-friendly policies, most notably flexible working times and child care facilities, can be effective at reducing gender inequality. We then investigate how the firm environment, specifically the presence of co-workers who are likely to have a working mother and hold more egalitarian gender attitudes, shapes mothers' return-to-work decisions and earnings trajectories after childbirth.

Project End Date: **31-MAY-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833714	**COOKIES**	**SH1** Markets, Individuals and Institutions

Principal Investigator: **Dr. BERND SKIERA**
Host Institution: Johann Wolfgang Goethe Universitaet Frankfurt Am Main, DE

Economic Consequences of Restrictions on the Usage of Cookies

Cookies (or "HTTP cookies") enable companies to collect and exchange extensive information about users. This information is often used to improve the performance of online advertising, which website publishers rely on in order to finance the "free" content to which their users have become accustomed. Yet, the collection of information leads to a loss of privacy. Accordingly, EU policy makers have put forward initiatives to restrict cookie usage (e.g., General Data Protection Regulation (GDPR), upcoming EU ePrivacy Regulation).

So far, there exists very little empirical knowledge on the trade-off between user privacy and the economic value that website publishers, advertisers, and even users derive from cookies. As a result, policy makers have no way of telling whether their restrictions on cookies have the intended positive consequences for user privacy, or whether any benefits are outweighed by negative effects on the profits of companies—which policy makers also seek to nurture.

This proposal's vision is to eliminate the gap in knowledge regarding the economic consequences of restrictions on the usage of cookies. I propose four work packages, each outlining the economic consequences of a specific type of restriction. In WP1-3, I will analyze a proprietary and massive (60-65 TB) set of "cookie data" that includes 472 publishers, 842 advertisers, 2.8 billion cookies and the prices of >110 billion ad impressions, that indicate the value of cookies for companies. In WP4, I collect "implementation data" to analyze the steps taken by thousands of the world's most highly-trafficked websites to become GDPR-compliant.

My results will provide a crucial empirical foundation for cookie restrictions in an industry worth more than €10 billion per year in the EU. The required interdisciplinary research will also involve the development of novel methodologies for deriving such information from big data, and theories as to why the observed economic consequences occur.

Project End Date: **30-NOV-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852172	**HarmfulTraditions**	**SH1** Markets, Individuals and Institutions

Principal Investigator: **Dr. LUCIA CORNO**
Host Institution: Universita Cattolica Del Sacro Cuore, IT

Harmful Traditions, Women Empowerment and Development

Harmful traditions (e.g. child marriage, female genital cutting (FGC), breast ironing) affect millions of girls in developing countries. These customs have a strong detrimental effect on women's human capital accumulation, empowerment and wellbeing, thus perpetuating gender imbalance and the vicious circle of poverty. Yet we know remarkably little on why these norms persist and what policies are able to eradicate them. This project will help to fill this gap. I will address the following research questions: How have harmful traditions originated in the first place and why do they persist over time? Given that simply legislating against harmful traditions is often ineffective, can we design policy interventions able to change them in a way that is conducive to development?

To answer to the first question, I will start by investigating the historical roots of female genital cutting since slavery. Combining contemporary survey data with historical data on slave shipments by ethnic group and across slave routes, I will test whether current variation in FGC prevalence within Africa can be traced back to the Red Sea slave trades, where women were sold as concubines and infibulation was used to ensure chastity. I will then examine whether contemporaneous factors, and in particular current political institutions, play a role in perpetuating harmful norms, manipulating the timing of FGC to influence electoral outcomes. Finally, using climate data, I will provide new insights on the relationship between global warming and child marriage.

To answer to the second question, I propose three randomized control trials uniquely designed to address specific determinants of the persistence of harmful traditions: alternative harmless rituals to remove cultural barriers, information provision to reduce breast ironing, peers' interactions to decrease FGC and child marriage. Original data will be collected through field work, overcoming data limitations characterizing existing research.

Project End Date: **30-APR-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864863	**UnStruct**	**SH1** Markets, Individuals and Institutions

Principal Investigator: **Dr. STEPHEN HANSEN**
Host Institution: Imperial College Of Science, Technology And Medicine, UK

Structural Models for Text and other Unstructured Data

Most usable data is unstructured. Examples include text, transaction data, images, and web browsing histories. Although rich and plentiful, most economists do not use unstructured data. The few that do generally quantify it with off-the-shelf algorithms that are unrelated to the economic environment in which it is generated, which makes connecting it to economic models difficult. I instead propose to build novel probabilistic models of unstructured data that link it directly to relevant economic parameters. This powerful approach will use the information in unstructured data to test and estimate economic models in a way that is not currently possible with existing methods.

I will focus on three distinct themes. The first studies how information about economic conditions is dispersed among agents, and how they aggregate it through interactions. This process it at the heart of the policymaking process, and the use of text data provides a unique opportunity to structurally model this information in innovative ways.

The second theme jointly models unstructured data and the evolution of an economy hit by multiple, unobserved shocks. This will provide a novel forecasting tool, which is of key interest to policymakers. But it will also use unstructured data to estimate equilibrium models of the macroeconomy, and hence recover economic fundamentals.

The final theme will use transaction payments between firms, and extend probabilistic models of network formation to create new definitions of markets that go well beyond anything in the current literature. This will contribute to measuring market power and the transmission of economic shocks, both questions of fundamental importance.

Beyond these specific themes, my research will also pave the way for the use of probabilistic machine learning that combines novel data with clear economic models. The frameworks I introduce will provide a template for others to follow in the future.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866181	**CLEAN**	**SH1** Markets, Individuals and Institutions

Principal Investigator: **Dr. PAOLO PINOTTI**
Host Institution: Universita Commerciale Luigi Bocconi, IT

Clean evidence on dirty deeds

Organized crime is systematically associated with lower economic development and higher corruption, political instability and political violence across countries. However, causal evidence on the economic and political effects of organized crime remains limited.

The present proposal advances our knowledge of organized crime in two main directions. First, I will explore the effects of organized crime on the allocation and effectiveness of public spending, focusing on two important areas of government spending: public procurement and public subsidies to private firms. This analysis will advance our knowledge of the practices through which captured politicians can distort the allocation of resources in favour of criminal organizations, their implications for the efficiency of government intervention, and the effectiveness of alternative policy responses.

Second, whilst previous research has focused almost exclusively on the traditional areas of origin of criminal organizations, I will study the effects of criminal groups moving to new regions and countries. I will focus in particular on three different contexts: i) the “transplant” of criminal organizations from southern to northern Italian regions; ii) interactions of immigrants and natives in criminal activity in the wake of recent migration to the Netherlands; and iii) the inflow of members of the Sicilian Mafia into the US during the period of alcohol prohibition (1920-1933). The present proposal will advance our understanding of how criminal groups can relocate to new regions and countries; their interactions with the criminal groups that may already be present there; and the economic and social effects in the areas of destination. From a methodological perspective, all projects will take advantage of unique micro-level data and state-of-the-art econometric methods for impact evaluation to provide clean evidence on causal relationships.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
883033	**UTHC**	**SH1** Markets, Individuals and Institutions

Principal Investigator: **Dr. DAVID DE LA CROIX**
Host Institution: Universite Catholique De Louvain, BE

Did elite human capital trigger the rise of the West? Insights from a new database of European scholars

My aim is to determine the role of elite knowledge and upper-tail human capital (UTHC) in triggering the rise of the West. I propose to build a database of a large sample of academic scholars in Europe over the period 1000CE-1800CE. Sources will be primary (published cartularia and matricula), secondary (books on the history of universities & academies), and tertiary (biographical dictionaries). To measure the quality of scholars, these data will be matched with the existing catalogues of publications.

Second, we will build a geographical grid of the density, composition, and quality of the UTHC across time, and correlate the UTHC at the cell level with the adoption of new techniques and better institutions, and the development of literacy, numeracy, and urbanization. The individual character of the data will allow basing causal identification on exogenous variations in the European network of both individuals and universities. The migration pattern of scholars will be used to identify sorting and agglomeration forces, witnessing to the functioning of an academic market in the medieval and early modern periods. Families of scholars will be identified to assess the importance of nepotism vs human capital transmission.

Third, we will develop a new theory of the complementarity between sciences and techniques, to deter-mine the incentives under which codified knowledge and practical skills interact, and ideas spread. A second new theoretical model will be devoted to revealing the dynamic interactions between conservative and modern forces within universities and learned societies; the key trade-off here is between vested interests and new paradigms, letting scholarly elites develop a culture of growth. With the data gathered, we will be able to measure the importance of these theoretical mechanisms and how the UTHC and society interact.

Overall, I intend to rethink economic growth by unraveling the rich interactions between scholars & literati and its emergence.

Project End Date: **31-DEC-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714589	**ELWar**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator:	**Dr. JOSIP GLAURDIC**
Host Institution:	Universite Du Luxembourg, LU

Electoral Legacies of War: Political Competition in Postwar Southeast Europe

We know remarkably little about the impact of war on political competition in postwar societies in spite of the fact that postwar elections have garnered tremendous interest from researchers in a variety of fields. That interest, however, has been limited to establishing the relationship between electoral democratization and the incidence of conflict. Voters' and parties' electoral behaviour after the immediate post-conflict period have remained largely neglected by researchers. The proposed project will fill this gap in our understanding of electoral legacies of war by analysing the evolution of political competition over the course of more than two decades in the six postwar states of Southeast Europe: Bosnia-Herzegovina, Croatia, Kosovo, Macedonia, Montenegro, and Serbia. Organised around three thematic areas/levels of analysis – voters, parties, communities – the project will lead to a series of important contributions. Through a combination of public opinion research, oral histories, and the innovative method of matching of individual census entries, the project will answer to which extent postwar elections are decided by voters' experiences and perceptions of the ended conflict, as opposed to their considerations of the parties' peacetime economic platforms and performance in office. In-depth study of party documents and platforms, party relations with the organisations of the postwar civil sector, as well as interviews with party officials and activists will shed light on the influence of war on electoral strategies, policy preferences, and recruitment methods of postwar political parties. And a combination of large-N research on the level of the region's municipalities and a set of paired comparisons of several communities in the different postwar communities in the region will help expose the mechanisms through which war becomes embedded into postwar political competition and thus continues to exert its influence even decades after the violence has ended.

Project End Date: **31-MAR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715132	**TRIPOD**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. JOHAN LILLIESTAM**
Host Institution: Institute For Advanced Sustainability Studies Ev, DE

The transition to a renewable electricity system and its interactions with other policy aims

In order to meet its long-term climate targets, the European Union has decided to reduce its power sector carbon emissions by 93-99% by 2050. This means that Europe aims to transition to a largely, or fully, renewable power system. This is however not the only energy policy aim: besides a transition to renewables, further aims include an energy efficiency increase and demand reduction; liberalisation of the power markets and exposure of renewables to competition; and europeanisation of renewable energy policy, power grids, and the creation of a European internal power market. Here, I investigate whether and how these policies interact and affect the chances for and costs of a transition to a renewable power system; how the other aims constrain the options for renewables; and how policy conflicts can be resolved. Current policy discourse treats these policy aims either as independent or synergistic. My hypothesis is that they are not at all independent and that pursuing the aims of demand reduction, liberalisation and europeanisation strongly influences the transition to renewables, and that the aims are partially antagonistic, implying a need for trade-offs. The purpose of my research is to test these hypotheses and explore the policy synergies or antagonisms, by investigating yet under-researched aspects of the interactions. These include how reaching the other aims influences the transition dynamics; how key actors may alter their behaviour due to such other developments; and how reaching another policy aim impacts the stability of a fully renewable power system. I adopt an interdisciplinary approach, drawing on transition research, engineering, political science and economics, with each perspective adding a piece of the puzzle. The answers will contribute to both the disciplinary and the policy-driven renewable energy research, and provide insights to help policy-makers define less conflicting policies, thus supporting the European transition to renewables.

Project End Date: **31-JUL-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716971	**INFO-LEG**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. NADEZHDA PURTOVA**
Host Institution: Stichting Katholieke Universiteit Brabant, NL

Understanding information for legal protection of people against information-induced harms

Information can harm people. Think of being denied mortgage or insurance based on your grocery shopping or online surfing profile. But what exactly is it in information that is harmful, and how can people be protected? The current legal answer is that protection (data protection principles, rights and obligations) is granted when a) there is information b) about or potentially affecting a person c) who is identified or identifiable. This is Personally Identifiable Information (PII). But now that virtually all information is PII, how can law meaningfully protect against information-induced harms?

Given modern data collection and processing techniques and unprecedented amounts of data available for analysis, everything can be translated into data and anyone can be identifiable in data sets. Therefore, PII-based legal protection will fail, since a law regulating everything is meaningless.

Yet, alternatives for structuring legal protection other than through the concept of PII are lacking. INFO-LEG innovates by looking for substitutes for the notion of PII to fundamentally re-organise legal protection. Promising new organising notions will be found through better understanding of information, how it links to people and harms. The approach is unique in integrating how law, economics, and information studies conceptualise information. INFO-LEG will theoretically and empirically explore external and internal conceptual boundaries of information and produce a multidisciplinary taxonomy of information. The notions from this taxonomy will be assessed on their suitability to substitute PII as new organising notions for legal protection against information-induced harms.

The multidisciplinary conceptualisation of information will impact scholarships studying how other areas of law regulate information in digital age: intellectual property (drawing borders of rights in information objects); constitutional law (if data is protected speech); telecommunication and cybercrime.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724191	**FASDEM**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. STAFFAN I. LINDBERG**
Host Institution: Goeteborgs Universitet, SE

Failing and Successful Sequences of Democratization

The study of democratization lies at the center of political science and is increasingly important in economics, sociology, and history, and has become a central foreign policy objective. Yet, there is little conclusive evidence about in particular endogenous sequences of democratization critical to our ability to provide sound policy advise. FASDEM promises to revolutionize our understanding of the trajectories that fail to lead to democracy, and the pathways that are successful, by addressing two key questions: Which are the failing versus successful sequences of democratization? What are the determining causal relationships in these sequences?

Critical is the just finalized Varieties of Democracy (V-Dem) dataset including some 350 indicators, 34 component-indices, and five main indices of varieties of democracy from 1900 to the present for 173countries – about 15 million data points on democracy. FASDEM, if funded, will use this data capitalizing on a set of novel analytical approaches, tools, and adaptations of modeling from evolutionary biology developed by a research team in a related, project, that together can establish sequences between sets of hundreds of ordinal variables. Under the second objective, FASDEM will take a step further developing upon the latest statistical methodologies of establishing causal identification in observational data, and use these to test each step of such manifest sequences. FASDEM will make a radical departure from the crude and "correlational" paradigm in democratization studies to detail and explain failing and successful sequences of democratization for the first time.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724431	**BEHAVE**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. CASPAR CHORUS**
Host Institution: Technische Universiteit Delft, NL

New discrete choice theory for understanding moral decision making behaviour

Discrete choice theory provides a mathematically rigorous framework to analyse and predict choice behaviour. While many of the theory's key developments originate from the domain of transportation (mobility, travel behaviour), it is now widely used throughout the social sciences.

The theory has a blind spot for moral choice behaviour. It was designed to analyse situations where people make choices that are optimal given their consumer preferences, rather than situations where people attempt to make choices that are right, given their moral preferences. This neglect of the morality of choice is striking, in light of the fact that many of the most important choices people make, have a moral dimension.

This research program extends discrete choice theory to the domain of moral decision making.

It will produce a suite of new mathematical representations of choice behaviour (i.e., choice models), which are designed to capture the decision rules and decision weights that determine how individuals behave in moral choice situations. In these models, particular emphasis is given to heterogeneity in moral decision rules and to the role of social influences. Models will be estimated and validated using data obtained through a series of interviews, surveys and choice experiments. Empirical analyses will take place in the context of moral choice situations concerning i) co-operative road using and ii) unsafe driving practices. Estimation results will be used as input for agent based models, to identify how social interaction processes lead to the emergence, persistence or dissolution of moral (traffic) equilibria at larger spatio-temporal scales.

Together, these proposed research efforts promise to generate a major breakthrough in discrete choice theory. In addition, the program will result in important methodological contributions to the empirical study of moral decision making behaviour in general; and to new insights into the moral aspects of (travel) behaviour.

Project End Date: **31-JUL-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
740426	**GeoViSense**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. SARA IRINA FABRIKANT**
Host Institution: Universitaet Zuerich, CH

GeoViSense: Towards a transdisciplinary human sensor science of human visuo-spatial decision making with geographic information displays

Well-designed mobile, human responsive geographic information technology could improve the lives of millions who daily need to make time critical and societally relevant decisions on the go. However, what are the basic processes with which humans make visuo-spatial decisions when guided by responsive geographic information displays? Visualization research todate has been driven by technical and computational advances to overcome data deluges, but we still have a poor understanding whether, how, and when visual displays support spatio-temporal decision making and action, and for which kinds of users. We will break new ground to overcome this transdisciplinary knowledge gap and aim to: (1) integrate fragmented human-visualization-environment research across the sciences including natural, social/behavioral, and the engineering sciences, all critical to tackle this interdisciplinary problem, (2) develop missing, empirically evaluated design guidelines for human-computer interfaces of current/emerging mobile geographic information technology to support affective, effective, and efficient spatio-temporal decision-making, (3) develop unconventional evaluation methods by critical examination of how perceptual, cognitive, psycho-physiological, and display design factors might influence visuo-spatio-temporal decision making across broad ranges of users and mobile use contexts, and (4) scale up empirical methods from to-date controlled behavioral lab paradigms towards a new in-situ mobile human sensor science. A paradigm shift from current lab-based neuro-cognitive and affective science towards a location-based, close human sensing science will radically change the way we study human behavior across science. In doing so, we can improve spatio-temporal every-day decision making with graphic displays, and facilitate sustainable solutions for the increasingly mobile digital information society having to mitigate environmental emergencies, human refugee crises, or terror attacks.

Project End Date: **31/oct./22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
740696	**SSID**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. JIAN KANG**
Host Institution: University College London, UK

Soundscape Indices

Eighty million EU citizens are suffering from excessive environmental noise and billions of euros are being spent on noise control, under the EU Directive on Environmental Noise. Unfortunately, the conventional approach, i.e. reduction of 'sound level', simply does not deliver the required improvements in quality of life. The growing field of 'soundscape studies' is addressing this gap by considering sound environment as perceived, in context, with an interdisciplinary approach. However, soundscapes are hugely complex and measuring them as a basis for environmental design requires a step change to the discipline. This research aims to achieve a ground-breaking development through the establishment of 'soundscape indices' (SSID), adequately reflecting levels of human comfort, the impact of which will be reminiscent of that of the Decibel scale created by Bell Systems a century ago. This will provide the underpinning science for soundscape in the field of built environment, with wider intellectual goals of moving from noise control to soundscape creation. Key objectives, as coherent steps for achieving the main aim, are: (1) To characterise soundscapes, by capturing soundscapes and establishing a comprehensive database, which will be a cornerstone for the proposed analysis, and an invaluable resource for scientists for years to come. (2) To determine key factors and their influence on soundscape quality based on the database, by conducting laboratory psychological evaluation, physical/psychoacoustic factors analysis, and more importantly, to research at a physiological/biological level, including the use of functional magnetic resonance imaging. (3) To develop, test and validate the soundscape indices, through analysing the influences by various factors, using a number of inter- & trans-disciplinary approaches. (4) To demonstrate the applicability of the soundscape indices in practice, by establishing frameworks for soundscape prediction, design, and standardisation.

Project End Date: **28-FEB-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
756194	**ENERGYA**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. ENRICA DE CIAN**
Host Institution: Universita Ca' Foscari Venezia, IT

ENERGY use for Adaptation

ENERGYA will improve our understanding of how energy and energy services can be used by households and industries to adapt to the risk posed by climate change. Specifically, the project will develop an interdisciplinary and scalable research framework integrating data and methods from economics with geography, climate science, and integrated assessment modelling to provide new knowledge concerning heterogeneity in energy use across countries, sectors, socioeconomic conditions and income groups, and assess the broad implications adaptation-driven energy use can have on the economy, the environment, and welfare.

The key novelty of ENERGYA is to link energy statistics and energy survey data with high spatial resolution data from climate science and remote sensing, including high-resolution spatial data on meteorology, population and economic activity distribution, electrification, and the built environment.

ENERGYA has three main objectives. First, it will produce novel statistical and econometric analyses for OECD and major emerging countries (Brazil, Mexico, India, and Indonesia) to shed light on the underlying mechanisms driving energy use. Second, it will infer future potential impacts from long-run climate and socioeconomic changes building on historical empirical evidence. Third, it will analyse the macro and distributional implications of adaptation-driven energy use with an economy-energy model characterising the distribution of energy use dynamics across and within countries.

Given the central role of energy as multiplier for socioeconomic development and as enabling condition for climate resilience, the research proposed in ENERGYA will result in timely insights for the transition towards sustainability described by the Sustainable Development Goals adopted by the United Nations as well as the Paris International Climate Agreement.

Project End Date: **28-FEB-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
756672	**HumanTrafficking**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. HILA SHAMIR**
Host Institution: Tel Aviv University, IL

Human Trafficking: A Labor Perspective

This project conducts a theoretical, methodological, and normative paradigm shift in the research and analysis of human trafficking, one of the most pressing moral and political challenges of our times. It moves away from the currently predominant approach to trafficking, which focuses on criminal law, border control, and human rights, towards a labor-based approach that targets the structure of labor markets that are prone to severely exploitative labor practices. This shift represents an essential development both in the research of migratory labor practices and in the process of designing more effective, and more just, anti-trafficking measures, that are context-sensitive as well as cognizant to global legal and economic trends. The project will include four main parts: 1) Theoretical: articulating and justifying the proposed shift on trafficking from individual rights and culpabilities to structural labor market realities. 2) Case-studies: conducting a multidisciplinary study of a series of innovative case studies, in which the labor context emerges as a significant factor in the trafficking nexus – bilateral agreements on migration, national regulations of labor standards and recruiters, unionization, and voluntary corporate codes of conduct. The case studies analysis employs the labor paradigm in elucidating the structural conditions that underlie trafficking, reveal a thus-far mostly unrecognized and under-theorized set of anti-trafficking tools. 3) Clinical Laboratory: collaborating with TAUs Workers' Rights clinic to create a legal laboratory in which the potential and limits of the tools examined in the case studies will be tested. 4) Normative: assessing the success of existing strategies and expanding on them to devise innovative tools for a just, practicable, and effective anti-trafficking policy, that can reach significantly more individuals vulnerable to trafficking, by providing them with legal mechanisms for avoiding and resisting exploitation.

Project End Date: **31-MAR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757455	**DUST**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. NICOLAS MALLESON**
Host Institution: University Of Leeds, UK

Data Assimilation for Agent-Based Models: Applications to Civil Emergencies

Civil emergencies such as flooding, terrorist attacks, fire, etc., can have devastating impacts on people, infrastructure, and economies. Knowing how to best respond to an emergency can be extremely difficult because building a clear picture of the emerging situation is challenging with the limited data and modelling capabilities that are available. Agent-based modelling (ABM) is a field that excels in its ability to simulate human systems and has therefore become a popular tool for simulating disasters and for modelling strategies that are aimed at mitigating developing problems. However, the field suffers from a serious drawback: models are not able to incorporate up-to-date data (e.g. social media, mobile telephone use, public transport records, etc.). Instead they are initialised with historical data and therefore their forecasts diverge rapidly from reality.

To address this major shortcoming, this research will develop dynamic data assimilation methods for use in ABMs. These techniques have already revolutionised weather forecasts and could offer the same advantages for ABMs of social systems. There are serious methodological barriers that must be overcome, but this research has the potential to produce a step change in the ability of models to create accurate short-term forecasts of social systems. The project is largely methodological, and will evidence the efficacy of the new methods by developing a cutting-edge simulation of a city – entitled the Dynamic Urban Simulation Technique (DUST) – that can be dynamically optimised with streaming 'big' data. The model will ultimately be used in three areas of important policy impact: (1) as a tool for understanding and managing cities; (2) as a planning tool for exploring and preparing for potential emergency situations; and (3) as a real-time management tool, drawing on current data as they emerge to create the most reliable picture of the current situation.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757995	**HEFT**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. SIMONE GINGRICH**
Host Institution: Universitaet Fuer Bodenkultur Wien, AT

Hidden Emissions of Forest Transitions: GHG effects of socio-metabolic processes reducing pressures on forests

A forest transition, i.e. forest expansion after a long period of deforestation, has occurred in many, mostly industrialized countries. Forest transitions have recently resulted in declining rates of global net deforestation and contributed to carbon (C) sinks in terrestrial ecosystems. Studies have shown the concurrence of forest transitions and industrialization processes, but the systemic links between forest transitions, their underlying socio-metabolic processes and associated greenhouse gas (GHG) emissions have been neither systematically explored nor quantified.

HEFT introduces the idea of “hidden emissions of forest transitions”, i.e. the GHG emissions from socio-metabolic processes reducing pressures on forests. Hidden emissions may stem from processes such as substitution of fuelwood by modern energy sources, intensification of agriculture, and externalization of biomass production to remote regions. Building on the concept of socio-ecological metabolism, HEFT develops a consistent methodological framework to quantify the full GHG emissions and sinks from socio-metabolic and ecological processes in the course of forest transitions, within which their hidden emissions are identified. Forest transitions in multiple contexts are analyzed at local, national and supranational scales: in Europe since c. 1850, North America since c. 1880, and South East Asia since 1980. A coarse global-scale assessment complements the regional case studies.

We will integrate sources and analytical methods from environmental and social sciences as well as the humanities to analyze context-specific trajectories and general features of socio-ecological GHG budgets and their respective socio-political contexts since the onset of forest transitions. The sound understanding of hidden emissions will be used to identify the least GHG-intensive trajectories and to draw lessons for future climate-friendly forest transitions.

Project End Date: **31-MAR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758014	**SCALAR**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. TATIANA FILATOVA**
Host Institution: Universiteit Twente, NL

Scaling up behavior and autonomous adaptation for macro models of climate change damage assessment

Damage associated with climate change is a core benchmark in science and policy. Macro Integrated Assessment Models estimating damages are criticized for neglecting risk distribution, adaptation dynamics and the possible collapse of regional economies. Micro-level social science studies contain substantial knowledge on individual behavior, decisions under risk and autonomous climate adaptation, and go beyond monetary losses by focusing on resilience. This knowledge can ameliorate theoretical and empirical flaws in current macro assessments, if adequate scaling up methods were to exist.

SCALAR aims to bridge the gap between micro and macro research traditions by modeling the behavioral aspects of autonomous adaptation processes of heterogeneous agents, and integrating them into macro level climate policy models. The project focuses on floods. Its innovative nature allows to revisit the classic micro-macro aggregation problem through a unique combination of:

1) New behavioral data on climate adaptation decisions collected in multiple survey waves using mobile applications, going beyond a snapshot to uncover evolving decision processes;

2) Advances in agent-based modeling to scale up adaptation decisions of heterogeneous households and firms to a regional economy while including land use and hazard data;

3) Cutting-edge ways of integrating micro-simulation models with traditional macro models to synergize the two approaches for developing new theory- and data-grounded macro damage assessments.

SCALAR will drive a major breakthrough in integrating behavioral aspects of human decision-making into macro climate policy models. It will enable the quantitative exploration of cross-scale damage cascades, the identification of thresholds over which autonomous adaptation impacts the macro level, and the tracing of the emergence of socio-economic resilience as climate change unfolds. The methodological advancements will have impact far beyond the domain of climate adaptation.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758149	**reFUEL**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. JOHANNES SCHMIDT**
Host Institution: Universitaet Fuer Bodenkultur Wien, AT

Going global? Renewable fuel trade and social land-use restrictions in a low-carbon energy system

Recent global integrated modelling studies indicate low intensities in trade of energy commodities between global regions in a future low-carbon global energy system. Also, research based on modelling indicates that deep greenhouse-gas emission cuts are possible in fully electrified renewable energy systems on a continental or country scale from a techno-economic perspective.
However, these modelling efforts partly neglect drivers of globalization and may therefore wrongly project regionalization of energy systems. In particular, (i) new, easily tradable, low-cost renewable fuels (e.g. solar & electric fuels), (ii) global bio-physical variability of renewables (e.g. solar radiation and freshwater availability), and (iii) regional differences in social land-use restrictions associated with the expansion of energy infrastructure can cause an increase of trade flows in the energy sector.
We aim at better understanding how the spatial configuration of renewables in low-carbon energy systems is affected by these drivers and develop a cutting-edge, open-source global renewable energy model that combines elements of energy system and land-use modelling. It takes into account bio-physical conditions for renewable fuel and electricity production, social land availability restrictions, and a map of existing energy infrastructure at unprecedented level of detail. Our approach integrates open data sources from public institutions, user-generated GIS data, and social networks. Existing models for Europe and Brazil are used for validation. Qualitative interviews in local case studies complement the global model and increase our understanding of land-use restrictions on the local scale.
Our project has impacts beyond energy systems analysis: in particular the identification of winning and losing regions in a global renewable energy system is highly relevant in climate change mitigation negotiations, and the generated spatial indicators and maps enable many potential applications.

Project End Date: **31-JUL-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758430	**SWFsEUROPE**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. ADAM DIXON**
Host Institution: Universiteit Maastricht, NL

Legitimacy, Financialization, and Varieties of Capitalism: Understanding Sovereign Wealth Funds in Europe

The number and size of sovereign wealth funds (SWF) has grown substantially in the last decade, leading to an unsettled debate regarding their legitimacy in the global political economy. Some suggest they represent the (re)emergence of state-led capitalism subject to geopolitical motivations that threaten free markets. For others, SWFs represent a source of long-term patient capital capable of mitigating market short-termism. Either way, SWFs challenge the norm, particularly in the West, that financial markets are spaces of exchange for non-state actors. In three complementary and interdisciplinary work programmes the SWFsEUROPE project will explain the evolving and variegated pattern of 'sovereign fund capitalism' in Europe, developing a new theory of the relationship between states and global finance. First, the project breaks new ground by explaining and theorizing how the legitimacy of SWFs as commercially oriented investors is performed when they are still entities of the state. No study has critically examined how legitimacy is performed via mechanisms such as the International Forum of Sovereign Wealth Funds and the Santiago Principles, or the growing evidence of collaboration with cognate institutional investors (e.g. pension funds). Second, this projects seeks a multi-layered explanation of the uneven pattern of investment flows and stocks of foreign SWFs into European countries through hypothesis testing of aggregate investment data with different theories of national-institutional variety, coupled with a comparative analysis of the bilateral investment-promotion relationships of investment-receiving countries. Third, the project will compare the growth and development of European SWFs. There is no comparative study exploring why some states are sponsors of an SWF (e.g. Italy, France, Ireland) and others are not (e.g. UK), what the motivations are and how they are made legitimate.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759079	**POLEMIC**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. GIJS SCHUMACHER**
Host Institution: Universiteit Van Amsterdam, NL

Politics and Emotions Investigated Comparatively

Many claim that politicians make more, and more extreme, emotional appeals than ever before, because these appeals win over the emotional citizen. With highly emotive language people like Donald Trump, Geert Wilders or Marine Le Pen are pounding on the portals to power. Do such emotional appeals affect citizens' political choices? Yes, they can. But, citizens' existing emotional attachments to parties, leaders or issues moderate the success of emotional appeals. POLEMIC will extend existing theory and use novel methods to explain when (types of) emotional appeals are persuasive, and when emotional attachments prevent persuasion.

Do politicians actually make more emotional appeals than in the past? And if so why are they doing it? We lack historical data of emotional appeals so we cannot answer these questions. POLEMIC will provide unique, historical data (1945-now, 9 countries) of emotional appeals by politicians in their speeches. I develop and test 3 alternative theories from different intellectual traditions that explain why politicians make emotional appeals: is it either (1) a vote-maximizing strategy, (2) a product of the personality of a politician or (3) just fashionable?

POLEMIC analyses emotional appeals of politicians and the emotional responses of citizens to these appeals. Emotional appeals are texts, and emotions are experiences by the brain. To measure them POLEMIC will use innovative methods in political science: automated text analysis to extract emotion from appeals; physiological measurement to measure emotions.

POLEMIC offers a ground-breaking combination of a macro-perspective (what politicians say) and a micro-perspective (how citizens respond) and forms a bridge between party politics and political psychology. The project's output will indicate the importance of emotion in the decision-making of citizens, and the level of rationality that is behind politicians' decision to make emotional appeals.

Project End Date: **31-MAR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759728	**TRICI-Law**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. PANAGIOTIS MERKOURIS**
Host Institution: Rijksuniversiteit Groningen, NL

The Rules of Interpretation of Customary International Law

This ERC proposal revolves around the rules of interpretation of customary international law (CIL). CIL along with treaties are the rules most often used in international law. However, whereas rules of interpretation of treaties have been enshrined in Articles 31-33 of the Vienna Convention on the Law of Treaties (VCLT), the rules of interpretation of CIL have not been the subject of critical study. This gap becomes even more pronounced if we consider that interpretation plays a key role in every judicial case, and that one of the basic markers of effectiveness of any legal system is its predictability. By not knowing the rules that govern the interpretation of CIL, we end up playing a 'game' the rules of which are unknown, and by consequence predictability is far from guaranteed.

Therefore the aim of this project is to determine the existence and to examine the content of the rules of interpretation of customary international law. It will: 1) prove the theoretical validity of CIL being open to interpretation; 2) induce the rules of interpretation of CIL and their content; 3) track the points of convergence/divergence and reasons thereof amongst rules of interpretation of CIL, treaties and unilateral acts as they evolve through time; and 4) create a set of articles/guidelines on the interpretation of CIL.

The results will influence the study and theory of CIL; will lead to a re-conceptualization of the theory of sources of international law; will spark a long overdue debate on the interaction between sources of international law; will further our understanding of the process of interpretation and of the basic precepts of the international legal system; and its findings will become the staple point of reference by any 'user' of international law.

Its ultimate outcomes will clarify the foundations of the international legal system, reduce normative conflict, and provide greater legal certainty and foreseeability in all international law-related interactions.

Project End Date: **30-APR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771082	**DRONETHICS**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. CHRISTIAN ENEMARK**
Host Institution: University Of Southampton, UK

Emergent Ethics of Drone Violence: Toward a Comprehensive Governance Framework

The increasing use of armed, uninhabited aircraft (drones) is a serious political challenge with implications for security and justice worldwide. Drone technology is attracting high levels of investment, drones controlled remotely are becoming more numerous, and technological momentum toward drones controlled by artificial intelligence (AI) is building. Many human lives are at stake in this, so the violent use of drones continues to raise ethical questions. DRONETHICS will systematically address an urgent need to clarify the morality of 'drone violence', defined as violence involving a weapon system that is radically remote from its immediate user. Such remoteness is achieved through extreme physical distancing or the devolution of agency from humans to machines, so drone violence disrupts traditional expectations about war and a warrior's exposure to risk. In turn, the disruptively innovative premise of this project is that such violence does not necessarily fall within the remit of the Just War framework according to which war is traditionally judged and governed. Moving beyond state-of-the-art Just War thinking, the project opens up an ethical inquiry into drone violence conceptualised as either war, law enforcement, interpersonal violence, or devolved (to AI) violence. An interdisciplinary research team, incorporating international relations, moral philosophy and computer science perspectives, will conduct rigorous analysis of documentary sources and engage closely with officials, drone operators, and roboticists. Through innovative exploration and application of alternative frameworks for governing violence, DRONETHICS will produce: the first integrated conceptual framework for explaining ethical concerns arising from current and potential forms of drone violence; concrete recommendations for policy-makers on how to manage this violence ethically; and a new normative vision for shaping the longer-term trajectory of drone violence for the good of all humanity.

Project End Date: **30-JUN-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771874	**SpaceLaw**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. KAIUS TUORI**
Host Institution: Helsingin Yliopisto, FI

Law, Governance and Space: Questioning the Foundations of the Republican Tradition

Administrative professionalization is the hallmark of a modern state, but its origins contain a dilemma. Why there were no offices in ancient Rome? How is it possible that it nevertheless formed the model for the Western administrative state? The purpose of this project is to challenge earlier research and to propose a new model of the Roman Republican governance that integrates domestic and private space and to reinterpret its links with the Republican tradition.

The significance of these issues extends much beyond this: the development of administrative space in the European context amounts to nothing less than the emergence of the concept of public. Ever since Weber, the conceptual separation of the office and its holder has defined the European way of governance. The origin of this separation of public and private has often been seen in the Roman Republican state with its strict responsibilities, term limits and defined powers of its magistracies, who operated in open public spaces.

Using unconventional methodological tools to challenge the conventional view, the project explores the social and cultural dimensions of legal and administrative space, transcending modern assumptions of public and private. Two main research questions explore the confrontation of ideas and their contexts from the Roman Republic to modern Republicanism:

1) How the conflict between Republican ideals, political power and administrative practices transformed the spaces of administration?

2) How this conflict changed the social topography of Rome, the public and private spheres of governance?

While much of the earlier research on Republican administration has been constitutional, focused on sovereignty or the individual magistrates, this project advances a radical new interpretation through spatial and topographical analysis. It is a comprehensive re-evaluation of the Roman administrative tradition and its links with the European heritage through the lens of administrative space.

Project End Date: **30-APR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788001	**GlobalGoals**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. FRANK BIERMANN**
Host Institution: Universiteit Utrecht, NL

Global Governance through Goals? Assessing and Explaining the Steering Effects of the United Nations Sustainable Development Goals

Achieving sustainable development worldwide remains probably the biggest political challenge of our time. In 2015, the international community adopted 17 'Sustainable Development Goals' with no less than 169 ‘targets’ as part of a global '2030 Agenda for Sustainable Development'. The ambition expressed in these goals is unprecedented. But can such goal-setting, as a new central approach in global governance, help resolve the pressing challenges of economic development, poverty eradication, social justice and global environmental protection? Nobody knows at this stage. While the United Nations and its member states place high hopes on this novel strategy, there is little scientific knowledge on whether such global goals can live up to exceedingly high expectations. Sustainability research has tended to focus on concrete institutions, actors and practices – not on aspirational goals that bring little in terms of normative specificity, stable regime formation or compliance mechanisms. How can ‘global governance through goals’ nonetheless be effective – and under which conditions? GLOBALGOALS will address this puzzle and break new ground in sustainability and global governance theories. It offers the first and most comprehensive data compilation, network mapping and comparative institutional analysis of the evolution, effectiveness and future prospects of 'global governance through goals' as a central novel steering mechanism in world politics. This 5–year study programme deploys a unique set of cutting-edge methodologies, including social network analysis and online surveys, to assess and explain the steering effects of nine Sustainable Development Goals through a detailed investigation of their institutional arrangements and actor networks, at international and national levels. GLOBALGOALS makes a crucial knowledge contribution to both the theory of global sustainability governance and the successful implementation of the 2030 Agenda for Sustainable Development.

Project End Date: **31-OCT-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788304	**ELHO**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. MICHAEL BRUTER**
Host Institution: London School Of Economics And Political Science, UK

The Age of Hostility: Understanding the Nature, Dynamics, Determinants, and Consequences of Citizens' Electoral Hostility in 27 Democracies

'I hate Brexiteers, they betrayed my future'. Those words of an 18 year old on Brexit Referendum Night represent a growing and worrying phenomenon: electoral hostility. Electoral disagreements have long been seen as results of social divisions, but recent research shows that they have become a basis of antagonism in their own right in the US. Two comparative pilots I ran also found electoral hostility widespread in recent French and British elections but rare in South Africa and Australia. In the UK Brexit referendum, 51% of citizens felt anger towards opposite voters and 46% disgust.

I define electoral hostility as negative feelings (frustration, anger, contempt, disgust) held towards individuals or groups as a result of their effective or perceived electoral preferences. It may occur in the campaign, post-election, and reinforce into self-perpetuating cycles of hostility as it is structured as a Mokken scale which can become 'stages' of hostility. While scepticism of political elites is well-studied, hostility towards fellow voters takes electoral negativity to a new level. Electoral hostility may have far reaching consequences, leading citizens to resent one another due to electoral stances and drift apart in increasingly divided societies, but also to the delegitimization of electoral outcomes and negative attitudes towards solidarity.

ELHO will answer the following research question: What are the causes and consequences of electoral hostility at individual, group, and aggregate levels and how does it develop over time? The project's innovative methods combine a 27 country multi-level panel survey, visual, physiological and field experiments, election diaries, family focus groups, a scoping survey of Election Management Bodies, and campaign and atmosphere coding. The project will also explore possible mitigation in ambitious partnership with psychiatrists, ergonomists, lawyers, EMBs and IGOs creating new Electoral Hostility Research Centre and Observatory.

Project End Date: **31-MAR-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802053	**JustSites**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. MIKKEL JARLE CHRISTENSEN**
Host Institution: Kobenhavns Universitet, DK

The Global Sites of International Criminal Justice

JustSites studies the multitude of localities in which international criminal justice is produced, received and has impact. Building an innovative scientific vocabulary, the project understands these justice sites to be social topographies in which the political, legal and professional activities that collectively create international criminal justice are developed. The justice sites include locations in which forensic exhumations are carried out, NGO offices in conflict zones, foreign ministries, private law firms, media outlets, academic research centers, and the international criminal courts. These sites are closely related, and all depend on and compete with each other to define the direction of international criminal justice. With its analysis of justice sites, the project moves beyond the conventional focus on courts and their context to investigate instead the balances of authority and power that affect the relations between these topographies and thus drive the development of international criminal justice as a field of law. To investigate the relational topography of justice sites, the multidisciplinary project analyzes how these sites produce international criminal justice ideas and practices, and how such ideas and practices are received and have impact in other sites. By following the impact of ideas and practices as they move from one site to another, the relative and perceived authority and power of these sites will be identified and analyzed. Through their productive and receptive character, the justice sites also communicate the results of international criminal justice to broader audiences, labelling them in the process as a success or a failure. Therefore, contributing the first investigation of the topography of justice sites is not only of significant value as frontier research, but is crucial for understanding the wider societal, legal and political impact of this field of law.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802070	**BROKEX**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. HEIDI ØSTBØ HAUGEN**
Host Institution: Universitetet I Oslo, NO

Brokering China's Extraversion: An Ethnographic Analysis of Transnational Arbitration

Chinese global engagements are deepening across sectors and geographic regions. The objective of BROKEX is to fill specific gaps in knowledge about how China's extraversion advances. The project takes an original approach by examining brokers who mediate in transnational fields. It opens the "black box" of China's global integration by moving beyond descriptions of input and output characteristics to elucidate underlying dynamics. The objective will be achieved in two phases. First, the PI and two postdoctoral researchers will carry out three ethnographic case studies that yield complementary information on the common challenge of brokering across geographic scales: (1) Connecting low-cost Chinese manufacturing with African markets; (2) Integrating Chinese academic research with global scientific communities; (3) Attracting new foreign investments to China to underpin industrial upgrading. The diverse cases offer insights into the mechanisms of brokerage across distinctive sectors. The team will collect data in the Pearl River Delta, South China, while based at Sun Yat-sen University, with which the PI has longstanding collaboration. In the second step, we build on the empirical findings and extant literature to develop brokerage theory. Social scientific research on brokerage commonly uses the morphology of social networks as its starting point, and focuses on how actors positioned at the intersection between groups operate. BROKEX adopts an innovative approach by examining how actors strategically seek to shape network morphologies in order to bridge gaps between groups. By directing theoretical attention towards relationship formation that precedes acts of brokerage, this line of inquiry advances understandings of how and why brokered connections emerge. Ethnographic case studies combined with critical theorization will generate new knowledge about the processes beneath the "rise of China" – one of the most consequential socioeconomic developments of our times.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802362	**BIT-ACT**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. ALICE MATTONI**
Host Institution: Alma Mater Studiorum - Universita Di Bologna, IT

Bottom-up initiatives and anti-corruption technologies: how citizens use ICTs to fight corruption

Corruption is a global challenge that affects the lives of millions of citizens. In the past decade, Information and Communication Technologies (ICTs) have become indispensable tools in the fight to reduce corruption, especially when employed from the bottom-up by civil society organizations. While pioneering initiatives in this direction have flourished, to date we only have unsystematic and descriptive evidence regarding how they work and the associated consequences. With the objective of significantly advancing knowledge on this topic, BIT-ACT will open a new line of inquiry by investigating what I call anti-corruption technologies (ACTs) to: (1) assess how civil society organizations engage with ACTs to counter corruption, (2) appraise how ACTs enable intersections between bottom-up and top-down efforts against corruption, and (3) evaluate how ACTs blend with the transnational dimension in the struggle against corruption. Based on an interdisciplinary framework that combines corruption studies, science and technology studies and social movement studies, BIT-ACT will use the constructivist grounded theory method to analyze a combination of textual and visual data in a comparative and transnational research design including nine countries – Algeria, Bangladesh, Brazil, Estonia, India, Italy, Spain, Ukraine, Uruguay. BIT-ACT will be groundbreaking in three ways. At the theoretical level, it will expand the debate on anti-corruption providing grounded concepts and models to explain ACTs; at the empirical level, it will advance knowledge on how the usage of ACTs is changing the relationship between citizens and democratic institutions; at the methodological level, it will innovate in the use of grounded theory assessing a new standard for cross-national comparative grounded theory. Finally, BIT-ACT will produce sound and useful knowledge for the stakeholders involved in the fight against corruption worldwide by suggesting how to best employ ICTs from the bottom-up.

Project End Date: **30-JUN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802441	**UNMAKING**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. GIUSEPPE FEOLA**
Host Institution: Universiteit Utrecht, NL

Societal transformation to sustainability through the unmaking of capitalism? A comparative study of radical grassroots innovations in Europe

Modern capitalist societies engage destructively with the natural environment. Societal transformation to sustainability is urged, but it implies a degree of disruption of modern, capitalist ways of being and doing. Radical grassroots innovations – those that posit a profound cultural, economic, and political transformation of dominant institutions and practices - hold the potential to lead such transformation, but may be constrained by their marginal, local, small-scale character.

This programme aims to understand to what extent, under what conditions, and through what processes radical grassroots innovations unmake modern, capitalist institutions and practices. This research will compare Italian and German radical grassroots innovations in agriculture to: (1) identify and categorize mechanisms of unmaking that are involved in radical grassroots innovations; (2) explain whether and how unmaking creates space for alternatives from the individual to the social-ecological level; (3) understand how mechanisms of unmaking at different levels interplay; (4) explain why unmaking may result in different outcomes in different context; (5) develop a theory of unmaking in societal transformation to sustainability.This research is ground breaking as it (1) approaches societal transformation from the perspective of unmaking of dominant institutions, rather than of the introduction of innovations, (2) mobilizes theories that have so far not been considered, and innovatively integrates theories and levels of analysis, (3) originally employs mixed methods that capture trajectories of change, and enable to generalize causal mechanisms in complex social-ecological systems. This programme will push the boundaries of our understanding of transformation to sustainability. It will generate scientific knowledge that will be relevant across the social sciences, offer a theoretical lens –unmaking-, and test a process-tracing methodological approach to stimulate interdisciplinary research.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802891	**LINKS**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. NADIA AMELI**
Host Institution: University College London, UK

Kick-starting global cLimate Investments:
uncovering hidden liNks in climate finance and exploring dynamic evolution of investment networKs for policy deSign

LINKS aims to contribute to a transformation of the climate finance system to deliver the scale and quality of investment needed to meet the Paris climate goals and ensure effective capital allocation. By understanding the architecture of the financial system, exploring macro patterns in low-carbon investment emerging from observed investors' behaviour and interactions, and designing cross-cutting policies aligned with long-term climate targets, LINKS will promote essential guidance for a re-orientation of financial flows towards low-carbon and energy efficiency investments.
LINKS aims to advance the understanding of the role of climate finance to foster the low-carbon transition by using network theory, advanced computational techniques and extensive empirical data to model the financial system as a complex adaptive system. LINKS will thus lay the foundations of, and pioneer a new field, namely climate finance networks, where dynamics of interconnected investors represented as a network, results in the complex behavior of the whole system.

LINKS will bring together interdisciplinary theories and developments in finance, environmental economics, sociology, computer science, network analysis and complexity in an integrated approach to study and model climate finance. Taking this approach will allow advancements in at least three directions: i) a new theoretical approach to account for complexity thinking and systemic perspective in climate finance, ii) more empirical analyses on networks structures of low-carbon investments and their dynamics to shape the development of the climate finance system, iii) policy modelling analyses to explore whether specific architectures of the climate finance system have significant impact on the effectiveness of climate public policies and invested public resources. LINKS will thus deliver robust conclusions on how the financial system could contribute to the required investments to achieve the low-carbon transition.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803981	**HRNUDGE**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. VERONIKA FIKFAK**
Host Institution: Kobenhavns Universitet, DK

A NUDGE IN THE RIGHTS DIRECTION? REDESIGNING THE ARCHITECTURE OF HUMAN RIGHTS REMEDIES

Recent years have seen a renewed interest in the effectiveness of human rights law and judgments, yet almost no attention has been given to the impact of remedies on states' compliance practices or the internalisation of human rights into their domestic legal systems. Through a combination of quantitative and qualitative research in six countries, the project aims to expose the dynamics of the (non)compliant state and the efficacy of different types of remedies in changing the behaviour of human rights violators. These goals will be achieved through three sub-studies: (1) an empirical study of 12,000 cases of the European Court of Human Rights (ECtHR) to determine the compliance and internalisation practices and their link to different remedies; (2) the exploration and analysis of states' internalisation practices and policies (including the identification of players that shape this practice) to determine whether remedies play a crucial role in shifting states' actions; (3) a computer simulation to discover how we can change the architecture of human rights remedies to increase compliance and internalisation, and to deter future violations.

The central aim of the project is to identify new remedy options – incentives or nudges – which human rights institutions can use to deter future violations. Using the example of the ECtHR and its caselaw, the research will build on insights from behavioural economics to interrogate widespread assumptions about monetisation of human rights, public shaming, and deference shown to states in the specification of remedies. Through computer simulation, the project will aim to predict how monetary and non-monetary remedies could be used separately or together to alter the behaviour of states and their key players. The research will be ground-breaking in many ways, reshaping the field of human rights remedies and contributing crucially to the emerging field of behavioural international law.

Project End Date: **29-FEB-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804024	**ImagiDem**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator:	**Dr. EEVA LUHTAKALLIO**
Host Institution:	Helsingin Yliopisto, FI

Imagi(ni)ng Democracy: European youth becoming citizens by visual participation

The current political and institutional crises render the future of European democracy uncertain. To gain deeper insights into what the current discontent may lead to, and how to address it for the good of an equal and inclusive democracy, we have to study future political actors, today's young citizens, and examine what are the means of political action prevalent to them. The public sphere of today's youth is increasingly dominated by visual content, and therefore the visual dimension of political participation is to be a key concern in research thereof. The current youth's understanding of political action – building arguments, mobilizing, and participating – is likely to become firmly anchored in repertoires of visual participation. ImagiDem will explore, analyze, and conceptualize visual participation of young European citizens in order to formulate a model of democratic practices in the 2020s.

ImagiDem addresses visual political participation and democratic practices among young citizens in the European context using a radical triple-strategy: it combines visual ethnography with computational big data minining and analysis, and deploys this combination to a comparative research setting. The project design includes four countries of comparison – Finland, France, Germany, and Portugal – with both an ethnographic and a computational subproject realized in each of them. Both methodological approaches – comparative online ethnography, and computational, machine learning based analysis of large sets of social media image data – are risky and hitherto scarcely explored.

The theoretical challenge ImagiDem takes is to develop pragmatist theorizing of visual justification and engagements on the one hand, and visual cultural toolkits and frames, on the other. With this methodologico-theoretical toolkit, ImagiDem provides overarching analysis of the future of European democracy.

Project End Date: **30-APR-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804051	**LO-ACT**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. VANESA CASTAN BROTO**
Host Institution: The University Of Sheffield, UK

Low Carbon Action in Ordinary Cities

The challenge of LO-ACT is to enable low carbon urban development in medium and small cities in rapidly urbanising areas in East, Central and West Africa, South Asia and South East Asia. The majority of emissions in the next century will be emitted by infrastructures that are yet to be built, particularly in rapidly urbanising areas where infrastructure is lacking. Population forecasts suggest that most population growth will take place in small and medium cities. Yet, to date, research on climate action has focused on showcasing strongly branded, successful initiatives in global cities. The low carbon transition depends on myriad of actions in ordinary cities, that is, cities outside global networks of climate innovation and leadership. LO-ACT will address this critical gap by delivering the first multi-dimensional, large scale assessment of low carbon action in ordinary cities. It will contribute a new framework to understand global environmental politics and urban governance.

First, LO-ACT will analyse the imaginaries of local action that have shaped global environmental politics over 30 years (Objective 1). The work programme will also analyse the mobility of low carbon urban policies in transport, energy, and housing across different urban contexts (Objective 2). LO-ACT will deliver a comparative analysis of urban trajectories in 113 ordinary cities, and five in-depth ethnographic case studies (Objective 3). Finally, it will provide a critical assessment of governance theory and a revised framework to acknowledge the messy and ordinary contexts of urban action (Objective 4).

LO-ACT will bring together an interdisciplinary, international team of researchers, an international network of academic advisors, and four regional hubs that will support context-specific data collection and analysis. The research will contribute to the fields of human geography, urban studies, environmental politics, sustainability transitions and science and technology studies.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804150	**CALENDARS**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. SCOTT BREMER**
Host Institution: Universitetet I Bergen, NO

Co-production of seasonal representations for adaptive institutions

Climate change may be undermining the stock of seasonal representations that society draws on to understand and live according to the weather. The CALENDARS project studies how modern society represents seasons, and how these representations shape institutions and help people live with seasonal change. The project opens an important emerging field in climate adaptation research by examining the representations of 'normal' seasons underlying key institutions, assesses their quality for successful adaptation to rapid climate change, and analyses facilitators and barriers to adopting representations more flexibly to new climates. It contributes a novel perspective on how to transform our institutions – from schools to farmer cooperatives – from the foundational culture and representations up, to better fit the changing seasonal cycles we are experiencing.

CALENDARS empirically explores the relationship between different institutions' ideas of seasons and their successful adaptation through an in-depth comparative study of a set of institutions in two local communities, in Norway and New Zealand. It is steered by an overall objective to: 'Advance knowledge and understanding of how seasonal representations shape and are shaped by institutions, and critically appraise the quality of these representations for contributing to successful adaptation to seasonal change'.

Conceptually, CALENDARS looks at representations as continuously 'co-produced' at the boundary of nature and society, and society and institutions. It tests a novel reconceptualisation of co-production as a prism; with each of the project's three phases looking at the complex processes by which representations emerge through different 'lenses' of co-production. Methodologically, the project tests the feasibility of a novel basket of bespoke methods spanning narrative interviews, calendar boundary objects and collaborative sustainability science.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804469	**CriticalMaaS**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. ODED CATS**
Host Institution: Technische Universiteit Delft, NL

Concepts, theories and models for planning , operating and evaluating the dynamics of Mobility as a Service

Online marketplaces enable in the travel context the dynamic matching of supply and demand. The shared economy can revolutionize urban mobility by blurring the traditional division between private and public transport, shifting from an ownership model to Mobility as a Service (MaaS).

Existing transport models are designed with the premise that transport consists of either fully scheduled and controlled fleets or individual privately owned vehicles. Since MaaS breaks the conventional division between individual (ownership) and collective (usage) travel alternatives, existing theories and models of travel behaviour, transport network and operations cannot explain the behavioural dynamics, interactions and evolution of both supply-side and demand-side of the marketplace.

This research program develops and tests theories and models of transport network in the domain of two-sided mobility market.

CriticalMaaS will produce a set of new behavioural models of traveller and supplier choices in transport marketplace settings. The supply- and demand-side dynamics and their interactions will be mathematically formalized and developed in both network flow distribution and agent-based modelling frameworks designed for the analysis of their co-evolution. Models will be used to study emerging patterns, transition phases and critical mass concepts by testing the conditions required for generating economies of scale in market adoption and evolution of MaaS.

Models will be estimated and validated using a series of surveys, choice experiments, laboratory experiments, observed behavioural data from on-demand services, focus groups and interviews.

The proposed research efforts will result with several theoretical and methodological breakthroughs in the field of transport modelling. In addition, the research program will make methodological and empirical contributions to the field of travel behaviour as well as insights into the dynamics of a two-sided (mobility) marketplace.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804599	**MARIPOLDATA**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. ALICE VADROT**
Host Institution: Universitaet Wien, AT

The Politics of Marine Biodiversity Data: Global and National Policies and Practices of Monitoring the Oceans

In order to protect marine biodiversity and ensure that benefits are equally shared, the UN General Assembly has decided to develop a new legally binding treaty under the United Nations Convention on the Law of the Sea. Marine biodiversity data will play a central role: Firstly, in supporting intergovernmental efforts to identify, protect and monitor marine biodiversity. Secondly, in informing governments interested in particular aspects of marine biodiversity, including its economic use and its contribution to biosecurity. In examining how this data are represented and used, this project will create a novel understanding of the materiality of science-policy interrelations in global environmental politics as well as develop the methodologies to do so. This is crucial, because the capacities to develop and use data infrastructures are unequally distributed among countries and global initiatives for data sharing are significantly challenged by conflicting perceptions of who benefits from marine biodiversity research. Despite broad recognition of these challenges within natural science communities the political aspects of marine biodiversity data remain understudied. Academic debates tend to neglect the role of international politics in legitimising and authorising scientific concepts, data sources and criteria and how this influences national monitoring priorities. The central objective of MARIPOLDATA is to overcome these shortcomings by developing and applying a new multiscale methodology for grounding the analysis of science-policy interrelations in empirical research. An interdisciplinary team, led by the PI, will collect and analyse data across different policy-levels and spatial scales by combining 1) ethnographic studies at intergovernmental negotiation sites with 2) a comparative analysis of national biodiversity monitoring policies and practices and 3) bibliometric and network analyses and oral history interviews for mapping marine biodiversity science.

Project End Date: **31-OCT-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
817652	**EQUALITY**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. NIELS PETERSEN**
Host Institution: Westfaelische Wilhelms-Universitaet Muenster, DE

CORRECTING INEQUALITY THROUGH LAW: HOW COURTS CONCEPTUALIZE EQUALITY IN THEIR CONSTITUTIONAL JURISPRUDENCE

Equality is one of the main political concerns of our time. Rising economic inequality is often cited as a major reason for the recent rise of political populism. But economic inequality is not the only problem. Inequalities based on gender, race or nationality are also major issues in the contemporary discussion. While most commentators discuss political solutions, the proposed research project analyzes the contributions that courts can make to correct inequalities. Norms protecting equality form part of all major national and international human rights instruments. However, the meaning of equality is fundamentally contested. There is no agreement on what equality exactly means or entails. The question, therefore, is not whether legal equality guarantees can tolerate inequality, but to what extent they can do. Because of these conceptual difficulties, the application of equality and non-discrimination clauses is not a straightforward exercise, in which courts simply apply legal norms to a given set of facts. Instead, courts need to develop doctrinal instruments to give meaning to the concept of equality. The proposed research project analyses how apex courts conceptualize equality in constitutional and international human rights law. It will be based on a comparative study of the equality jurisprudence of 16 jurisdictions and has three aims. Firstly, it intends to create a comparative map of equality jurisprudence, i.e. to describe and categorize the constitutional jurisprudence on equality: Which doctrinal choices do courts make and how do these choices inform the conception of equality? Secondly, it seeks to explain the doctrinal choices of the analyzed courts: Which factors influence courts to arrive at particular conceptions of equality? Thirdly, it has a normative goal and examines whether courts are better suited to correct certain kinds of inequalities than other kinds of inequalities.

Project End Date: **31-MAY-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
817680	**HomoJuridicus**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. BENJAMIN VAN ROOIJ**
Host Institution: Universiteit Van Amsterdam, NL

Homo Juridicus: Correcting Law's Behavioural Illiteracy

Recent scientific research has revolutionised our understanding of how law can reduce misconduct. It shows that legal incentives are often flawed, and that strict punishment alone cannot deter misbehaviour. It offers a new approach for law to address wrongdoing, incorporating social norms and morals, tapping into unconscious cognition, and applying practical and technical interventions that obstruct misconduct. Yet, these fundamental insights continue to be ignored, and with every new disaster, scandal or major risk, we produce more rules with stronger punishment, without successfully addressing the true behavioural mechanisms at fault. The core problem is that the field of law has not made conduct central, nor produced a behavioural legal theory to guide these scientific insights into legal research, education and practice. As a result, legal rules to code conduct are made and operated by lawyers that are behaviourally illiterate. The proposed research will instigate the necessary behavioural revolution in the field of law. To do so, it will develop a behavioural jurisprudence through three steps. First, it will provide a comprehensive synthesis of the scientific insights about how legal rules affect misconduct. Second, it will empirically analyse flaws and biases in the behavioural assumptions of lawyers tasked with addressing misconduct. This will produce a fundamental critique of existing legal thinking, to be summarized in the Homo Juridicus, shorthand for the flawed legal model of human conduct just like behavioural economics helped produce the Homo Economicus to show the fallacies in traditional economic thinking. Third, the research will synthesize this into a behavioural jurisprudence offering a normative framework that makes successful internalization of positive conduct central in the field of law, and that guides legal research and education to incorporate the social science to enhance the effectiveness of law to improve behaviour.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
817855	**PLEDGEDEM**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. CARSTEN JENSEN**
Host Institution: Aarhus Universitet, DK

Pledges in democracy

Election pledges are supposedly a vital part of representative democracy. Yet we do not in fact know whether and how pledges matter for vote choice and accountability. This project thus asks: Do election pledges matter for voters' democratic behavior and beliefs?

The role of pledges in citizens' democratic behavior and beliefs is, surprisingly, virtually unexplored. This project's ambition is therefore to create a new research agenda that redefines how political scientists think about the link between parties and voters. The project not only advances the research frontier by introducing a new, crucial phenomenon for political scientists to study; it also breaks new ground because it provides original theoretical and methodological tools for this new research agenda.

The key empirical contribution of this project is to collect two path-breaking datasets in the United States, France, and Norway that produce an unbiased estimate of voters' awareness and use of pledges. The first consists of a set of innovative panel surveys with embedded conjoint experiments conducted both before and after national elections. The second dataset codes all pledges; whether or not they are broken; and how the mass media report on them.

This project is unique in its scientific ambition: It studies the core mechanism of representative democracy as it happens in real time, and does so in several countries. If successful, we will have much firmer knowledge about how voters select parties that best represent them and sanction those that betray their trust – and what this all implies for people's trust in democracy.

Project End Date: **31-JUL-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818002	**URBAG**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. GARA VILLALBA**
Host Institution: Universidad Autonoma De Barcelona, ES

Integrated System Analysis of Urban Vegetation and Agriculture

This research aims to find out how urban green infrastructures can be most efficient in contributing to urban sustainability. This will evaluate which combinations of urban, peri-urban agriculture and green spaces result in the best performance in terms of local and global environmental impact.
For this purpose, I will use novel and comprehensive analysis that will integrate the life cycle impacts of the resources required for green infrastructures with the understanding of how green infrastructures impact the urban atmosphere interaction. This comprehensive approach allows to capture the urban metabolism to optimize the food-energy-water nexus. In previous works, the impacts had been only studied individually.
The analysis will consist of 1) A geo-referenced land-use model to optimize urban and peri-urban food production in terms of nutrients, water, and energy, considering urban morphology and determining life cycle impacts 2) A spatially-temporally resolved framework for quantitative analysis and simulation of green infrastructures to determine the direct and indirect effects on the urban and regional atmosphere. The research will be implemented in two selected cities with different profiles, Barcelona and Oslo. The study ambitions to gather substantial quantitative evidence in green infrastructures and sustainability, contributing to cover the existing gap in previous works.
This project and the envisaged: Green infrastructures - A Guide for city planners and policy makers, are timely and urgent. Many cities are implementing green infrastructures despite having little quantitative and comprehensive knowledge as to which infrastructure strategies are more effective in promoting food production, air quality and temperature while reducing environmental impact. This intended Guide will contain evidence-based guidance and tools to create green infrastructure strategies; to help to meet sustainability targets, and promote wider and diffused social benefits.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819213	**SECURITY FLOWS**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. CLAUDIA ARADAU**
Host Institution: King'S College London, UK

Enacting border security in the digital age: political worlds of data forms, flows and frictions.

Datafication, the process transforming our everyday lives into quantifiable digital data, is also transforming borders today. Data collection, exchange and interoperability have become key for EU border security. How does data enact border security in the digital age? What are the political and ethical implications of these processes of datafication? This project proposes to develop a novel interdisciplinary framework to understand how data is generated, exchanged and contested in border encounters, and to investigate the complex epistemic, practical, political and ethical implications of these transformations. Starting from a socio-material reconceptualisation of datafication as the production of data forms, flows and frictions, the project advances an innovative theorisation of the (i)epistemic effects of datafication as producing both knowledge and ignorance. It will shed light on how data forms make things intelligible or unintelligible, and how digital data flows and frictions redistribute knowledge and ignorance among border security actors, NGOs and irregular migrants. To trace the (ii)practical implications of datafication, the project will devise a multi-modal methodology for 'following the data' along the Eastern, Central and Mediterranean routes as well as the routes leading to these from Morocco, Niger and Turkey, and finally along return routes. (iii)Politically, the project investigates how data reconfigures the worlds of actors involved in the governance of border security by enacting new power relations between these actors and reshaping decision-making. Finally, the project also advances a socio-material approach to (iv)ethics to account for how data protection and the rights of both citizens and non-citizens are transformed by datafication. Through its ambitious theoretical and methodological innovations, which will shape an emergent field of research, the project will have long-lasting impact for border and security studies.

Project End Date: **31-MAY-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819566	**PICASSO**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. DETLEF VAN VUUREN**
Host Institution: Universiteit Utrecht, NL

Project on Integrated Assessment model-based Scenarios for Sustainable development Objectives

In 2015, nearly all nations agreed on a set of ambitious Sustainable Development Goals (SDGs) to ensure environment protection and human development. Accounting for the coherence of the overall set of goals presents a major scientific challenge as there are many complex relationships and feedbacks between them and across various scales (local to global, near- and long-term). However, in fact very little scientific information exists on how to achieve such a diverse set of goals simultaneously. In the proposed research, I will address the scientific gap by developing a novel set of model-based scenarios that explore the efforts required to achieve a set of key sustainable development targets by 2050 simultaneously (i.e. using a backcasting approach). These targets are based on the SDGs and other international agreements, and cover key sustainability issues such as food production, energy and land use, climate change, water scarcity, and nutrient cycles.
The purpose of the analysis is to identify 1) transformation processes needed for achieving these targets (including timing), 2) key synergies and trade-offs among sustainability issues, and 3) the relationships between different geographic scales. In PICASSO, I will use the integrated assessment model IMAGE 3.0 to develop such scenarios and explore the key linkages. For this purpose, important model improvements will be made to better cover the feedbacks and response options relevant for the SDG targets. Additional project activities will cover uncertainty analysis, and questions related to implementation (the role of different actors in these transitions). Stakeholder interaction is vital and will be formalised in a project forum with key stakeholders that will meet on a regular basis. The scenarios may thus be used to implement and evaluate the SDGs, and they will also result in new scientific understanding of integrated response strategies that can be used by other researchers in more detailed analysis.

Project End Date: **31-MAY-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819877	**FIAT**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. EOIN CAROLAN**
Host Institution: University College Dublin, National University Of Ireland, Dublin, IE

The Foundations of Institutional AuThority: a multi-dimensional model of the separation of powers

'Almost three centuries later, it is past time to rethink Montesquieu's holy trinity' (Ackerman, 2010).

As Ackerman (and many others) have observed, political reality has long left the traditional model of the separation of powers behind. The problems posed by this gap between constitutional theory and political practice have recently acquired fresh urgency as developments in Hungary, Poland, Turkey, Russia, the UK, US, Bolivia and elsewhere place the separation of powers under strain. These include the emergence of authoritarian leaders; personalisation of political authority; recourse to non-legal plebiscites; and the capture or de-legitimisation of other constitutional bodies.

This project argues that these difficulties are rooted in a deeper problem with constitutional thinking about institutional power: a constitution-as-law approach that equates the conferral of legal power with the authority to exercise it. This makes it possible for a gap to emerge between legal accounts of authority and its diverse –and potentially conflicting (Cotterrell)– sociological foundations. Where that gap exists, the practical authority of an institution (or constitution) may be vulnerable to challenge from rival and more socially-resonant claims (Scheppele (2017)).

It is this gap between legal norms and social facts that the project aims to investigate – and ultimately bridge.

How is authority established? How is it maintained? How might it fail? And how does the constitution (as rule? representation (Saward)? mission statement (King)?) shape, re-shape and come to be shaped by those processes? By investigating these questions across six case studies, the project will produce a multi-dimensional account of institutional authority that takes seriously the sociological influence of both law and culture.

The results from these cases provide the evidential foundation for the project's final outputs: a new model and new evaluative measures of the separation of powers.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833177	**DiCED**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. RACHEL GIBSON**
Host Institution: The University Of Manchester, UK

Digital Campaigning and Electoral Democracy

Overview: This project will set a new agenda and direction for the study of political campaigns. It will examine whether and how new digital technologies are transforming election campaigns and citizen behaviour in new and established democracies. More specifically, it will assess claims that democracies are now entering a new data-driven era of political campaigning that is profoundly reconfiguring how campaigns' are run, who runs them and their implications for the quality of voter decision-making, the vibrancy of political parties and ultimately, the future of representative democracy. It will do so in three main stages: (1) First, it will define what data-driven campaigning is and critically assess whether it forms new and distinct era of electioneering in conceptual and historical terms? In particular, it will argue that the two key traits of this new mode of campaigning are the increased individualization or micro-targeting of party messages and the automated use of misinformation to mobilize and persuade voters. (2) Based on this definition it will map the 'supply' of the new mode of campaigning across new and older democracies by designing an innovative new index to compare use of data-driven techniques by parties. Where is it most commonly seen and why are some parties and countries more likely to promote its growth? (3) Finally, it will assess the impact of these new methods on key political actors and assess the consequences for the longer term future of liberal democracy. Does use of these techniques help counter recent declines in voter turnout by identifying under-mobilized groups? Or, do they ensure parties focus on the already engaged, bypassing those that are harder to reach? Can data-driven campaigning improve citizen choices by giving them the information on the issues they primarily care about or does it help to increase disinformation and even manipulation of voter choices?

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833647	**CompuLaw**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. GIOVANNI SARTOR**
Host Institution: Alma Mater Studiorum - Universita Di Bologna, IT

Computable Law

The project addresses the regulation of computations (processes and systems) through an innovative legal & technological framework: it provides epistemic, technical and normative guidance for the development of computable laws and law compliant computations.

The context is the ongoing transformation of the social world into a hybrid infosphere, populated by a huge and growing number of increasingly pervasive, autonomous and intelligent computational enti-ties. The scale, speed, ubiquity and autonomy of computations make it impossible for humans to di-rectly monitor them and anticipate all possible illegal computational behaviours. The law can hold the hybrid infosphere under its rule – providing protection, security and trust – only if it be-comes computation-oriented: legal and ethical requirements must be integrated with, mapped onto, and partially translated into, computable representations of legal knowledge and reasoning.

Current legal culture still has not adequately addressed risks and potentials of computable law. My project will fill this gap, providing concepts, principles, methods and techniques and normative guidelines to support law-abiding computations. It has the normative purpose to uphold the principle of rule of law, translating legal norms and legal values into requirements for computable laws and legally-responsive computational agents. My project will provide major methodological and substantive breakthroughs. On the one hand, it pro-poses a socio-technical methodology for regulatory design and evaluation, integrating three discipli-nary clusters: a social-legal one, a philosophical-logical one and a computing-AI one. On the other hand, it develops a framework including: (a) norms, legal values and principles for developers, de-ployers and users; (b) languages and methods to specify requirements of computations and norms directed to them; (c) cognitive architectures for legally-responsive computational agents.

Project End Date: **31-OCT-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833915	**TrafficFluid**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. MARKOS PAPAGEORGIOU**
Host Institution: Polytechneio Kritis, GR

Lane-free Artificial-Fluid Environment for Vehicular Traffic

Traffic congestion is a serious threat for the economic and social life of modern societies as well as for the environment, which calls for drastic and radical solutions. The proposal puts forward an utterly original idea that leads to a novel paradigm for vehicular traffic in the era of connected and automated vehicles (CAVs) and is based on two combined principles.

The first principle is lane-free traffic, which renders the driving task for CAVs smoother and safer, as risky lane-changing manoeuvres become obsolete; increases the static and dynamic capacity of the roadway due to increased road occupancy; and mitigates congestion-triggering manoeuvres. The second principle is the nudge effect, whereby vehicles may be "pushing" (from a distance, using sensors or communication) other vehicles in front of them; this allows for traffic flow to be freed from the anisotropy restriction, which stems from the fact that human driving is influenced only by downstream vehicles. The nudge effect may be implemented in various possible ways, so as to maximize the traffic flow efficiency, subject to safety and convenience constraints.

TrafficFluid combines lane-free traffic with vehicle nudging to provide, for the first time since the automobile invention, the possibility to design (rather than merely describe or model) the traffic flow characteristics in an optimal way, i.e. to engineer the future CAV traffic flow as an efficient artificial fluid. To this end, the project will develop and deliver the necessary vehicle movement strategies for various motorway and urban road infrastructures, along with microscopic and macroscopic simulators and traffic management actions.

TrafficFluid risk stems from the immense challenge of designing a new traffic system from scratch; however, we expect that the project will trigger a whole new path of international innovative research developments and testbeds that would pave the way towards a new efficient traffic system in the era of CAVs.

Project End Date: **30-NOV-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850706	**State Silence**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. DANAI AZARIA**
Host Institution: University College London, UK

The Silence of States in International Law

International law is the law between States. It is identified by observing the behaviour of States and deriving rules from their behaviour. But, what happens when States do nothing? Can States be bound by their own silence? Can international law develop through the silence of States? Can States be responsible for doing nothing? What happens when States do not appear before international courts and tribunals? These questions are immensely significant for States, international courts and tribunals, domestic courts, and individuals, who are all interested in knowing what the obligations of States are and how they can be enforced within and outside international courts and tribunals. Yet, there are major gaps in our understanding of the meaning of State silence and its legal effects. This project is the first comprehensive study of the silence of States in international law. It will explore and analyze whether the silence of States can bind them, and if so, under which circumstances; the role of State inaction for the responsibility of States; and the effect of State inaction in the field of international dispute settlement, focusing particularly on the proceedings before international courts and tribunals. It aims (a) to make a major contribution to knowledge on the meaning of silence by providing a comprehensive taxonomy of the 'silences' of States and on the legal effects of different 'silences'; and (b) to critically analyse whether a change in the law may be called for. The project will conduct research in wide-ranging and geographically representative State practice available in the six official languages of the United Nations, international jurisprudence and literature. It will also employ empirical analysis of the reasoning of government officials' and international judges in order to assess the advantages and disadvantages of States silence, in the form of non-appearance, in international judicial procedures.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850717	**ATLANTIS**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. FRANCESCA VERONES**
Host Institution: Norges Teknisk-Naturvitenskapelige Universitet Ntnu, NO

Whales, waste and sea walnuts: incorporating human impacts on the marine ecosystem within life cycle impact assessment

The marine ecosystem covers around 70% of the planet. Today, every single part of this vast ecosystem is affected by at least one anthropogenic driver of change. This fact should cause us to pause and think: such a huge space, yet habitat and species loss are occurring at an unprecedented rate. The marine ecosystem provides us with a wealth of services and has an economic value exceeding 20 trillion US Dollars. In addition, the marine ecosystem is considered crucial for our sustainable future and is often regarded as the “next economic frontier”.

However, despite its importance for humankind, the marine ecosystem is significantly underrepresented in sustainability research. We currently have no holistic approach to quantify the impacts caused by a large number of human pressures in the marine ecosystem.

A powerful tool for identifying such impacts is life cycle assessment (LCA). LCA is the best available tool to assess potential environmental impacts of products and processes in a comprehensive way. However, methods have never been properly developed for including marine impacts in LCA results.

I will contribute to closing this substantial research gap by developing novel models for quantifying impacts on ecosystem service losses (“whales”), as well as impacts of marine plastic debris (“waste”) and of marine invasive species (“sea walnuts”) within the LCA framework. These models will be developed based on impacts on species richness and ecosystem service potential. Including ecosystem services will be a paradigm extension and a substantial advancement for the LCA framework. All models will be tested in an overarching case study.

Currently we are unable to determine whether planned marine activities and processes are sustainable. By developing these models, we will be able to do so with a holistic perspective. This is of unprecedented importance, if we want to manage this vital ecosystem in a sustainable way and preserve it for future generations.

Project End Date: **31-MAR-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851255	**ARCTIC**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. MASSIMILIANO ZANIN**
Host Institution: Agencia Estatal Consejo Superior De Investigaciones Cientificas, ES

Air Transport as Information and Computation

Air transport has by and large been studied as a transportation process, in which different elements, e.g. aircraft or passengers, move within the system. While intuitive, this approach entails several drawbacks, including the need for large-scale simulations, the reliance on real data, and the difficulty of extracting macro-scale conclusions from large quantities of micro- scale results. The lack of a better approach is in part responsible for our inability to fully understand delay propagation, one of the most important phenomena in air transport. ARCTIC proposes an ambitious program to change the conceptual framework used to analyse air transport, inspired by the way the brain is studied in neuroscience. It is based on understanding air transport as an information processing system, in which the movement of aircraft is merely a vehicle for information transfer. Airports then become computational units, receiving information from their neighbours through inbound flights under the form of delays; processing it in a potentially non-linear way; and redistributing the result to the system as outbound delays. In this proposal I show how, as already common in neuroscience, such computation can be made explicit by using a combination of information sciences and statistical physics techniques: from the detection of information movements through causality metrics, up to the representation of the resulting transfer structures through complex networks and their topological properties. The approach also entails important challenges, e.g. the definition of appropriate metrics or the translation of the obtained insights into implementable policies. In the main text of the proposal I present a number of preliminary results that point towards a radically new way of thinking about the dynamics of air transport. ARCTIC's methodology will be used over the next five years to characterize and model delay propagation, as well as to limit its societal and economic impact.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851621	**RESHUFFLE**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. ELISE MUIR**
Host Institution: Katholieke Universiteit Leuven, BE

RESHUFFLING OUR UNDERSTANDING OF FUNDAMENTAL RIGHTS LAW IN EUROPE

Our continent is being shaken by a set of major challenges ranging from economic to security, refugee and rule of law crises. These events place unprecedented pressure on the institutional framework designed to hold Europe together since the second world war.

The EU has emerged as the key player whenever the most fundamental rights of individuals are at stake. This is somewhat surprising. Since the 1950s, scientists have understood the European edifice as being based, on the one hand, on the Council of Europe designed to protect European values and fundamental rights in particular; and, on the other, on the EU intended to advance European (economic) integration. Therefore, it is the Council of Europe, an international organization distinct from the EU, that was initially placed at the forefront of fundamental rights protection.

Yet, the EU is now taking the lead on setting fundamental rights standards. Benefits may be considerable where the EU offers strong institutional support. There may however also be a profound mismatch between the new function of the EU and its constitutional design. For instance, it may be inappropriate to address religious discrimination in employment – such as regulating the conditions for headscarf bans - through the same harmonization tools ensuring the free movement of goods. Are new concepts and legal tools needed to ensure trust in the EU system?

The principal investigator, an EU constitutional and fundamental rights expert, will critically assess the shift in the nature of the EU's contribution to European fundamental rights law with a view to making recommendations to improve its ability to perform its new function. For that purpose, she will draw on three aspects: legal research highlighting the main features of this stronger decision-making powers of the EU; theory of law informing the implications of the EU's new quest for European values; and political and social science investigating the impact on stakeholders' strategies.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851940	**RadicalHOUSING**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. MICHELE LANCIONE**
Host Institution: The University Of Sheffield, UK

Radical Housing: Cities and the global fight against housing precarity

According to UN-Habitat, each year millions of people face forced eviction from their homes, while a staggering 1.6 billion are inadequately housed. Forecasts suggest housing precarity will continue to grow in future, worldwide. In response, grassroots housing movements are becoming increasingly common. Crucially, these groups fight for more than just housing, often advancing critiques of wider societal inequalities. Yet little is known of the broader significance of these struggles, and research has failed to offer an understanding of geographically dispersed movements. The ways in which the fight for the right to housing operates is essential to understand contemporary urban life. RadicalHOUSING will fill these critical gaps through an innovative Radical Housing Approach and pioneering empirical research at a global scale.

First, the project identifies the importance of a historical understanding of dwelling precarity, to appreciate the relevance of housing struggles worldwide (Objective I). Second, it investigates and profiles prominent grassroots networks in the Americas, Europe, Africa, and Asia to analyse their goals and organisational culture (Objective II). To appreciate the wider significance of radical housing resistance, the project deploys an ambitious ethnographic encounter with grassroots struggles in eight emblematic cities (Objective III). It then brings selected participants and experts together in a Global Forum of Radical Housing, fostering the exchange of peer-to-peer knowledge to generate further findings (Objective IV). Finally, the project will gather these insights into an innovative critical comparative framework, which will lead to agenda-setting publications, interventions, and academic scholarship (Objective V).

RadicalHOUSING is a ground-breaking project that will contribute to housing, urban and geographical studies, as well as to grassroots knowledge, opening a new phase in understanding the global fight against housing precarity.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852123	**AUTONORMS**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. INGVILD BODE**
Host Institution: Syddansk Universitet, DK

Transforming Norms Research through Practices: Weaponised Artificial Intelligence, Norms, and Order

Weapons systems with an increasing number of autonomous features are emerging as revolutionary technologies of war. In particular, this concerns systems with autonomy in their critical functions that relate to selecting and engaging targets without human input. This weaponisation of Artificial Intelligence (AI) signals the looming absence of meaningful human control in warfare, which has become a central focus of the debate on autonomous weapons systems (AWS). Here, states either seek to introduce new norms governing AWS or to leave the field open in order to increase their room of manoeuvre. These uncertainties make monitoring to what extent AWS will shape and transform international norms governing the use of force a matter of great importance. But existing International Relations research on norms despite producing excellent critical work does not yet enable us to understand the dynamics of this vital process because it does not capture adequately how norms emerge and develop. The state of the art conceptually connects norms predominantly to international law and limits attention to how norms emerge in deliberative international forums. Instead, the AUTONORMS project will develop a new ground-breaking theoretical approach that allows us to study how norms, understood as standards of appropriateness, manifest and change in practices. Taking this bottom-up perspective, we will monitor norm emergence and change across four contexts of practices (military, transnational political, dual-use, and popular imagination) in four countries (USA, China, Japan, Russia). This flexible portrayal allows us to adequately understand how norms related to AWS will develop, as well as considering the impact such emerging norms have on the current international security order of which norms are constitutive building blocs. The project thus provides an innovative analytical model for studying uncertain processes of technological innovation associated with the AI revolution.

Project End Date: **31-JUL-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852439	**EVaP**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. URSULA DAXECKER**
Host Institution: Universiteit Van Amsterdam, NL

Elections, Violence, and Parties

Since 1990, deadly violence has occurred in more than 30% of elections held outside of advanced, industrialized democracies. In the 2007 Kenyan elections and the 2010 Côte D'Ivoire elections, violence killed thousands of people in just a few months, undoing years of institution-building and undermining democracy. Much of contemporary politics unfolds in countries holding competitive elections but lacking institutionalized democracy. In these countries, election violence still happens routinely because politicians use violence to influence election outcomes in their favor.

A major political and scholarly problem is that we know a lot about the conditions that make elections more or less violent, but lack insight into the more fundamental issues of how violence plays out on the ground. Departing from the focus on intensity in existing work, I develop a novel party-centered theory to explain the nature, organization, and consequences of election violence. Political parties are crucial actors linking politicians and citizens, and I attribute a central role to parties' organizational and social links. The diversity of parties' social support influences whether violence provides electoral benefits, implying that parties supported by a single group benefit more from violence. Party organization at the local level in turn explains whether groups can engage in targeted violence or have to rely on poorly-controlled thugs-for-hire. This theory changes how we think about election violence, explaining (1) how and why election violence happens and (2) the consequences of election violence for citizens.

EVaP breaks new empirical ground by testing these claims subnationally in India and Nigeria, two of the world's largest emerging democracies. EVaP uses a multi-method approach to examine within-country variation in party institutions, social support, and election violence in India and Nigeria, combining fieldwork interviews, quantitative data, survey experiments, and surveys.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852633	**Niche4NbS**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. ASSAF SHWARTZ**
Host Institution: Technion - Israel Institute Of Technology, IL

Beyond assuming co-benefits in Nature-based Solutions: Applying the niche concept for optimizing social and ecological outcomes

Urbanization is emerging as one of the major environmental global issues of the 21st century, with strong implications on the health of humans and natural ecosystems. Nature-based Solutions (NbS), broadly defined as cost-effective solutions that are inspired and supported by nature to simultaneously provide several environmental and social benefits, has shown promise in addressing this challenge. However, NbS implementation and assessments often rely on a one-size-fits-all approach, although interventions that maximize one benefit can have no influence on, or even negatively affect others. Furthermore, the current pathways from NbS to various benefits do not rely on a deep understanding of the underlying processes and functional relationships. As a result, the current use of NbS relies on broad targets that exhibit considerable risk of falling short of their objectives, eroding public support in their wake. This project will address these shortcomings by developing and demonstrating a widely applicable, theory-grounded, approach for understanding trade-offs and identifying optimal planning scenarios that maximize co-benefits. Using a mechanistic approach we will assess the effectiveness of NbS across domains in a way that allows mapping, upscaling and predicting NbS implementation outcomes. Innovative use of the ecological niche concept and a set of nature dose-response experiments will enable spatially-explicit multidimensional modelling of biodiversity and health and well-being measures. This will allow us to predict how NbS influence where species will be, and where people will be healthy and happy, equipping us with the tools to achieve coexistence of multiple benefits and social justice. Niche4NbS will demonstrate how to plan NbS that delivers co-benefits and provide planners with a robust tools to identify optimal planning solutions. Beyond the fundamental value Niche4NbS will push the European Commission along its path towards becoming a world leader in NbS.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852816	**ResilienceBuilding**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. JANA KRAUSE**
Host Institution: Universiteit Van Amsterdam, NL

Social Resilience, Gendered Dynamics, and Local Peace in Protracted Conflicts

How can 'resilient communities' remain resilient in protracted conflicts and contribute to sustainable peace rather than to increased vulnerability to renewed conflict? How do local conflicts link to national conflicts and what are the implications for peacebuilding? What are the gender dimensions of social resilience? Is resilience always 'a good thing' or may it impede conflict resolution? This project pioneers an interdisciplinary research agenda into resilience building. The need for a greater analytical focus on the causes and consequences of social resilience is evident in the modest international record of peacebuilding and civilian protection. Scholarship increasingly invokes resilience terminology but lacks mature conceptual and empirical work. Building on the PI's expertise in social resilience, communal conflict, and gender and peacebuilding, this project will establish an empirically-grounded research agenda on social resilience and sustainable peace. By providing a comparative analysis of resilience building and barriers to peace in Nigeria, South Sudan, the Central African Republic (CAR) and Kenya, the project will create a new agenda for resilience research that rests on novel conceptual development and interdisciplinary approaches to resilience combined with the systematic study of social resilience and local peace produced by an integrated team of specialist researchers. The project will involve a fieldwork-based multi-method research design that combines advanced quantitative techniques for assessing the consequences of international peacebuilding with regard to local peace and women's empowerment with context-sensitive qualitative analysis of the often unintended consequences of social resilience and hidden barriers to local peace and changing gender relations. The project will result in a new scholarly community with a shared intellectual focus on social resilience and sustainable peace in protracted conflicts.

Project End Date: **31-JUL-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852990	**N-EXTLAW**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. MARIJA BARTL**
Host Institution: Universiteit Van Amsterdam, NL

Law as Vehicle for Social Change: Mainstreaming Non-Extractive Economic Practices

The current economic model is overdue for revision. The relentless focus on economic growth is ravaging the environment, and the concomitant social problems have either already reached glaring levels (rocketing global inequality) or seem poised to do so (climate displaced persons). A number of radical proposals, such as prosperity without growth, circular economy, or doughnut economics, have been proposed to chart a trajectory towards socio-ecological transformation, arguing that a profound change in our ways of living and modes of production is necessary in order to respond to the threats we face. Yet such proposals, however commendable, have gained only modest political traction, insofar as they seem unthinkable from the vantage point of our current economic system, consumption patterns, political discourse and legal institutions.

This project will show how law can contribute to making such transformative projects politically credible. More specifically, it will demonstrate how law, and private law in particular, can be used to nurture those existing economic practices that already build on the environmental and social aspirations embodied by such projects. The two main objectives are, first, to offer a set of legal tools and policy proposals that would make the adoption of environmentally and socially non-extractive economic practices, such as social cooperatives or solidary financial institutions, more attractive for people to implement. Second, N-EXTLAW theorizes how law can turn seemingly utopian projects for socio-ecological transformation into a realistic legal-political project. By refashioning the concrete socio-legal arrangements for pursuing non-extractive economic practices as well as re-shaping the values on which economic decision-making draws, law can make non-extractive economic practices more present in everyday action, and thereby uphold those cultural frames that affirm the sense that socio-ecological transformation is within our reach.

Project End Date: **31-JUL-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
853050	**SMOOTH**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. EMANUELE CAMPIGLIO**
Host Institution: Alma Mater Studiorum - Universita Di Bologna, IT

Sustainable finance for a smooth low-carbon transition

The threat of climate change calls for a rapid transition to a low-carbon society. Aligning the financial system with climate stability is a crucial prerequisite for achieving decarbonisation while preserving economic prosperity and societal welfare. However, we currently lack a comprehensive understanding of how the institutional and behavioural features of financial systems may affect the speed and shape of the low-carbon transition. Additionally, the coevolving socioeconomic, financial and environmental repercussions of such a large-scale societal transformation have not yet been systematically analysed. The SMOOTH project will lay the foundations of an innovative macro-financial analytical framework to provide essential insights on the links between financial systems and decarbonisation dynamics. Methodologically, I will introduce a breakthrough by linking macroeconomic analysis with an original evidence-based representation of investment decisions based on forward-looking expectations of transition pathways. In the course of five years, this integrated modelling framework will enable the first comprehensive assessment of the transition financial drivers and obstacles, and their implications for growth, financial stability, employment, private/public debt and functional distribution, with a focus on Europe. Building on this knowledge, a harmonised set of policies aimed at achieving a rapid and smooth transition can be designed. I will go beyond the current state of the art by integrating the analysis of fiscal policies with monetary policies and financial regulation, and investigating their institutional requirements and implications. SMOOTH will create a new interdisciplinary field of research integrating elements from macroeconomic modelling, climate economics, behavioural finance, socio-technical transition theory and political science, lifting the analytical power of transition modelling to a new level and opening up novel avenues for future research.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
853487	**2D4D**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. ELENA VERDOLINI**
Host Institution: Universita Degli Studi Di Brescia, IT

Disruptive Digitalization for Decarbonization

By 2040, all major sectors of the European economy will be deeply digitalized. By then, the EU aims at reducing greenhouse gas emissions by 60% with respect to 1990 levels. Digitalization will affect decarbonization efforts because of its impacts on energy demand, employment, competitiveness, trade patterns and its distributional, behavioural and ethical implications. Yet, the policy debates around these two transformations are largely disjoint.

The aim of the 2D4D project is ensure that the digital revolution acts as an enabler – and not as a barrier – for decarbonization. The project quantifies the decarbonization implications of three disruptive digitalization technologies in hard-to-decarbonize sectors: (1) Additive Manufacturing in industry, (2) Mobility-as-a-Service in transportation, and (3) Artificial Intelligence in buildings.

The first objective of 2D4D is to generate a one-of-a-kind data collection to investigate the technical and socio-economic dynamics of these technologies, and how they may affect decarbonization narratives and scenarios. This will be achieved through several data collection methods, including desk research, surveys and expert elicitations.

The second objective of 2D4D is to include digitalization dynamics in decarbonization narratives and pathways. On the one hand, this entails enhancing decarbonization narratives (specifically, the Shared Socio-economic Pathways) to describe digitalization dynamics. On the other hand, it requires improving the representation of sector-specific digitalization dynamics in Integrated Assessment Models, one of the main tools available to generate decarbonization pathways.

The third objective of 2D4D is to identify no-regret, robust policy portfolios. These will be designed to ensure that digitalization unfolds in an inclusive, climate-beneficial way, and that decarbonization policies capitalize on digital technologies to support the energy transition.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864724	**TRUST**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. ZAILI YANG**
Host Institution: Liverpool John Moores University, UK

TRUST: Towards Resilient and SUStainable ConTainer Supply Chains

Risk research represents an important challenge for the resilience and sustainability of container supply chains (CSCs). Its foci are being expanded from classical safety, through security to climate adaptation. Addressing such risks simultaneously requires integration across disciplines and research methodologies. The research community currently lacks a critical understanding of non-classical CSC risks arising from climate change, security threats (e.g. cyber-attacks), and emerging technologies (e.g. autonomous ships) in the digital industrial era. Through ground-breaking and interdisciplinary research, TRUST aims to address the key research question regarding which kinds of risk schemes can harness science and technology most effectively to achieve long-term resilient and sustainable CSC systems. The findings will shift the traditional risk management practice paradigm and deliver a novel programme that will enable the quantification, integration and communication of risk information from different areas and facilitate the movement of risk culture from a reactive single-dimensional scheme towards a proactive multi-dimensional regime. The programme divides into three integrated domains: 1) exploring and quantifying climate risks to rationalise adaptation planning; 2) forecasting security risks to address the most commanding threats in CSCs; and 3) advancing holistic safety approaches for CSCs involving new techniques and environments (e.g. Arctic shipping). The combination of objective (from historical accidents) and subjective (from stakeholders' perceptions) risk data will inform the exploitation of the advances in new safety and security risk models to enhance climate risk and adaptation studies in a complementary way. The work will address the significant methodological issues associated with resilience and sustainability sciences and advance the state-of-the-art to a point where robust CSCs can be developed and realised, even under deep uncertainty.

Project End Date: **30-NOV-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865956	**PARTYOPINION**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. RUNE SLOTHUUS**
Host Institution: Aarhus Universitet, DK

The Informational Role of Political Parties in Citizens' Opinion Formation

Citizens' opinions about public policy lies at the heart of democracy. A long-standing, but little researched, claim in political science is that political parties provide a vital informational basis that citizens can use to inform their policy opinions. However, current literature shows the opposite: Parties distort citizens' decision-making and make them dogmatic defenders of their party without caring about policy substance. Therefore, we lack a theory of how – or even if – parties can provide policy information citizens use to inform their opinions.

This project advances a new research agenda to examine the informational role of political parties in citizens' opinion formation. The project is not only pioneering in developing a novel theoretical model of when and how citizens use parties to inform their opinions; it also breaks new ground methodologically by combining experiments with a cross-national design. The project is unique in that it integrates macro-level party characteristics with micro-level opinion formation, helping scholars ask new questions and seek novel answers to how parties affect citizens' opinions.

As key empirical contribution, the project will develop a new survey instrument to offer the first mapping of how citizens view parties' "policy reputations"; develop and use new measures of citizens' policy reasoning; conduct a series of innovative survey experiments across party systems to obtain generalizable causal estimates of when and how parties inform opinions across individuals, parties and countries in Western Europe; and implement a panel survey to track how parties inform opinions during a real-world debate.

The project will significantly improve our understanding the relationship between citizens and political parties. Timely and innovative, the project will answer how current transformations of party systems affect citizens' ability to participate meaningfully in democracy, and if parties still play a role in that process.

Project End Date: **31-JUL-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866155	**NUCLEARREV**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. ANDREW FUTTER**
Host Institution: University Of Leicester, UK

Towards a Third Nuclear Age? Strategic Conventional Weapons and the Next Revolution in Global Nuclear Order

The world stands on the cusp of a major transformation in nuclear affairs. This paradigmatic shift is being driven by the development and deployment of an entirely new class of strategic weaponry, facilitated by the latest information revolution. The most important characteristics of these weapons are that they are all hi-tech and non-nuclear; that they can be used against an adversary's nuclear forces, and that they are increasingly able to augment and even replace nuclear weapons for key national security functions. Taken together, we can think of these of these systems as Strategic Conventional Weapons (SCW), and as representing a fundamental challenge to the way that our nuclear world is managed. SCW raise questions about deterrence strategy, mutually assured destruction, future arms racing and arms control, and how best to retain and maintain global nuclear stability and peace. NUCLEARREV will therefore provide the first ever systematic scholarly study of SCW, make the case for a paradigmatic shift in nuclear studies, set the stage for a complete rethinking of the global nuclear order. The main research question is: How will Strategic Conventional Weapons change the Global Nuclear Order? To answer this the objectives are to: Chart the SCW phenomenon, globally; Analyse how SCW will impact regional nuclear relations and balances; Examine what the development of SCW means for the frameworks and dogma that govern international nuclear relations; Make the case for a revolution in nuclear affairs and define the embryonic Third Nuclear Age. This urgently required research will provide the landmark study of this phenomenon and the centrepiece for a whole new generation of interdisciplinary and multidisciplinary work on nuclear affairs. The project combines interviews with politicians, defence contractors, scientists, bureaucrats, and experts across the world; an innovative War Game exercise, as well as extensive archival research and Regional Feedback Workshops.

Project End Date: **31-JUL-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866535	**SECURITY VISION**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. FRANCESCO RAGAZZI**
Host Institution: Universiteit Leiden, NL

The Algorithmic Security Politics of Computer Vision

How do technologies of computer vision, which promise to replace humans in the understanding of images, work in practice in the field of security, and what are their ethical and political implications? Vision, understood as the capacity not only to see but also to make sense of what is seen, is increasingly being delegated to autonomous computer systems which influence how human operators determine suspicious behaviour. We currently lack an understanding of how these technologies impact governmental and private sector actors, their decision-making, and their accountability as well as the fundamental rights of those who are targeted. This project address these challenges through an innovative theoretical and methodological framework which investigates the theoretical, empirical and political implications of the development of computer vision in the field of security. In order to carry out this task, the project builds on and advances debates at the intersection of critical security studies, science and technology studies, and visual ethnographic practices. Theoretically, the project advances the debates in International Relations and critical security studies by offering a synthetic framework of analysis of socially embedded technical devices. Methodologically, the experimental use of visual ethnography not only as a method of data collection and dissemination, but also of data analysis within a multi-modal research design will advance, through visual practices, debates in International Relations about the status of non-propositional knowledge as well as alternatives modalities of presentation of research. Empirically it will bring a new understanding of the workings of computer vision technologies in the fields of social media content moderation of extremist content, “smart” Closed Circuit Television Vision (CCTV) cameras and “lie detectors” deployed at the border, participating thus to the ethical and political debates in the public sphere.

Project End Date: **31-DEC-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679651	**ConFooBio**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. NILS BUNNEFELD**
Host Institution: The University Of Stirling, UK

Resolving conflicts between food security and biodiversity conservation under uncertainty

Resolving conflicts between food security and biodiversity conservation under uncertainty

Conflicts between food security and biodiversity conservation are increasing in scale and intensity and have been shown to be damaging for both biodiversity and human livelihoods. Uncertainty, for example from climate change, decreases food security, puts further pressure on biodiversity and exacerbates conflicts.

I propose to develop a novel model that predicts solutions to conflicts between biodiversity conservation and food security under uncertainty. ConFooBio will integrate game theory and social-ecological modelling to develop new theory to resolve conservation conflicts. ConFooBio will implement a three-tiered approach 1) characterise and analyse 7 real-world conservation conflicts impacted by uncertainty; 2) develop new game theory that explicitly incorporates uncertainty; and 3) produce and test a flexible social-ecological model, applicable to any real-world conflict where stakeholders operate under conditions of extreme uncertainty.

The project has importance for society at large because ecosystems and their services are central to human wellbeing. Managing a specific natural resource often results in conflict between those stakeholders focussing on improving food security and those focussed on biodiversity conversation. ConFooBio will illuminate resolutions to such conflicts by showing how to achieve win-win scenarios that protect biodiversity and secure livelihoods. In this project, I will develop a practical, transparent and flexible model for the sustainable future of natural resources that is also robust to uncertainty (e.g., climate change); this model will be highly relevant for environmental negotiations among stakeholders with competing objectives, e.g., the negotiations to set the United Nations Sustainable Development Goals in September 2015.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714222	**CHILDMOVE**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. ILSE DERLUYN**
Host Institution: Universiteit Gent, BE

The impact of flight experiences on the psychological wellbeing of unaccompanied refugee minors

Since early 2015, the media continuously confront us with images of refugee children drowning in the Mediterranean, surviving in appalling conditions in camps or walking across Europe. Within this group of fleeing children, a considerable number is travelling without parents, the unaccompanied refugee minors.

While the media images testify to these flight experiences and their possible huge impact on unaccompanied minors' wellbeing, there has been no systematic research to fully capture these experiences, nor their mental health impact. Equally, no evidence exists on whether the emotional impact of these flight experiences should be differentiated from the impact of the traumatic events these minors endured in their home country or from the daily stressors in the country of settlement.

This project aims to fundamentally increase our knowledge of the impact of experiences during the flight in relation to past trauma and current stressors. To achieve this aim, it is essential to set up a longitudinal follow-up of a large group of unaccompanied refugee minors, whereby our study starts from different transit countries, crosses several European countries, and uses innovative methodological and mixed-methods approaches. I will hereby not only document the psychological impact these flight experiences may have, but also the way in which care and reception structures for unaccompanied minors in both transit and settlement countries can contribute to reducing this mental health impact.

This proposal will fundamentally change the field of migration studies, by introducing a whole new area of study and novel methodological approaches to study these themes. Moreover, other fields, such as trauma studies, will be directly informed by the project, as also clinical, educational and social work interventions for victims of multiple trauma. Last, the findings on the impact of reception and care structures will be highly informative for policy makers and practitioners.

Project End Date: **31-JAN-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714868	**EmergingWelfare**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. ERDEM YORUK**
Host Institution: Koc University, TR

The New Politics of Welfare: Towards an "Emerging Markets" Welfare State Regime

This research project aims to identify a new welfare regime in emerging market economies and explain why it has emerged. The project will compare Brazil, China, India, Indonesia, Mexico, South Africa and Turkey to test two hypotheses: (i) emerging market economies are forming a new welfare regime that differs from liberal, corporatist and social democratic welfare regimes of the global north on the basis of extensive and decommodifying social assistance programmes, (ii) the new welfare regime emerges principally as a response to the growing political power of the poor as a dual source of threat and support for governments. Based on a comparative and interdisciplinary perspective, the project follows a multi-method strategy that combines state-of-the-art computer-based protest event data collection techniques, macro-historical methods, quantitative data analyses and qualitative content analysis. The project will radically expand the literatures on welfare regimes, welfare state development and contentious politics, by challenging the existing paradigms dominated by structuralist perspectives, a myopic focus on Western countries, and limited data collection and analysis techniques. This project is genuinely innovative, unprecedented, ground-breaking, ambitious and high-risk/high-gain in three ways: (i) it re-shapes the welfare regimes literatures as the first study to classify and explain welfare systems of emerging markets as a new welfare regime and (ii) the project demonstrates a causal link between changes in grassroots politics and welfare policies and challenge the structuralist preponderance in the existing welfare state development literature (iii) it makes a prodigious contribution to our empirical knowledge on contentious politics in emerging markets by creating the first cross-national databases on protest event, employing state-of-the art computer methods, such as natural language processing and machine learning, on newspaper archives.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715125	**METRO**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. SOTIRIA GREK**
Host Institution: The University Of Edinburgh, UK

International Organisations and the Rise of a Global Metrological Field

The production of global metrics by International Organisations has not only penetrated the transnational social and policy fields; it has also become an integral mode of the ways International Organisations interconnect. Through their collaborative practices of quantification and commensuration, International Organisations are both constituting new realities and being reconstituted themselves. Thus, the dominance of global measurement regimes has profound implications for the ways International Organisations interact, and for the environments these new interrelationships come to generate.

How is one to make sense of this emerging reality? The embryonic –but rapidly deepening– alliances between International Organisations to find global solutions to global crises, is an opportune moment for a two-fold enquiry: a. an in-depth investigation of the labour of the joint production of metrics; and b. an examination of the ways this labour reconfigures interdependencies between International Organisations and hence the field of transnational governance itself. This is a novel, problem-driven perspective that goes beyond the role and impact of International Organisations through 'governing by numbers': instead, we bring together multiple bodies of knowledge in order to cast light on the role metrics play in re-shaping the data collectors themselves.

Hence, focusing on the policy areas of Education and Development, this is an interdisciplinary study of the ways International Organisations co-exist, compete and survive in an increasingly quantified yet uncertain world. Building on International Relations theory, Science and Technology Studies, and using theoretical perspectives from Organisational Sociology, as well as the newly emerging field of the social studies of metrics, this research will apply a mixed-methods research design to examine the interrelationships of International Organisations in co-constructing the global metrological field.

Project End Date: **30-APR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724351	**Struct. vs. Individ**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. HADAS MANDEL**
Host Institution: Tel Aviv University, IL

The 'Declining Significance of Gender' Reexamined: Cross-Country Comparison of Individual and Structural Aspects of Gender Inequality

The comparative research of long-term trends largely neglects structural mechanisms of gender inequality, i.e. the gender bias in which jobs and activities are evaluated and rewarded. I argue that as more women become integrated in positions of power, the stronger the role of structural elements is likely to become. However, because these are less visible and amenable to empirical assessment, they are under-researched compared to individual aspects, and are commonly assumed to be gender-neutral. The implication is that the importance of gender as a determinant of economic inequality in the labour market becomes insufficiently acknowledged, and thus difficult to track and eradicate.

My empirical objective is to track structural vs. individual processes of gender inequality over a period of 40 years, using the case of occupations. My aim is to uncover the countervailing processes of women's (individual) upward occupational mobility versus women's (collective) effect on occupational pay. I argue that the effects of structural aspects of gender inequality increase over time, but are concealed by women's (individual) upward mobility.

I expect the dynamic of the two processes to vary between countries and also by class. I thus seek to examine the processes in four representative countries – Sweden, Germany, Spain and the United States – that differ in many of the institutional aspects that affect gender inequality, including the provision of welfare, gender ideology, wage structure, and political economy factors. Therefore, gender in/equality processes in these countries are expected to take different forms in both structural and individual appearances. That said, in all countries I expect gender equality processes to be more pronounced and rapid for advantaged women. At the structural level, however, the rapid upward occupational mobility of skilled and educated women may expose highly rewarded occupations to devaluation and pay reduction more than others.

Project End Date: **30-JUN-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724460	**DISCRETION**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. MARIT SKIVENES**
Host Institution: Universitetet I Bergen, NO

Discretion and the child´s best interests in child protection

DISCRETION aims to unlock the black box of discretionary decision-making in child protection cases by a comparative-empirical study of how discretionary decisions are made and justified in the best interests of the child. There are huge research gaps in this important area of the welfare state, with a great deal of uncertainty concerning how, when and why discretionary decisions about the child´s best interests are different between decision-makers within and between child protection systems.

The main objectives for this project are to reveal the mechanisms for exercising discretion, and improve the understanding of the principle of the child´s best interests.

These objectives will be reached by systematically examining the role of institutional, organisational and individual factors including regulations of best interest principles; professions involved; type of courts; type of child protection system; demographic factors and individual values; and the populations' view on children and paternalism. DISCRETION employs an innovative methodological approach, with multilevel and cross-country studies.

DISCRETION will, by conducting the largest cross-national study on decision-making in child protection to date, lift our understanding of international differences in child protection to a new level. By conducting randomized survey experiments with both decision-makers in the system and the general population, DISCRETION generates unique data on the causal mechanisms explaining differences in discretionary decisions.

The outcomes of DISCRETION are important because societies are at a crossroad when it comes to how children are treated and how their rights are respected, which creates tensions in the traditional relationship between the family and the state. DISCRETION will move beyond the field of child protection and provide important insights into the exercise of discretion in all areas where the public interest as well as national interest must be interpreted.

Project End Date: **31-MAY-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725128	**CIC**	**SH3** Environment, Space and Population

Principal Investigator:	**Dr. MICHELLE RYAN**
Host Institution:	The University Of Exeter, UK

Context, Identity and Choice: Understanding the constraints on women's career decisions

There has been vast improvement in workplace gender equality, but there remain marked differences in the roles in which women and men work. Explanations for this inequality have focused on the barriers women face. However, as women begin to enter male-dominated roles, a new explanation has arisen: that remaining gender inequality must reflect fundamental differences between women and men, including differences in (a) ambition and desire for power, (b) needs for work-life balance, and (c) willingness to take career risks. Central to this analysis is the assumption that the glass ceiling is broken and thus inequality must be due to women's active choices. This explanation downplays the fact that social context continues to be a barrier to women's success and places responsibility for gender inequality on women themselves. Indeed, there has arisen the suggestion that gender equality necessitates women overcoming 'internal obstacles', 'leaning-in' and altering their choices (Sandberg, 2013), rather than challenging the status quo. I argue that diametrically contrasting structural barriers with women's choices is unhelpful. Instead, I suggest that women's choices are shaped and constrained by the gendered nature of organisational and social contexts and how women see themselves within these contexts. I propose a programme of research, across 3 integrated streams, that investigates how social and organisational structures define identities and constrain women's choices in relation to ambition, work-life balance, and career risk-taking. I have four key objectives: (1) to clarify how organisational and social contexts define identity and constrain women's choices, (2) to use an interdisciplinary, multi-methodological approach, to produce innovative theory and data, (3) to work collaboratively with stakeholders, and (4) to inform practical interventions designed to facilitate the increase of women's participation in hitherto male-dominated roles.

Project End Date: **30-JUN-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725238	**EUROMIX**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. BETTY DE HART**
Host Institution: Stichting Vu, NL

Regulating mixed intimacies in Europe

This project is a study of the regulation of 'mixture'('interracial' sex, relationships and marriage) in Europe's past and present. Informed by critical race and critical mixed race studies, it challenges the common assumption that Europe never had 'anti-miscegenation' laws comparable to those in the United States. In exploring if, when, how and why forms of regulation aiming to prevent or restrict 'interracial mixture' developed in Europe in certain times and places, the project delivers a vital contribution to our knowledge of the development of racial thinking in Europe. The concept of 'mixture' provides an eminently suitable approach to the construction of 'race', since 'mixture' confuses and destabilizes racialized categories that seem fixed and essentialized in specific times and places, such as 'black/white'.

The project consist of a historical and a contemporary part. The historical part looks at the regulation of 'mixture' in four European countries: France, Italy, the Netherlands, and the United Kingdom, in their African colonies, and wartime Europe. The contemporary part explores whether and how, in spite of norms of formal equality and colour-blindness, 'race' and 'monoracial family norms' still play a part in European law and the lived experiences of 'interracial' couples with law in their everyday lives. Through archival research, legal analysis and interviews with modern-day 'mixed' couples and families, this approach helps us understand what lawmakers and enforcers believed 'race' was, what they believed 'mixture' was, how this was translated into legal practices, and how targeted couples responded.

Theoretically, the project delivers a groundbreaking contribution to the genealogy of racial thinking in Europe, especially in addressing the understudied role of law and legal scholarship in the social construction of 'race' and 'mixture' in a increasingly diverse Europe.

Project End Date: **31-OCT-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757364	**CAPE**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. TINA KRETSCHMER**
Host Institution: Rijksuniversiteit Groningen, NL

Ghosts from the past: Consequences of Adolescent Peer Experiences across social contexts and generations

Positive peer experiences are crucial for young people's health and wellbeing. Accordingly, multiple studies (including my own) have described long-term negative psychological and behavioral consequences when adolescents' peer relationships are dysfunctional. Paradoxically, knowledge on adult social consequences of adolescent peer experiences –relationships with others a decade later - is much less extensive. Informed by social learning and attachment theory, I tackle this gap and investigate whether and how peer experiences are transmitted to other social contexts, and intergenerationally, i.e., passed on to the next generation. My aim is to shed light on how the "ghosts from peer past" affect young adults' relationships and their children. To this end, I examine longitudinal links between adolescent peer and young adult close relationships and test whether parents' peer experiences affect offspring's peer experiences. Psychological functioning, parenting, temperament, genetic, and epigenetic transmission mechanisms are examined separately and in interplay, which 1) goes far beyond the current state-of-the-art in social development research, and 2) significantly broadens my biosocially oriented work on genetic effects in the peer context. My plans utilize data from the TRAILS (Tracking Adolescents' Individual Lives' Survey) cohort that has been followed from age 11 to 26. To study intergenerational transmission, the TRAILS NEXT sample of participants with children is substantially extended. This project uniquely studies adult social consequences of peer experiences and, at the same time, follows children's first steps into the peer world. The intergenerational approach and provision for environmental, genetic, and epigenetic mediation put this project at the forefront of developmental research and equip it with the potential to generate the knowledge needed to chase away the ghosts from the peer past.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758791	**TIMEISNOW**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. JORIS MULDER**
Host Institution: Stichting Katholieke Universiteit Brabant, NL

The Time is Now: Understanding Social Network Dynamics Using Relational Event Histories

Relational event history data are becoming increasingly available due to new technical developments. These data contain detailed information about who interacted with whom in a network and when. For example, employees wear sociometric badges storing time-stamped interactions between colleagues, classrooms are monitored to observe interactions between teachers and students, and police databases store violent interactions between criminal gangs in city districts.

This new type of data has the potential to greatly contribute to our understanding of dynamic social networks by providing new insights about speed, rhythm, duration, and lag in social interactions. However a crucial problem is that statistical tools for analyzing such data are currently underdeveloped. We are therefore unable to exploit this treasure of information, resulting in a limited understanding about the evolution of social relations in continuous time.

I will undertake the following actions to resolve this fundamental shortcoming. First, I will develop an innovative Bayesian statistical framework for the analysis of relational event histories by building upon the novel relational event model, which has great potential but is in a preliminary stage of development. Second, I will implement the new framework in free and user-friendly software to ensure general utilization among social scientists. Third, in collaboration with network experts in organizational sociology, sociology of education, and criminology, I will develop tailor-made extensions for dynamic social processes in important applications.

In sum, this project will yield a groundbreaking new methodology for testing and building theories on time-sensitive processes in social networks. It will allow us to research, among others, how fast integration occurs among teams with workers from different cultures, how long it takes to develop respect in the classroom, and when violent interactions between criminal gangs will occur in the near future.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759776	**PLABOR**	**SH3** Environment, Space and Population

Principal Investigator:	**Dr. NIELS VAN DOORN**
Host Institution:	Universiteit Van Amsterdam, NL

Platform Labor: Digital transformations of work and livelihood in post-welfare societies

Digital platforms like Uber and Airbnb are transforming how people work, create and share value, and sustain themselves in their everyday lives. As such, platforms are becoming increasingly ubiquitous as new institutional actors that redraw relations between civil society, the market, and the state. Yet, as many scholars have shown, such relations have historically been shaped by pervasive gender, class, and racial subordination. It is therefore crucial to ask to what extent platforms, as new sites of capital accumulation, governance, and norm-making, remediate existing inequalities and if/how they also generate new vulnerabilities or tools for empowerment. Accordingly, this research project aims to determine how digital platforms are reconfiguring the gendered, classed, and racialized organization of labor and social reproduction in post-welfare societies. To achieve this aim, three objectives have to be met:

• determining how on-demand labor platforms distribute new opportunities and vulnerabilities for workers along gender, class, and racial lines;
• determining how digital platforms create new solutions and challenges for the gendered, classed, and racialized problem of social reproduction in post-welfare societies;
• determining which policy and legal issues arise when labor and social reproduction are increasingly organized through platforms and identifying ways to tackle these issues.

These objectives will be met through a cross-national comparative study that examines how platforms operate in three quickly growing and distinct tech hubs: Amsterdam, Berlin, and New York City. To organize this transatlantic study an innovative research platform will be developed and implemented, which enables (1) participatory research, (2) international scholarly collaboration and stakeholder engagement, and (3) the dissemination and discussion of research findings. The participatory research will combine ethnography and methods from software studies.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771217	**MISFIRES**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. SUSI GEIGER**
Host Institution: University College Dublin, National University Of Ireland, Dublin, IE

Misfires and Market Innovation: Toward a Collaborative Turn in Organising Markets

MISFIRES opens up new theoretical and empirical horizons for analysing and innovating 'concerned markets', where multiple actors' interests, values and concerns clash. It asks how actors can engage with a market's failures to challenge its organisation and make it more collaborative, more open to civic values and to social or political concerns. Concerned markets are contested by diverse actors with equally diverse perspectives and value measures. Evaluating such a market's efficiency is as much of an illusion as redesigning its inner workings on a blackboard. We need new conceptual frameworks to understand how to innovate concerned markets from the inside to make them 'better' (as defined by concerned actors), and we urgently need empirical insights into how collaborative action in markets with such social and political stakes may translate into market change. MISFIRES relies on science and technology studies, pragmatic sociology and critical market studies to shift thinking around market organisation from failure and design to collaboration and experimentation. I devise an ethnographic and participatory inquiry to explore how a market's failures can lead us to markets that are more attentive to and accommodating of the concerns they create. I choose three exemplary contested markets in healthcare (licensing of antiretroviral drugs, Hepatitis C pricing, and the sale of DNA information) and two emergent controversies to investigate the activities concerned actors undertake, and the instruments and devices they experiment with, to re-organise that market. MISFIRES will comprehensively map, engage in, and conceptualise this collaborative turn in organising markets. With this, MISFIRES will guide new academic and policy thinking by establishing how:

1) concerned actors voice and mobilise around the notion that a market has 'failed' them;
2) concerned actors seek to negotiate and address market failures;
3) this process may lead to 'better' markets.

Project End Date: **31-JUL-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771290	**CAPABLE**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. MARA YERKES**
Host Institution: Universiteit Utrecht, NL

Enhancing Capabilities? Rethinking Work-life Policies and their Impact from a New Perspective

We have witnessed significant work-life policy advancements designed to help men and women more equally combine employment with other spheres of life in recent decades, yet gender inequality persists. Improving gender equality in work-life balance is therefore high on policy agendas throughout Europe. Decades of research in this area have produced key insights but work-family theories fail to sufficiently explain the tenacity of this inequality. Earlier applications of a capabilities approach to work-life balance offer promising inroads, yet the importance of community remains absent. The CAPABLE project will generate fundamentally new knowledge on how work-life balance policies impact an individual's capability to achieve this balance in Europe by incorporating the understudied dimension of community.

Capabilities reflect what individuals are effectively able to achieve. CAPABLE asks: To what extent do work-life balance policies enhance men and women's capabilities to achieve work-life balance? To answer this question, we will develop and apply complex models derived from Sen's capability approach to analyse: 1. the availability, accessibility and design of work-family policies; 2. what these policies mean for men and women's capabilities to achieve work-life balance based on their embeddedness in individual, community and social contexts; 3. whether work-life policies enhance individual wellbeing; and 4. what policy tools are needed for developing sustainable work-life balance policies that enhance gender equal work-life capabilities. CAPABLE will progress scientific and policy frontiers using innovative, mixed-methods approaches at multiple policy levels. The conceptual clarity and empirical advancements provided will significantly expand our understanding of work-life policies in relation to individual capabilities. Furthermore, it will produce key insights into how sustainable work-life policies addressing gender inequality in work-life can be developed.

Project End Date: **30-NOV-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772268	**InfoSampCollectJgmt**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. GAEL LE MENS**
Host Institution: Universitat Pompeu Fabra, ES

The Implications of Selective Information Sampling for Individual and Collective Judgments

Much research has shown that judgments are the products of imperfect information processing heuristics. Recently, an alternative theoretical perspective has been proposed. It emphasizes that people form judgments by observing information samples about the alternatives. Sampling-based theories can explain numerous judgment patterns such as risk aversion, overconfidence, illusory correlations, the in-group out-group bias, or social influence.

The sampling approach has illustrated how these and other important patterns of human judgments can be parsimoniously explained by assuming a common source of bias. But at least two important questions remain:
1. How do sampling explanations for judgment biases can be integrated with explanations that focus on information-processing biases in order to explain judgment patterns in naturally occurring environments?
2. What are the implications of selective information sampling for collective judgments and the distribution of beliefs and attitudes over social networks?

I set to answer these pressing questions by (1) developing integrative belief formation models that incorporate both sampling-based mechanisms and information processing-based mechanisms; (2) collecting and analyzing experimental and field data to test these integrative models and uncover how the two classes of mechanisms interact; (3) building on these insights to develop models that lead to testable predictions about collective judgments and test these predictions with field and experimental data; (4) running experiments to measure the extent to which social network driven information sampling can contribute to opinion polarization.

The project will carry novel prescriptions to limit judgment biases such as the prevalence of negative stereotypes about socially distant others or the resistance to institutional change. It will also carry prescriptions to limit the emergence of collective illusions, and contain the polarization of opinions across social groups.

Project End Date: **30-APR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
785934	**ISLAM-OPHOB-ISM**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. AYHAN KAYA**
Host Institution: Istanbul Bilgi Universitesi, TR

Nativism, Islamophobism and Islamism in the Age of Populism: Culturalisation and Religionisation of what is Social, Economic and Political in Europe

The main research question of the study is: How and why do some European citizens generate a populist and Islamophobist discourse to express their discontent with the current social, economic and political state of their national and European contexts, while some members of migrant-origin communities with Muslim background generate an essentialist and radical form of Islamist discourse within the same societies? The main premise of this study is that various segments of the European public (radicalizing young members of both native populations and migrant-origin populations with Muslim background), who have been alienated and swept away by the flows of globalization such as deindustrialization, mobility, migration, tourism, social-economic inequalities, international trade, and robotic production, are more inclined to respectively adopt two mainstream political discourses: Islamophobism (for native populations) and Islamism (for Muslim-migrant-origin populations). Both discourses have become pivotal along with the rise of the civilizational rhetoric since the early 1990s. On the one hand, the neo-liberal age seems to be leading to the nativisation of radicalism among some groups of host populations while, on the other hand, it is leading to the islamization of radicalism among some segments of deprived migrant-origin populations. The common denominator of these groups is that they are both downwardly mobile and inclined towards radicalization. Hence, this project aims to scrutinize social, economic, political and psychological sources of the processes of radicalization among native European youth and Muslim-origin youth with migration background, who are both inclined to express their discontent through ethnicity, culture, religion, heritage, homogeneity, authenticity, past, gender and patriarchy. The field research will comprise four migrant receiving countries: Germany, France, Belgium, and the Netherlands, and two migrant sending countries: Turkey and Morocco.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788448	**GULAGECHOES**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. JUDITH PALLOT**
Host Institution: Helsingin Yliopisto, FI

Gulag Echoes in the "multicultural prison": historical and geographical influences on the identity and politics of ethnic minority prisoners in the communist successor states of Russia Europe.

The project will examine the impact of the system of penality developed in the Soviet gulag on the ethnic identification and political radicalisation of prisoners in the Soviet Union and the communist successor states of Europe today. It is informed by the proposition that prisons are sites of ethnic identity construction but that the processes involved vary within and between states. In the project, the focus is on the extent to which particular "prison-styles" affect the social relationships, self-identification and political association of ethnic minority prisoners. After the collapse of the Soviet Union, the communist successor states all set about reforming their prison systems to bring them into line with international and European norms. However, all to a lesser or greater extent still have legacies of the system gestated in the Soviet Gulag and exported to East-Central-Europe after WWII. These may include the internal organisation of penal space, a collectivist approach to prisoner management, penal labour and, as in Russian case, a geographical distribution of the penal estate that results in prisoners being sent excessively long distances to serve their sentences. It is the how these legacies, interacting with other forces (including official and popular discourses, formal policy and individual life-histories) transform, confirm, and suppress the ethnic identification of prisoners that the project seeks to excavate. It will use a mixed method approach to answer research questions, including interviews with ex-prisoners and prisoners' families, the use of archival and documentary sources and social media. The research will use case studies to analyze the experiences of ethnic minority prisoners over time and through space. These provisionally will be Chechens, Tartars, Ukrainians, Estonians, migrant Tadjik workers and Roma and the country case studies are the Russian Federation, Georgia and Romania.

Project End Date: **31-OCT-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802202	**MeaningfulMobility**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. LOUISE MEIJERING**
Host Institution: Rijksuniversiteit Groningen, NL

Meaningful Mobility: a novel approach to movement within and between places in later life

Mobility or physical movement contributes to health and well-being in later life and is a key issue in gerontological research. Most studies have focused on the contribution of outdoor mobility to active ageing, but physical and cognitive impairments restrict the mobility of many older adults. MeaningfulMobility will take a more comprehensive approach than previous research. It will be the first to connect the capability approach to mobility research to study diversity in movement within and between places by healthy and impaired older adults.

MeaningfulMobility aims to develop and employ an integrative approach to explain mobility practices in later life in relation to well-being. The research objectives are:

1. To compare objectively measured mobility patterns of older adults within and between places, and between impaired and healthy older adults in three socio-cultural contexts;
2. To conduct an in-depth study of the subjective mobility experiences within and between places of impaired and healthy older adults, in three socio-cultural contexts;
3. To use these insights to connect mobility research with the capability approach to gain comprehensive understanding of the diversity in mobility practices in later life in relation to well-being.

An in-depth comparative study will be carried out of three categories of older adults: healthy older adults; older adults with early stage Alzheimer's; and older stroke survivors in three socio-cultural contexts of the Netherlands, the UK and India. The study will apply an innovative convergent mixed-methods design to measure objective mobility patterns and subjective mobility experiences. Data will be subject to geographic, regression, and thematic analysis, and the findings integrated using advanced grounded visualisation methods. This study has the potential to transform gerontological mobility research and to provide policy inputs on the mobility, well-being and health of our ageing population.

Project End Date: **31-MAR-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802227	**DONORS**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. EVA-MARIA MERZ**
Host Institution: Stichting Vu, NL

Who gives life? Understanding, explaining and predicting donor behaviour

Background: Why do individuals repeatedly help strangers even when this incurs personal costs? Current evidence on prosocial behaviour is contradictory, scattered across disciplines, restricted to one-country studies, not taking into account contextual influences, and fails to capture its dynamic nature. An integrated model is needed to increase understanding of prosociality as a societal core value.

Aim: To break with monodisciplinary approaches, and grasp the dynamic and contextual nature of prosocial behaviour, I propose a life course model to link individual determinants, social network characteristics and societal contexts. I will test the model in the case of blood donation, as example of real world prosociality where a stranger is helped at a donor's personal costs.

Approach: DONORS comprises three interlinked work packages. 1) Dynamic interplay among individual and network determinants of donor behaviour over the life course. 2) Genetic determinants of prosociality. 3) Contextual variation in donor behaviour. To validate my model, I use six unique, complementary datasets, including prospective, retrospective, country-comparative survey, genetic and registry data.

Innovation: 1) A multidisciplinary view —including demography, sociology, psychology— within a dynamic life course approach to enhance theory building. 2) A multi-method design, linking sociological survey with objective health-registry data and combining psychosocial with genetic data. 3) Using country-comparisons to account for the societal contexts in which donor behaviour occurs.

Impact: DONORS will inspire a new era of multidisciplinary research on prosocial behaviour. With backgrounds in Medicine, Social Sciences and Psychology, years of experience in science and practice and high-level, award-winning international publications, I am uniquely suited to combine insights from social and health sciences to set the stage for a comprehensive, innovative scientific view on donor behaviour.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802421	**DAFINET**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. MICHAEL QUAYLE**
Host Institution: University Of Limerick, IE

Dynamic Attitude Fixing: A novel theory of opinion dynamics in social networks and its implications for computational propaganda in hybrid social networks (containing humans and bots)

Understanding the coordination of attitudes in societies is vitally important for many disciplines and global social challenges. Network opinion dynamics are poorly understood, especially in hybrid networks where automated (bot) agents seek to influence economic or political processes (e.g. USA: Trump vs Clinton; UK: Brexit). A dynamic fixing theory of attitudes is proposed, premised on three features of attitudes demonstrated in ethnomethodology and social psychology; that people: 1) simultaneously hold a repertoire of multiple (sometimes ambivalent) attitudes, 2) express attitudes to enact social identity; and 3) are accountable for attitude expression in interaction. It is proposed that interactions between agents generate symbolic links between attitudes with the emergent social-symbolic structure generating perceived ingroup similarity and outgroup difference in a multilayer network. Thus attitudes can become dynamically fixed when constellations of attitudes are locked-in to identities via multilayer networks of attitude agreement and disagreement; a process intensified by conflict, threat or zero-sum partisan processes (e.g. elections/referenda). Agent-based simulations will validate the theory and explore the hypothesized channels of bot influence. Network experiments with human and hybrid networks will test theoretically derived hypotheses. Observational network studies will assess model fit using historical Twitter data. Results will provide a social-psychological-network theory for attitude dynamics and vulnerability to computational propaganda in hybrid networks.
The theory will explain:
(a) when and how consensus can propagate rapidly through networks (since identity processes fix attitudes already contained within repertoires);
(b) limits of identity-related attitude propagation (since attitudes outside of repertoires will not be easily adopted); and
(c) how attitudes can often 'roll back' after events (since contextual changes 'unfix' attitudes).

Project End Date: **30-NOV-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803194	**PIDS**	**SH3** Environment, Space and Population

Principal Investigator:	**Dr. ERIC ROBINSON**
Host Institution:	The University Of Liverpool, UK

Population level interventions to improve diet and reduce social inequality

Addressing social inequality in diet and health is a major public health challenge; the socially disadvantaged have the poorest diets and die the youngest. A further cause for concern is that commonly adopted public health interventions may be inadvertently worsening social inequalities in diet. We therefore need to identify interventions that benefit all, but are particularly effective in improving the diet of the disadvantaged, as this approach will reduce inequality and be the most effective way of improving overall population health. By testing a novel psychological theory, across two work packages (WPs) I will establish the type of population level interventions that worsen social inequalities in diet and identify interventions that not only improve the diet of the overall population, but also reduce inequality. WP1 will test the new hypothesis that the social patterning of executive function results in information-based nutrition interventions benefitting the socially advantaged but failing the disadvantaged, whilst structural interventions benefit all and also reduce social inequalities in diet. In WP1 I will use newly developed immersive digital reality methods to study dietary choice and laboratory feeding paradigms to examine dietary consumption in the socially advantaged vs. disadvantaged, before conducting the first ever large scale randomized control trial to identify how the real-world implementation of information vs. structural interventions affect social inequalities in diet. WP2 will exploit the knowledge generated in WP1 in order to develop a state of the art epidemiological model to simulate how the implementation of different information vs. structural nutrition policy interventions would affect population level health and health inequalities in Europe. By using inter-disciplinary methods this project will identify nutrition intervention approaches that can be used to improve population health and reduce social inequality.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803211	**WhoP**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. AIKE PETER ROTS**
Host Institution: Universitetet I Oslo, NO

Whales of Power: Aquatic Mammals, Devotional Practices, and Environmental Change in Maritime East Asia

In various parts of East Asia, aquatic mammals are associated with divine power, and serve as objects of devotion. In south and central Vietnam, cetaceans are worshipped as life-saving deities. In some Japanese coastal areas, the spirits of whales are venerated during ritual ceremonies. In China, Cambodia and the Ryukyu Islands, aquatic mammals have all been associated with water deities. These animals continue to carry significant symbolic capital today – if no longer as gods, at least as local "heritage" and symbols of nature conservation, acquiring new meanings in the context of secularisation, (forced) displacement, and environmental degradation.

Whales of Power is concerned with the comparative study of human-cetacean relations in maritime East Asia, as expressed in popular worship practices and beliefs. We will examine several of these traditions in different parts of the region, through a combination of historical and ethnographic research. Our main hypothesis is that changes in local worship traditions reflect changes in human-nature relations, which are caused by wider social, economic and environmental developments. Thus, marine mammals and associated worship practices serve as a prism, through which we approach human responses to socio-economic and environmental change in Asian coastal communities.

The innovative character of Whales of Power lies in the ways in which it combines state-of-the-art theoretical approaches from different disciplinary backgrounds in order to reach new understandings of the ways in which human-nature-god relations reflect social and environmental changes. It has three important theoretical objectives: 1) apply recent theoretical developments associated with "environmental humanities" to the comparative study of popular religion; 2) reconsider the role of local worship traditions in the Asian Secular Age, examining the new meanings attributed to ritual practices; and 3) establish a new comparative paradigm in Asian studies.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804031	**ReligSpace**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. PAZIT BEN-NUN BLOOM**
Host Institution: The Hebrew University Of Jerusalem., IL

The Effect of Manifestations of Religion in the Public Space on Sociopolitical Integration of Minority-Religion Immigrants

Recent globalization and immigration trends are motivating tremendous efforts to regulate manifestations of minority religions in the public space, such as religious structures, stores, attire, and rituals (hereafter, spatial religious manifestations). Yet the empirical literature has, to date, not taken on the methodologically and conceptually challenging undertaking of theorizing, operationalizing, and assessing this dimension of religion. In particular, it remains unclear what causal effect manifestations of religion in the public space have on minority-religion immigrants' sociopolitical integration: do they, by validating immigrants' identity, facilitate a sense of belonging and the endorsement of local practices, or nurture alienation and hostility toward the host society?

Integrating up-to-date theories and methods from political science, psychology, sociology, and geography, and optimizing external and internal validity, this project is the first large-scale research to examine the causal effect of exposure to spatial religious cues on sociopolitical integration, studying minority-religion immigrants of the three monotheistic religions in four urban settings.

The research will be divided into three work packages: (1) conceptualization and operationalization of spatial religious manifestations; (2) comparative naturalistic and survey-embedded experiments examining the effect of real-world spatial religious cues on minority-religion immigrants' sociopolitical integration; and (3) a panel survey with longitudinal geocoded data analyzing the conditions in which spatial religious cues are particularly instrumental in local-level integration.

Besides developing a novel approach to the study of religion in politics, this project will open new horizons in the understanding of aggregated religious priming effects in real-world settings, with insights into the dynamics that would advance a more inclusive society via nuanced policies and informed urban planning.

Project End Date: **31-MAR-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804761	**CEAD**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. LUCY ANNE PARKER**
Host Institution: Universidad Miguel Hernandez De Elche, ES

Contextualizing Evidence for Action on Diabetes in low-resource Settings: A mixed-methods case study in Quito and Esmeraldas, Ecuador.

The relentless rise in diabetes is one of the greatest global health emergencies of the 21st century. The increase is most pronounced in low and middle income countries where today three quarters of people with diabetes live and over 80% of the deaths attributed to non-communicable diseases occur. In light of the wealth of knowledge already available about how to tackle the problem, most major international organizations call for the adoption healthy public policies and initiatives to strengthening health systems. However, implementation of recommended action remains limited in many settings. Most evidence comes from high-income settings and may generate recommendations that cannot be successfully implemented in other settings without careful consideration and contextualization. I propose here that this “know-do” gap can be reduced by revealing the barriers to implementing evidence-based recommendations, engaging local stakeholders in developing context-led innovations and developing a tool-kit for contextualizing and implementing diabetes recommendations in low-resource settings. I plan the research in two carefully selected settings in Ecuador, with mixed-methods combining quantitative epidemiological research and qualitative methodology to generate the rich and varied knowledge that is required to trigger policy action and/or changes in care models. Furthermore, I will engage patients, community members, health workers and decision makers in the process of knowledge generation, interpretation and use. The overarching objective is hence, to explore the process by which global recommendations can be translated into context-specific, evidence-informed action for diabetes prevention in low-resource settings. The findings will support the global endeavour to bridge the global “know-do” gap, one of the most important public health challenges this century and a great opportunity for strengthening health systems and achieving health equity.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
805425	**WorkFREE**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. NEIL HOWARD**
Host Institution: University Of Bath, UK

Slavery, Work and Freedom: What Can Cash Transfers Contribute to the Fight for Decent Work?

WorkFREE builds on the widespread empirical observation that everywhere people who are stuck in indecent, exploitative or 'unfree' work nevertheless choose that work because doing so represents their best available option, and asks a simple yet potentially revolutionary question: What happens if we just give them money? It will answer this question by creating a world-first social experiment, administering 18 months of unconditional cash transfers (UCTs) to four communities typically associated with that work and contrasting findings from them with those from parallel control communities. WorkFREE will thus become the first project anywhere to combine research on cash transfers (CTs) with that on labour (un)freedom. It will also innovate methodologically, employing a unique combination of ethnography, surveys, and participatory qualitative techniques. This will allow the WorkFREE team – myself (the PI), a post-doctoral economist and two anthropology PhD students – to answer a question at the heart of the UN Sustainable Development Goals (SDGs): What can cash transfers contribute to the fight for decent work? It will further enable the co-creation of grounded theory around concepts central to the SDGs, including freedom, slavery, consent, coercion, vulnerability, exploitation, emancipation and (in)decent work. This, in turn, could call into question prevailing, hegemonic theorisations of these concepts, along with mainstream approaches to generating those theorisations and the policies with which they are associated. In this way, WorkFREE will push the empirical, theoretical and political boundaries at the intersection of development studies, labour studies, social theory and social policy. Given its focus and approach, it will also contribute to cognate debates around Social Protection (SP) and Unconditional Basic Income (UBI), positioning Europe at the forefront of contemporary efforts to achieve social justice in globalised market society.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
805550	**FluidKnowledge**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. SARAH DE RIJCKE**
Host Institution: Universiteit Leiden, NL

How evaluation shapes ocean science. A multi-scale ethnography of fluid knowledge.

New forms of evaluation are reconfiguring science in ways we are only beginning to understand. Through the rich case of ocean science, this project addresses a key challenge in social-scientific research regarding how evaluations are implicated in scientific understandings of the world. Ocean science is increasingly multivalent. Not only is it expected to contribute to a more systemic understanding of the ocean as an ecosystem, it is also called on to analyze environmental effects of climate change, and help fight effects of intensified exploitation. At the same time, it operates in a highly research-focused and efficiency-oriented academic system whose norms partly work against societal relevance. The ambition of FluidKnowledge is to 1) investigate how research agendas are shaped in ocean scientific research; 2) analyze how the value of ocean science is enacted in European and national science policy contexts; 3) develop concepts on the basis of the outcomes of 1) and 2), to theoretically grasp how research evaluation shapes knowledge making. Ocean science provides a planet-critical research site in which to analyze how steering efforts toward interdisciplinary engagement and societal relevance relate to other norms and criteria of scientific quality (e.g. excellence) in actual practice. This project creates a new interface between longitudinal scientometric analysis and rich ethnographic studies. This paves the way for a new interdisciplinary field. A second contribution is conceptual. Whereas many evaluation experts treat the heterogeneity of practice as a problem, I engage such heterogeneity as a resource. The project will build theory that encourages a more comprehensive understanding of how evolving evaluation and knowledge production are mutually implicated. A third novelty is the focus on ocean science. Systematic analysis of its workings and policy implications is crucial for understanding a world in which trust in scientific knowledge is no longer obvious.

Project End Date: **29-FEB-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
817577	**HONORLOGIC**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. AYSE USKUL**
Host Institution: University Of Kent, UK

The Cultural Logic of Honor and Social Interaction: A Cross-Cultural Comparison

Understanding (un)willingness to coordinate with others, to compromise when faced with different choices, or to apologize for transgressions is crucial as these behaviors can act as strong facilitators or inhibitors of important interpersonal processes such as negotiations and coalition building. These behaviors play a major role when individuals from different cultural backgrounds work together to solve disputes or address joint challenges. Yet, we know little about what these behaviors mean in different cultural groups or how they are approached. With HONORLOGIC, I aim to initiate a step-change in our understanding of cultural variation in these important domains of social behavior by providing unique, multimethod, comparative and converging evidence from a wide range of cultural groups. I will answer the question "How do cultural groups that promote honor as a core cultural value approach coordinating with others, reaching compromise, and offering apologies?" by integrating insights from social/cultural psychology, behavioral economics, and anthropology. I will do this by collecting quantitative data using economic games, experiments, and surveys from Spain, Italy, Greece, Turkey, Cyprus, Lebanon, Egypt and Tunisia, as cultural groups where honor has been shown to play a defining role in individuals' social worlds. I will also run the proposed studies in the US, the UK, Japan and Korea to provide a broader comparative perspective.

HONORLOGIC will produce transformative evidence for theories of social interaction and decision making in psychology, economics, and evolutionary science by (a) producing innovative theory and data with an interdisciplinary and multi-method approach, (b) increasing the diversity of the existing evidence pool, (c) testing established theoretical assumptions in new cultural groups, and (d) contributing to capacity building in under-researched cultural groups in psychological research.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818210	**CAPTURE**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. ISTO HUVILA**
Host Institution: Uppsala Universitet, SE

CApturing Paradata for documenTing data creation and Use for the REsearch of the future

Considerable investments have been made in Europe and worldwide in research data infrastructures. Instead of a general lack of data about data, it has become apparent that the pivotal factor that drastically constrains the use of data is the absence of contextual knowledge about how data was created and how it has been used. This applies especially to many branches of SSH research where data is highly heterogeneous, both by its kind (e.g. being qualitative, quantitative, naturalistic, purposefully created) and origins (e.g. being historical/contemporary, from different contexts and geographical places). The problem is that there may be enough metadata (data about data) but there is too little paradata (data on the processes of its creation and use).

In contrast to the rather straightforward problem of describing the data, the high-risk/high-gain problem no-one has managed to solve, is the lack of comprehensive understanding of what information about the creation and use of research data is needed and how to capture enough of that information to make the data reusable and to avoid the risk that currently collected vast amounts of research data become useless in the future. The wickedness of the problem lies in the practical impossibility to document and keep everything and the difficulty to determine optimal procedures for capturing just enough.

With an empirical focus on archaeological and cultural heritage data, which stands out by its extreme heterogeneity and rapid accumulation due to the scale of ongoing development-led archaeological fieldwork, CAPTURE develops an in-depth understanding of how paradata is #1 created and #2 used at the moment, #3 elicits methods for capturing paradata on the basis of the findings of #1-2, #4 tests the new methods in field trials, and #5 synthesises the findings in a reference model to inform the capturing of paradata and enabling data-intensive research using heterogeneous research data stemming from diverse origins.

Project End Date: **30-APR-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819025	**RUSINFORM**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. FLORIAN TOEPFL**
Host Institution: Universitat Passau, DE

The Consequences of the Internet for Russia's Informational Influence Abroad

Over the past decade, Russia's ruling elites have massively stepped up their efforts to influence media audiences abroad. Amongst others, Russia has been alleged to have sought to sway votes in Austria, France, Germany, Ukraine, and the US. This project's overarching research question is: How, and with what consequences, have new Internet-based technologies contributed to the emergence of novel resources, techniques, and processes by which political elites in Moscow can influence media audiences abroad? In order to address this question, a theoretical work package (WP4) will undertake the first major systematic effort to interrogate how much, or how little, we can leverage extant in-depth knowledge of former-Soviet foreign propaganda, conducted in the broadcast era, in order to make sense of Russia's recent digitally-enabled efforts. WP4 will be informed by three empirical WPs. They will scrutinize three heavily digitally-enabled elements of Russia's recent efforts: • WP1 will conduct the first in-depth study of the foreign online audiences who co-create and disseminate Russia-related content. • WP2 will produce pioneering research about how social media platforms function as key transmission channels that connect Russia's domestic media with Russian-speaking audiences abroad. • WP3 will be the first study to scrutinize the role of the Kremlin-controlled search engine Yandex as a resource of foreign influence. Methodologically, WP1-3 are highly innovative because they combine new computational methods (data mining, automated text analysis) with traditional methods (surveys, in-depth inter-views, grounded theory).
In response to Russia's recent efforts, countermeasures have been ushered in by a plurality of actors, including the EU, NATO, and NGOs. These actors will benefit immensely from the knowledge generated, which will enable them to enhance their initiatives to secure democratic electoral processes against undue informational interference.

Project End Date: **31-OCT-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819458	**PoliticsOfPatents**	**SH3** Environment, Space and Population

Principal Investigator:	**Dr. KATRINA JUNGNICKEL**
Host Institution:	Goldsmiths' College, UK

Politics of Patents: Re-imagining citizenship via clothing inventions 1820 - 2020

From Victorian women cyclists, who suffered social stigma for daring to replace their skirts with bloomers a century ago, to the recent French burkini ban, where women were forcibly removed from beaches, specifically clothed bodies have long been sites of debate about gender, race, class and religion in public space. Clothing is directly connected to social life and the political world and as such is central to ideas around the politics of identity, participation and belonging. Yet, it is under explored in relation to citizenship studies. This five-year project undertakes for the first time a transnational sociological investigation of 200 years of clothing inventions. It focuses on clothing patents in Espacenet, the European Patent Office's free online database. Inventors are the focus as they operate on the cutting edge of social and political change; building on the past to make claims on the present and imagine different futures. Central to this research is the idea that clothing inventors can be explored as citizen-makers and that clothing patents are rich untapped sources of data that render visible alternative citizenship possibilities, which may provoke new questions about things we take for granted. The research will be located in a Patent Lab using an inventive mixed-methods approach including quantitative and in-depth visual and document analysis, interviews with inventors and garment reconstruction.

Project End Date: **29-FEB-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819533	**INSCONS**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. SIMCHA JONG**
Host Institution: Universiteit Leiden, NL

Addressing Global Challenges through International Scientific Consortia (INSCONS); Case studies in biomedicine, the geosciences, and nuclear fusion research

INSCONS is a groundbreaking, large-scale examination of the organisational dynamics of international scientific consortia (ISCs) and the interactions of these consortia with broader scientific communities, national bureaucracies, and industry. ISCs are very complex organisations with work being carried out at geographically dispersed sites, and involving international stakeholder groups from across the realms of science, policy, and industry. As these ISCs are becoming more important in efforts to address global challenges in areas such as health, the environment, and clean energy, our understanding of the distinctive organizational dynamics governing these consortia has lagged behind. Accordingly, there is a pressing need for novel organisational theory and frameworks that will advance our understanding of ISCs. INSCONS is an ambitious effort to address this need, using a comparative, interdisciplinary approach. Three case studies of large, international ISCs in nuclear fusion research, biomedicine, and the geosciences are at the core of INSCONS. The INSCONS project will examine four aspects of these ISCs. It will 1) Map the internal organisational dynamics of ISCs using interviews, bibliometric network analyses, and ethnographic field studies on everyday work in ISCs. 2) It will study ISCs' interactions with the broader scientific community by conducting a survey among researchers in the scholarly fields ISCs operate in, and by analysing these fields' co-authorship networks. 3) It will examine the (inter)national political processes and bureaucratic wrangling shaping ISCs. 4) It will examine relationships of dependency and influence between ISCs and industry through case studies as well as analyses of patenting and publication activities. Taken together, the project outputs of INSCONS will bring into clear focus the sociology and politics, as well as the operational complexities that govern this important, new organisational form in contemporary science.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833577	**REsPecTMe**	**SH3** Environment, Space and Population

Principal Investigator:	**Dr. VALERIA PULIGNANO**
Host Institution:	Katholieke Universiteit Leuven, BE

Resolving Precariousness: Advancing the Theory and Measurement of Precariousness across the paid/unpaid work continuum

The traditional dichotomy of paid (productive or waged) versus unpaid (reproductive or unwaged) work marginalizes unpaid work when conceptualizing precariousness, i.e. the exposure to unpredictability towards an individual's future. It also neglects several types of unpaid work such as care work, work as a precondition for welfare payments, and newly emerging on- and offline work in the gig economy for which people in paid work are not compensated or where it is used to access paid work. A novel scientific perspective is needed, which breaks the paid/unpaid distinction, and rethinks precariousness on the paid/unpaid work continuum by uncovering the unpaid activities that increasingly underlie paid employment as a source of 'value' creation in the labour market. ResPecTMe will generate a new theoretical model of, and a measurement approach and monitoring tools for, precariousness at the paid and unpaid work continuum.

Using my unique experience of studying workers' subjectivity within their societal contexts, I will achieve this by i) using a sequential mix of qualitative and quantitative methodologies to study precariousness at the paid/unpaid work continuum, and its social effects, in three core areas of work (i.e. care, crowd/gig- and creative), across and within eight European countries; ii) developing a comprehensive theory of precariousness at this continuum; iii) generating a valid, standardized and multi-indicator measurement (i.e. survey module) of precariousness at this continuum; iv) implementing monitoring tools for precariousness at the European level (i.e. rotating module for ESS and EPM). The theoretical knowledge, the measurement and the monitoring tools will address ongoing scientific and social challenges on how to study precariousness by innovating current conceptualisation of work in the scientific and policy community dealing with precarious work.

Project End Date: **31-MAR-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834103	**MigrantLife**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. HILL KULU**
Host Institution: The University Court Of The University Of St Andrews, UK

Understanding Life Trajectories of Immigrants and Their Descendants in Europe and Projecting Future Trends

In recent decades, European countries have witnessed increasing immigration streams and ethnic heterogeneity of their populations. Facilitating immigrant integration and social cohesion has become a major societal issue. The project moves beyond previous research by first investigating how employment, housing and family trajectories evolve and interact in the lives of descendants of post-WWII immigrants and post-1990 immigrants in the UK, France, Germany and Sweden, and how factors related to a societal context, an early life context and critical transitions shape their life histories. Second, the study will project their future life trajectories using innovative simulation techniques, considering the main life domains and diversity between and within immigrant groups. Although recent studies report substantial diversity in employment, in housing and in family patterns among descendants of post-war immigrants and recent immigrants in Europe, the causes of this heterogeneity remain far from clear. Furthermore, it is not known whether observed differences between immigrants and natives are short-term outcomes in a long-term process of cultural and economic integration or rather reflections of different pathways and outcomes for immigrants and their descendants. The project will exploit large-scale longitudinal data from four countries and apply advanced longitudinal methods, including multichannel sequence analysis and multilevel event history analysis. Microsimulation will be applied to project life histories for immigrants and their descendants. The project will significantly deepen our understanding of the relationships between the three life domains, and the causes of less and more successful life trajectories among immigrants and their descendants. This project will show whether the current heterogeneity between and within immigrant and minority groups vanishes over time or rather persists, suggesting an increasing diversity of European societies.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834441	**GlobalOrthodoxy**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. HELEEN MURRE-VAN DEN BERG**
Host Institution: Stichting Katholieke Universiteit, NL

Rewriting Global Orthodoxy Oriental Christianity in Europe between 1970 and 2020

Over the last fifty years, Oriental Orthodox Christians (Armenians, Copts, Syriacs/Arameans, Ethiopians and Eritreans) from the Middle East and Africa have settled in Europe, fleeing war-related violence and societal pressures. One of the prominent aspects of religious practice of these transnational Oriental communities is their strong emphasis on the writing and publishing of texts. These include traditional religious texts (from liturgy to history), re-translated and re-contextualized texts, and completely new texts. From simple leaflets and books to sophisticated internet productions where text is persuasively embedded in sound and image, these textual practices aim to transmit the religious heritage to a new generation in an increasingly globalized context.

Scholarship has largely ignored these texts, being too popular or too modern for scholars of the written religious traditions and too textual for social scientists working on these transnational communities, even though they make up a crucial source for the study of these communities' European integration, especially as to the hybrid character of many of these traditions, among Oriental and Eastern Orthodox Christianities, and among European and global Christianity. Unfortunately, the popular nature of these texts, whether published on paper or digitally, threatens their long-term survival.

The project takes these textual practices as its main source to understand how these Oriental Christians inscribe themselves in European societies and so contribute not only to the transformation of their own transnational churches but also to that of Orthodoxy worldwide. It hypothesizes that diachronic and synchronic comparison among Oriental and Eastern Orthodox churches will show that this rewriting includes the actualization of their religious heritage vis-à-vis ethnic and national self-definitions, vis-à-vis European society, and vis-à-vis other churches, particularly Orthodox ones.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834587	**EMOTIONACCULTURATION**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. BATJA GOMES DE MESQUITA**
Host Institution: Katholieke Universiteit Leuven, BE

Emotional Acculturation: Emotions as Gateways to Minority Inclusion

International migration has often been referred to as one of the major challenges of the 21st century. Numbers of immigrants have been increasing, but social integration of migrants and their children is lagging at the detriment of immigrant minorities themselves and often resulting in conflict within receiving societies. EmotionAcculturation investigates the role of emotions, as key processes of interaction, for immigrant minorities' social inclusion, and their wellbeing. It builds on research showing that, in each culture, emotions are socialized to fit the most valued kinds of relationships, and that the prevalent emotions, therefore, vary across different cultures. I postulate that misfit of the emotions of immigrant minorities with the typical majority emotions compromises interactions, and that this will hamper their social integration, and therefore their opportunities in the larger society. I study how and when emotional acculturation forms an important gateway to the social inclusion and wellbeing of immigrant minority individuals. The grant is organized around three Objectives: to better understand 1) the nature of emotional acculturation, 2) its conditions, and 3) its outcomes. I adopt a multi-method approach, following large numbers of immigrant minority and majority participants over time, in their everyday lives, and in real-time interactions in the laboratory. The project will span two receiving national contexts with different diversity climates (Belgium, California). It will shed light on understudied micro-processes involved in minority inclusion, and their social and health consequences. EmotionAcculturation offers a novel approach to psychological acculturation that goes beyond attitude change. Moreover, by studying emotional change beyond childhood, it also contributes to our understanding of how emotions are constructed through relational engagements, and how they facilitate social coordination and cohesion.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851022	**NeoliberalTerror**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. CHARLOTTE HEATH-KELLY**
Host Institution: The University Of Warwick, UK

Neoliberal Terror: The Radicalisation of Social Policy in Europe

This project is the first to systematically investigate the introduction of counterterrorism within Health and Social care across Europe. The longstanding separation of medicine and care from policing/intelligence in liberal societies has been superseded in the era of Countering Violent Extremism (CVE). This study explores the political, economic and discursive mechanisms behind this dramatic policy shift, as well as the consequences for medical ethics and society. The project makes a major research contribution by exploring the integration of counterterrorism within caregiving professions as an effect of neoliberalism, through a methodologically pluralist approach. The project also contributes to research on policy diffusion by tracing the spread of deradicalisation programs between member states and EU institutions, with special attention paid to uptake by Europe's small states.

The first stage of the project operates at the European policy level. Data analysis is performed on political, economic and social data from all member states to determine the extent to which neoliberalism affects CVE implementation. Policy diffusion dynamics are then illuminated through Critical Discourse Analysis of institutional speeches, policies, and the work of the EU's Radicalisation Awareness Network (RAN), which attempts to standardise counter-radicalisation practice in Europe. The second stage of the project explores the local implementation of counter-radicalisation in health and social care sectors of the UK; France; Norway; Finland; Croatia; and Lithuania. Interviews and site visits enable the research to investigate standardisation and variation in CVE practice within Health and Social Care. The final stage of the project embarks on participant research with persons referred to CVE programs, creating a documentary film which highlights the competing visions of care, security and medical ethics at play within European counterterrorism.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851132	**Ports**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. ELISABETH SCHOBER**
Host Institution: Universitetet I Oslo, NO

Between Sea and City: Ethnographic explorations of infrastructure, work, and place around leading urban container ports

How to study the turbulent transitions and risky mobilities of global capitalism today? An illuminating, but often overlooked site that lends itself to explorations into the changing nature of our economic system can be found at the interface between sea and city, i.e. at the port. Container ports have often been pushed to the edges of the urban spaces that they used to be centrally located in. A study on the city/sea-nexus will illuminate the dynamics behind the ways in which the center of global capitalism is currently on the move east-wards. This is not a uni-linear shift from “the West” to “the Rest”, but rather, is brought into existence by the nature of the ever-changing interplay between local territorialization and global connectedness. By investigating the relationship between port and city, PORTS will achieve three objectives: 1. to uncover the daily practices that port-related infrastructures enable in order to ensure the flow of commodities travelling through them; 2. to document the ways in which workers employed in the orbit of the port are affected by, and relate to, race-to-the-bottom-dynamics within the maritime world; and 3. to analyze the gradual move of the port away from the city center, and the urban waterfront changes that come with it, and how these are experienced, discussed, and justified by various stake-holders. PORTS will engage with local histories, unruly presents, and possible futures in four of the most important port-cities in the world: Singapore, Pusan (Korea), Rotterdam (Netherlands) and Piraeus (Greece). Through ethnographic work, it will clarify the changing nature of work, the significance of “place” as a site of accumulation and resistance, and the role of infrastructure for the inner workings of ports. Given the dearth of work addressing logistics-driven capitalism from an urban angle, this is the first study that systematically utilizes the ethnographic tool-kit to explore the economic frontier between city and sea.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851293	**SIBMOB**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. KRISTIAN BERNT KARLSON**
Host Institution: Kobenhavns Universitet, DK

Social Class Mobility in Comparative Perspective: Bringing Siblings In

While sociologists studying how social class positions are passed on from parents to children emphasize the family as the basic theoretical unit of intergenerational transmission processes, the comparative literature on social class mobility has paid no attention to how and why siblings from the same family end up in the same or in different classes. Indeed, all existing class mobility studies examine the mobility of individuals, thereby neglecting the key question of how societal differences in class mobility patterns result from social processes operating at the level of families.

SIBMOB will fill this puzzling gap in the class mobility literature by developing a comprehensive approach to and conducting a large-scale comparative study of the class mobility of siblings. The project argues that insofar as we want to understand how class mobility is generated and why societies differ in their class mobility patterns, the total pattern of class mobility in a society needs to be viewed as a sum of different types of families with distinct class mobility patterns. SIBMOB offers a novel statistical approach to analyzing these family types, including describing how and explaining why they differ both within and between countries. The project hypothesizes that cross-national and temporal variation in class mobility results from institutional and sociodemographic factors affecting families' overall mobility opportunities in a given society. In a comparative study, the project will apply its novel approach to data on siblings born during the 20th century in 10 countries to test this and related hypotheses about why countries, or different birth cohorts within countries, differ in their overall class mobility patterns.

Key outcomes of SIBMOB will be a deeper understanding of families' role in mobility processes, a comprehensive statistical methodology with wide applicability, and new comparative evidence on class mobility that is much richer than the existing evidence.

Project End Date: **31-JAN-26**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851725	**DONNI**	**SH3** Environment, Space and Population

Principal Investigator:	**Dr. STEPHANIE VON HINKE**
Host Institution:	University Of Bristol, UK

Developmental Origins: exploring the Nature-Nurture Interplay

The "Developmental Origins of Health and Disease" (DOHaD) hypothesis states that insults in early life can have lifelong, irreversible impacts, affecting individuals' health and well-being in older age. My proposed research builds on this in two main ways. First, I will use natural experiments to investigate the causal impact of early life circumstances on later life outcomes, focusing on novel (1) nutritional, (2) toxicological, (3) health and (4) economic environments in early life. Within these, I will consider insults (i) for which there is insufficient knowledge of their long-term impacts, (ii) which are relevant today, and (iii) importantly, which are modifiable. Second, I will go beyond the old "nature versus nurture" debate and investigate how individuals' genes ('nature') interacts with the above early life environments ('nurture') in creating inequalities in health and well-being.

Whilst neither the estimation of causal effects within DOHaD, nor the estimation of the gene-environment (GxE) interplay is new, their combination is. Indeed, it is currently not known how the early life environment interacts with genetic predisposition to causally shape later life outcomes, as well as whether certain environments exacerbate or reduce health inequalities in the population. Combining advancements across disciplines, I will evaluate the long-term effects of short-term variations in early life conditions (objective 1), and I will directly test the hypothesis that gene-environment interactions causally shape later life outcomes (objective 2). I will digitize historical data on early life environmental exposures and merge these with large-scale individual-level data. As such, my proposal will investigate the extent to which genes interact with the environment, using natural experiments to identify interventions that can ameliorate inequalities in health and well-being (objective 3).

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851890	**SOAR**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. NETTA WEINSTEIN**
Host Institution: Cardiff University, UK

Solitude: Alone but Resilient

It is undeniable that social connections and interactions are key to the human experience. Perhaps for this reason, laypeople and scientists alike have assumed that being alone is aversive, a state inexorably tied to lonely emotions and sense of isolation. Yet solitude is experienced daily by nearly everyone, and though it can be negative it can also be a constructive and rewarding time. What makes some more psychologically resilient to solitude and why do some experience fewer of the negative and more of the positive emotions associated with this potentially challenging state? The SOAR project will integrate fragmented literatures and model contributions of predictors at event, individual, and cultural levels. This ambitious three-part project consists of complementing qualitative and quantitative approaches and will be the first to build a conceptual model through open science methods, offering intrinsic value to research conducted outside of the field of solitude. WP1 explores what solitude, and psychological resilience within it, means to people in different circumstances through semi-structured interviews, imagery, and written narratives. WP2 tests predictors of psychological resilience within solitude to develop a conceptual model, first with a novel diary study approach to capture solitude as it occurs, then with a large-scale multi-nation assessment, and finally with older adults. Finally, WP3 develops a resilience in solitude intervention as an experimental test of the model, and conducts a field experiment with older adults. The radical shift in theory, and use of novel, multifaceted approaches, will guide our understanding of how humans respond in the immediate absence of social connections, and pave the way for further understanding self-processes, the role of the self in relation to interpersonal interactions and society, and psychological resilience more broadly.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852317	**MIMIc**	**SH3** Environment, Space and Population

Principal Investigator:	**Dr. LAURA VANDENBOSCH**
Host Institution:	Katholieke Universiteit Leuven, BE

Malleability in mediated ideals: A paradigm to understand effects of contemporary media in adolescents' well-being

MIMIc will develop and establish a new theoretical perspective that will fundamentally redirect the current research on idealised representations of life in mass and social media and their effects on (adolescent) audiences. MIMIc combines insights from cultural sociology, media theory, and developmental psychology to define the effects of 'malleable ideals' in media. Malleable ideals are idealised representations of different achievements and are characterised by the malleability that surrounds these achievements; they approach ideals from a utilitarian, individualistic discourse that links personal responsibility and dedication with both the failure and success of achievements. By focusing on malleable ideals and thus applying a sociocultural analysis to media ideals, a crucial perspective will be added to our understanding of the development of adolescents and, more precisely, the pressures they experience. These pressures are viewed as an important factor in the relatively high prevalence of both internalising and externalising problems in adolescence. Content analytical, diary, and longitudinal studies in three different cultural contexts will be triangulated to develop a theoretical model: MIME. Content analyses map the extent to which media abound with aesthetic, sexual, professional, romantic, and social ideals as well as the importance of malleability in these representations. Longitudinal and diary research examine the internalisation of these ideals as a key explanatory process for the effects they may have both on outcomes regarding personal and societal problems and among different groups of adolescents. The multimethod approach further allows the theorisation and testing of the role of varying time intervals associated with understanding the effects of mediated ideals. For this research, the applicant who is experienced in multimethod research on media effects among adolescents will compose and lead a cross-national team of researchers.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
853271	**H-MIP**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. JOHN PALMER**
Host Institution: Universitat Pompeu Fabra, ES

Human-Mosquito Interaction Project: Host-vector networks, mobility, and the socio-ecological context of mosquito-borne disease

This project will use mobile phone positioning, DNA fingerprinting, and citizen science, combined with traditional socio-demographic methods to trace the host-vector biting networks through which mosquito-borne diseases flow and illuminate the behavioural, socio-demographic, and environmental mechanisms that shape these networks in a spatially explicit manner. It will merge this ground-breaking data with existing datasets on population, urban structure, land cover, and climate, analysing it using network techniques, spatial models, and machine learning to test hypotheses about the determinants of these networks. The results will make it possible to improve dynamic models of mosquito-borne disease and recommend targeted policy interventions for reducing disease risk in Europe and around the world. In doing so, it will address the critical need for greater social science perspective iThis project will use citizen science, mobile phone geo-localization, genetic analysis, surveys, interviews, and cutting-edge modelling techniques to trace the host-vector contact networks through which mosquito-borne diseases flow, illuminate the mobility patterns and other behavioural mechanisms that shape these networks, and evaluate policy interventions aimed at reducing the risk of these diseases in urban and suburban settings. In doing so, it will address the critical need for greater social science perspective in mosquito-borne disease research, making it possible to improve disease models and public health management through a fuller understanding of the socio-ecological context driving dengue, chikungunya, Zika and other mosquito-borne diseases that place enormous burdens on society and exacerbate social inequality across the globe. It will draw on the the PI's unique interdisciplinary background, straddling socio-demography, public policy, and disease ecology, and his pioneering work on citizen science in public health research and mobile phone tracking in demographic research.

Project End Date: **31-MAR-25**

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Project ID:	Project Acronym:	Evaluation Panel:
853517	**Outside-In**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. MATTEO GILETTA**
Host Institution: Universiteit Gent, BE

Outside-in: How Bullying in Adolescence Gets Into The Mind and Under the Skin

Being bullied is a major stressor for many adolescents and it is recognized as a public health concern worldwide. Adolescents who are exposed to bullying are at increased risk for mental and physical health problems, which could even perpetuate into adulthood. Unfortunately, current understandings of how bullying can pose such deleterious effects remain poor, thus limiting our ability to inform prevention and intervention efforts. This project addresses this fundamental gap and substantially extends prior research in two unique ways. First, I will examine fine-grained processes as they occur within adolescents in real-time in their real-life as a crucial pathway for uncovering mechanisms underlying the negative effects of bullying. Second, I will adopt a multilevel perspective to examine the dynamic interplay between multiple psychological and biological processes and how they unfold over time. In this regard, I will examine the possibility that bullying influences gene expression processes resulting in a gene expression profile that increases risk for health problems. In a first study, I will use a longitudinal measurement burst design, allowing me to examine how bullying exposure can influence within-person processes over time at the daily level. I will assess psychological (e.g., emotional) and physiological (e.g., HPA-axis) functioning in situ, and I will use transcriptional profiling to examine how gene expression changes over adolescence as a function of bullying. In a second study, I will utilize data from the Netherlands Twin Register to identify monozygotic twins who differ from each other in their history of victimization in adolescence and examine their gene expression profiles in early adulthood, while accounting for genetic confounds. Together, this research will offer unprecedented insights about short- and long-term interplays between psychological, physiological and molecular processes through which bullying may get into the mind and under the skin.

Project End Date: **31-AUG-25**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
864137	**GREENTEENS**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. SANDER THOMAES**
Host Institution: Universiteit Utrecht, NL

Understanding and Unleashing Adolescents' Eco-Friendly Behavior

The world faces an unprecedented environmental crisis, and human activity is its root cause. This poses a call to action for psychology and the social sciences more broadly. GREENTEENS proposes that our adolescents—a segment of the population whose collective behavior will shape the future of the planet—can play a vital role in creating a more sustainable world. Adolescents, however, are "closet idealists": As a group, they care about the environment but often fail to act on their concerns. The aim of the proposed research is to develop a new approach to understanding and promoting adolescents' eco-friendly behavior. It will generate new understanding of what keeps adolescents from engaging in eco-friendly behavior, and devise methods to help youth contribute to a sustainable future for themselves and generations to come.

I have developed a new hypothesis for this project: the "Motive-Match Hypothesis". It casts adolescents' eco-friendly behavior as driven by their personal motives. Based on the hypothesis, I will design methods to transform the way adolescents construe eco-friendly behavior, from a low-priority chore to an activity that embodies what they deeply care about—developing autonomy and gaining peer status.

Building on my international network, I will pursue the research aim using a cross-national investigation involving adolescents (age 12-17) from The Netherlands, Colombia, and China. The project will integrate longitudinal research to understand how adolescents' eco-friendly behavior develops over time, with experiments to understand how adolescents' core motives can be harnessed as powerful motivating force for eco-friendly behavior. GREENTEENS will advance the science of adolescent behavior change beyond the state of the art. The payoff of the research promises to be high: It will yield fundamental understanding of what drives adolescents' eco-friendly behavior and help improve pro-environmental policies targeting millions of youth worldwide.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864347	**PerInterv**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. ERAN HALPERIN**
Host Institution: The Hebrew University Of Jerusalem., IL

Personalized Interventions to Improve Intergroup Relations and Promote Peace

The recent increase in intergroup hostilities and the intertwining of local and global crises emphasizes the importance of finding ways to attenuate the destructive effects of intergroup conflicts. In recent decades, social psychologists have shown an increasing interest in offering interventions to reduce intergroup prejudice and promote intergroup reconciliation. Yet, in contrast to other scientific fields that strive towards more personalized approaches, most research on intergroup interventions applies the same interventions to all target populations. The proposed project aims to address this gap by introducing an innovative framework for personalized intergroup interventions. The proposed framework is composed of three main layers: a. personalization parameters, b. mechanisms connecting personalization parameters to concrete interventions, and c. the relevant interventions to be tested. The project includes four sequential parts. In part one (WP1) I will conduct six (one for each intervention) meta-analyses in which all available data of studies using these interventions will be gathered and moderations by personalization parameters will be tested. In WP2, online versions of all interventions will be created and tested in two large-scale online studies in two different contexts (Israeli-Palestinian and immigration in Europe) against relevant personalization parameters. Then, in WP3, I will attempt to pinpoint optimal compositions of different interventions, to maximize effects for distinct individuals. Finally, in WP4, I will conduct field interventions in two domains: education and social media, in which screening based on the parameters for personalization is plausible. The project will identify novel mechanisms by which different intergroup interventions differently influence different individuals. It will make important conceptual discoveries and apply them in order to shift intergroup relations using more accurate, theory-driven, personalized methods.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864616	**HEALIN**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. IÑAKI PERMANYER**
Host Institution: Centro De Estudios Demograficos, ES

Healthy lifespan inequality: Measurement, trends and determinants

Despite its widespread use and popularity, life expectancy (LE) has two shortcomings. First, its definition only takes into consideration mortality levels, thus ignoring the health status of those who remain alive. Second, LE is an average that does not explain how length of life is distributed across the population. These limitations have generated two strands of research (i.e. the study of 'health expectancies' (HE) and 'lifespan inequality' (LI)) that, so far, have developed independently from each other. The overarching objective of the HEALIN project is to bring together these research avenues into a coherent whole to get a more comprehensive understanding of contemporary population health dynamics. To attain this goal, I put forward the new concept of 'healthy lifespan inequality' (HLI), which is designed to investigate the extent to which healthy lifespans are unequally distributed across the population.

The HEALIN project will (i) investigate the trends and determinants of HLI, (ii) assess whether the specific ages and causes that drive changes in HLI are the same ones determining the changes in LE, HE and LI indicators, and (iii) investigate how these indicators behave across and within countries and socio-economic groups. In addition, the project aims at making innovative contributions to the measurement of co-morbidity and to our understanding on how the latter can in turn influence the measurement of health expectancy and healthy lifespan inequality. To attain these objectives, the project will develop path-breaking analytical methods inspired in the models applied for the study of inequality and multidimensional poverty. Besides traditional socio-economic and health data sources, the project will complementary draw from the vastly underutilized health registers for the entire population in Catalonia (7.5 million residents). Their huge size and micro-level design allow investigating trends in HLI and co-morbidity with unprecedented detail.

Project End Date: **30-APR-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865931	**TRUSTPATH**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. SHAUL SHALVI**
Host Institution: Universiteit Van Amsterdam, NL

Responsible sharing: Paving the path for transparent trust

The collaborative economy is estimated to add €160-€572 billion to the EU economy. Faced with blurry definitions in this emerging market, regulators use a top-down approach and introduce regulations that often fail to consider users' behaviour. Although considerable knowledge on top-down regulatory solutions for the collaborative economy is accumulating, little is known about the bottom-up psychological factors driving the collaborative economy users' behaviour. Online platforms rely and promote trust between users and service providers. For responsible sharing, however, trust is necessary but not sufficient. Only when trust is encouraged transparently can users share responsibly. TRUSTPATH will assess, if: (1) users are aware of, or motivated to learn about, the side effects of trade; (2) platforms' promotion of trust increases users' information neglect; and (3) transparent environments reduce information neglect and increase responsible sharing. Building on my expertise on trust and cooperation, and using insights from psychology, management, and economics, I will develop and test a novel psychological theory of how people use the collaborative economy: Transparency Based Trust theory (TBT). TBT's novel hypothesis suggests trust encouraged without transparency leads users to neglect the negative side effects trade has on others. TRUSTPATH innovates by developing a novel methodology (the collaborative economy game) and using cutting-edge technologies (large-scale experiments). Support for TBT implies a major step forward in the systematic understanding of the collaborative economy in the social sciences, and the psychological mechanisms underlying users' behaviour on platforms like Airbnb, Uber, and others. TRUSTPATH will contribute to establish a new field of study: the psychology of the collaborative economy; inform policymakers seeking to regulate the collaborative economy; and inform companies seeking to promote responsible sharing among users.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866006	**SmartForests**	**SH3** Environment, Space and Population

Principal Investigator:	**Dr. JENNIFER GABRYS**
Host Institution:	The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

Smart Forests: Transforming Environments into Social-Political Technologies

Forests are crucial to acting on environmental change. They are key contributors to the carbon cycle and biodiversity, as well as air and water quality. At the same time, digital technologies are reshaping forests in order to manage and enhance their environmental contributions. However, these new technologies are generating social-political impacts that have yet to be extensively researched. For the first time, this groundbreaking project addresses the vital question of how forests are becoming "smart" through the increasing use of digital technologies to manage these environments. Smart forests span locations from Germany to New York City to Thailand, and from remote to urban areas. While there is now extensive research on smart cities, other "smart" environments have been less well studied. This is problematic, since it is necessary to assess how these technologies enable and constrain particular modes of governance and engagement. Without this research, smart environments such as smart forests run the risk of producing social-political inequities and undemocratic governance, as has been identified with smart cities. Using inventive digital practices, fieldwork, participatory workshops and mapping, the research will investigate the transformation of forests and forest communities through digital technologies. Through 5 case studies, the project will analyze the ways in which forest technologies are transforming practices of observing, mitigating, participating in, and regulating environmental change. SmartForests asks not just how digital technologies are remaking forests, but also investigates how forests become social-political technologies for addressing environmental change. Situated at the intersection of science and technology studies (STS) and digital media studies, the research will demonstrate how these technologies impact socio-ecological relations, and will propose more equitable approaches to digital and environmental practice and policy.

Project End Date: **30-APR-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866207	**LABFER**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. ANNA MATYSIAK**
Host Institution: Uniwersytet Warszawski, PL

Globalisation- and Technology-Driven Labour Market Change and Fertility

LABFER is the first project that will LABFER is the first project that will comprehensively describe and evaluate fertility consequences of the unprecedented changes in the labour market, caused by digitalisation and globalisation. These changes have been taking place during the last three decades and intensified after the Great Recession. They are reflected in: rising demand for skills, massive worker displacement, spread of new work arrangements, increasing work demands and growing inequalities in labour market prospects between the low-and-medium and the highly skilled. They are likely driving the post-crisis fertility decline in the most advanced nations, which is to date not understood. LABFER is thus highly relevant and timely. It has four main objectives:

1) to study the impact of the ongoing labour market change on fertility (macro-level);

2) to examine the individual-level mechanisms behind the observed macro-level fertility effects of the ongoing labour market change;

3) to investigate the role of the growing inequalities between the low-and-medium and the highly skilled for the relative fertility patterns of the two groups;

4) to study the role of family and employment policies in moderating the fertility effects of the labour market change.

Our methodological approach is innovative. We will link data at several layers of observation (country, region, industry, firm, couple and individual) to account for the policy, work and family context of childbearing. We will also use novel labour market measures to capture the ongoing labour market change. Mixture cure models will be employed to separate the effects of covariates on birth timing and probability that the birth occurs.

LABFER will break the ground by providing understanding of how the dynamic labour market changes are associated with and potentially affect the current and future fertility dynamics and its socio-economic gradients. It will also have implications for family and employment policies.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866340	**POLINEQUAL**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. SONJA ZMERLI**
Host Institution: Institut D'Etudes Politiques De Grenoble, FR

The Politicisation of Economic Inequality: The Impact of Welfare Regimes, Elites' Discourse and Media Frames on Citizens' Perceptions, Justice Evaluations and Political Behaviour

POLINEQUAL aims to investigate the causes and mechanisms that motivate citizens to respond to economic inequality. Conceptually, it is based on the assumptions that 1) perceptions of economic inequality are biased as they are mediated by justice evaluations and, thus, do not mirror objective levels of economic inequality, 2) perceptions of economic inequality are informed by facts, ideological cues, media representations or personal heuristics, 3) perceptions and evaluations are malleable to the extent that economic inequality is being politicized and becomes politically salient, and 4) politically salient perceptions and evaluations of economic inequality evoke emotional, attitudinal and behavioural responses.

In my conceptualization, perceptions of inequality – and justice evaluations that instil them - originate from social norms that are deeply rooted in the 'moral economies' of welfare regimes and are malleable as a function of individual exposure to and receptivity of facts, ideological cues, representations and heuristics of economic inequality.

POLINEQUAL pursues two paths. First, it investigates the nature of interrelationship between media representations, ideological cues and individual perceptions and evaluations of economic inequality and to what extent the latter are conditioned by collectively shared distributive justice norms. Second, it investigates the impact of politically salient individual perceptions and evaluations of inequality on emotions and political behavior. Its aim is to develop a theoretical framework which explains the causes and mechanisms of individual perceptions of income inequality being contingent on national institutional arrangements, ideological cues, media frames and personal heuristics and destabilizing democracies. The research design is based on a mixed-methods approach, organized in different stages and combining data derived from focus groups, discourse and content analysis, an online survey and an experimental study

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
646696	**AUDADAPT**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. JONAS OBLESER**
Host Institution: Universitaet Zu Luebeck, DE

The listening challenge: How ageing brains adapt

Humans in principle adapt well to sensory degradations. In order to do so, our cognitive strategies need to adjust accordingly (a process we term “adaptive control”).The auditory sensory modality poses an excellent, although under-utilised, research model to understand these adjustments, their neural basis, and their large variation amongst individuals. Hearing abilities begin to decline already in the fourth life decade, and our guiding hypothesis is that individuals differ in the extent to which they are neurally, cognitively, and psychologically equipped to adapt to this sensory decline.

The project will pursue three specific aims: (1) We will first specify the neural dynamics of “adaptive control” in the under-studied target group of middle-aged listeners compared to young listeners. We will employ advanced multi-modal neuroimaging (EEG and fMRI) markers and a flexible experimental design of listening challenges. (2) Based on the parameters established in (1), we will explain interindividual differences in adaptive control in a large-scale sample of middle-aged listeners, and aim to re-test each individual again after approximately two years. These data will lead to (3) where we will employ statistical models that incorporate a broader context of audiological, cognitive skill, and personality markers and reconstructs longitudinal “trajectories of change” in adaptive control over the middle-age life span.

Pursuing these aims will help establish a new theoretical framework for the adaptive ageing brain. The project will further break new ground for future classification and treatment of hearing difficulties, and for developing individualised hearing solutions. Profiting from an excellent research environment and the principle investigator’s pre-established laboratory, this research has the potential to challenge and to transform current understanding and concepts of the ageing human individual.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
693400	**ORIENT**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. JOHN VAN OPSTAL**
Host Institution: Stichting Katholieke Universiteit, NL

Goal-directed eye-head coordination in dynamic multisensory environments

Rapid object identification is crucial for survival of all organisms, but poses daunting challenges if many stimuli compete for attention, and multiple sensory and motor systems are involved in the processing, programming and generating of an eye-head gaze-orienting response to a selected goal. How do normal and sensory-impaired brains decide which signals to integrate ("goal"), or suppress ("distracter")?

Audiovisual (AV) integration only helps for spatially and temporally aligned stimuli. However, sensory inputs differ markedly in their reliability, reference frames, and processing delays, yielding considerable spatial-temporal uncertainty to the brain. Vision and audition utilize coordinates that misalign whenever eyes and head move. Meanwhile, their sensory acuities vary across space and time in essentially different ways. As a result, assessing AV alignment poses major computational problems, which so far have only been studied for the simplest stimulus-response conditions.

My groundbreaking approaches will tackle these problems on different levels, by applying dynamic eye-head coordination paradigms in complex environments, while systematically manipulating visual-vestibular-auditory context and uncertainty. I parametrically vary AV goal/distracter statistics, stimulus motion, and active vs. passive-evoked body movements. We perform advanced psychophysics to healthy subjects, and to patients with well-defined sensory disorders. We probe sensorimotor strategies of normal and impaired systems, by quantifying their acquisition of priors about the (changing) environment, and use of feedback about active or passive-induced self-motion of eyes and head.

I challenge current eye-head control models by incorporating top-down adaptive processes and eye-head motor feedback in realistic cortical-midbrain networks. Our modeling will be critically tested on an autonomously learning humanoid robot, equipped with binocular foveal vision and human-like audition.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714150	**FASTPARSE**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. CARLOS GÓMEZ RODRÍGUEZ**
Host Institution: Universidade Da Coruna, ES

Fast Natural Language Parsing for Large-Scale NLP

The popularization of information technology and the Internet has resulted in an unprecedented growth in the scale at which individuals and institutions generate, communicate and access information. In this context, the effective leveraging of the vast amounts of available data to discover and address people's needs is a fundamental problem of modern societies.

Since most of this circulating information is in the form of written or spoken human language, natural language processing (NLP) technologies are a key asset for this crucial goal. NLP can be used to break language barriers (machine translation), find required information (search engines, question answering), monitor public opinion (opinion mining), or digest large amounts of unstructured text into more convenient forms (information extraction, summarization), among other applications.

These and other NLP technologies rely on accurate syntactic parsing to extract or analyze the meaning of sentences. Unfortunately, current state-of-the-art parsing algorithms have high computational costs, processing less than a hundred sentences per second on standard hardware. While this is acceptable for working on small sets of documents, it is clearly prohibitive for large-scale processing, and thus constitutes a major roadblock for the widespread application of NLP.

The goal of this project is to eliminate this bottleneck by developing fast parsers that are suitable for web-scale processing. To do so, FASTPARSE will improve the speed of parsers on several fronts: by avoiding redundant calculations through the reuse of intermediate results from previous sentences; by applying a cognitively-inspired model to compress and recode linguistic information; and by exploiting regularities in human language to find patterns that the parsers can take for granted, avoiding their explicit calculation. The joint application of these techniques will result in much faster parsers that can power all kinds of web-scale NLP applications.

Project End Date: **31-JAN-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714977	**PEP**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. DISA SAUTER**
Host Institution: Universiteit Van Amsterdam, NL

An Empirical Foundation for Understanding Positive Emotions

Positive emotions are of great importance for our physical and mental health and for our social relationships. However, scientific knowledge of positive emotions is lacking, with research to date being both fractionated and scarce. The Positive Emotions Project (PEP) takes on the challenge of formulating a foundational, empirically-based framework of positive emotions. This is accomplished by a set of studies combining methodologies that examine both subjective and objective elements of 17 positive emotions, including gratitude, awe, amusement, compassion, and relief. Central to the investigation is the integration of cross-cultural and developmental approaches, in order to differentiate between consistent patterns and idiosyncratic features. Project 1 will use experience sampling to map out the experience of positive emotions across ten dramatically different cultures, examining subjective elements of emotions, such as antecedent events and psychological states. Project 2 will comprehensively establish which nonverbal facial and vocal signals are associated with different positive emotions across cultures and ages. Project 3 will provide an integrated multi-level account of positive emotions, considering similarities and differences across emotions, taking into account cross-cultural and developmental patterning of subjective and objective features. The empirical and theoretical results of PEP will result in new, innovative paradigms, and substantial, freely available datasets that will help to redress the current dearth of data and approaches for understanding positive emotions. It will also provide the basis for a much-needed scientific, multifaceted account of positive emotion. Such a model will benefit scientists across many disciplines, including affective computing, behavioural economics, and psychiatry, whose work builds on psychological models of emotions.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715016	**ChangeBehavNeuro**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. TOM SCHONBERG**
Host Institution: Tel Aviv University, IL

Novel Mechanism of Behavioural Change

Understanding how values of different options that lead to choice are represented in the brain is a basic scientific question with far reaching implications. I recently showed that by the mere-association of a cue and a button press we could influence preferences of snack food items up to two months following a single training session lasting less than an hour. This novel behavioural change manipulation cannot be explained by any of the current learning theories, as external reinforcement was not used in the process, nor was the context of the decision changed. Current choice theories focus on goal directed behaviours where the value of the outcome guides choice, versus habit-based behaviours where an action is repeated up to the point that the value of the outcome no longer guides choice. However, in this novel task training via the involvement of low-level visual, auditory and motor mechanisms influenced high-level choice behaviour. Thus, the far-reaching goal of this project is to study the mechanism, by which low-level sensory, perceptual and motor neural processes underlie value representation and change in the human brain even in the absence of external reinforcement. I will use behavioural, eye-gaze and functional MRI experiments to test how low-level features influence the neural representation of value. I will then test how they interact with the known striatal representation of reinforced behavioural change, which has been the main focus of research thus far. Finally, I will address the basic question of dynamic neural plasticity and if neural signatures during training predict long term success of sustained behavioural change. This research aims at a paradigmatic shift in the field of learning and decision-making, leading to the development of novel interventions with potential societal impact of helping those suffering from health-injuring behaviours such as addictions, eating or mood disorders, all in need of a long lasting behavioural change.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715058	**InStance**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. AGNIESZKA WYKOWSKA**
Host Institution: Fondazione Istituto Italiano Di Tecnologia, IT

Intentional stance for social attunement

In daily social interactions, we constantly attribute mental states, such as beliefs or intentions, to other humans – to understand and predict their behaviour. Today we also routinely interact with artificial agents: from Apple's Siri to GPS navigation systems. In the near future, we will casually interact with robots. However, since we consider artificial agents to have no mental states, we tend to not attune socially with them in the sense of activating our mechanisms of social cognition. This is because it seems pointless to socially attune to something that does not carry social meaning (mental content) under the surface of an observed behaviour. INSTANCE will break new ground in social cognition research by identifying factors that influence attribution of mental states to others and social attunement with humans or artificial agents. The objectives of INSTANCE are to (1) determine parameters of others' behaviour that make us attribute mental states to them, (2) explore parameters relevant for social attunement, (3) elucidate further factors – culture and experience – that influence attribution of mental states to agents and, thereby social attunement. INSTANCE's objectives are highly relevant not only for fundamental research in social cognition, but also for the applied field of social robotics, where robots are expected to become humans' social companions. Indeed, if we do not attune socially to artificial agents viewed as mindless machines, then robots may end up not working well enough in contexts where interaction is paramount. INSTANCE's unique approach combining cognitive neuroscience methods with real-time human-robot interaction will address the challenge of social attunement between humans and artificial agents. Subtle features of robot behaviour (e.g., timing or pattern of eye movements) will be manipulated. The impact of such features on social attunement (e.g., joint attention) will be examined with behavioural, neural and physiological measures.

Project End Date: **30-APR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715154	**AMORE**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. GEMMA BOLEDA TORRENT**
Host Institution: Universitat Pompeu Fabra, ES

A distributional MOdel of Reference to Entities

When I asked my seven-year-old daughter "Who is the boy in your class who was also new in school last year, like you?", she instantly replied "Daniel", using the descriptive content in my utterance to identify an entity in the real world and refer to it. The ability to use language to refer to reality is crucial for humans, and yet it is very difficult to model. AMORE breaks new ground in Computational Linguistics, Linguistics, and Artificial Intelligence by developing a model of linguistic reference to entities implemented as a computational system that can learn its own representations from data.

This interdisciplinary project builds on two complementary semantic traditions: 1) Formal semantics, a symbolic approach that can delimit and track linguistic referents, but does not adequately match them with the descriptive content of linguistic expressions; 2) Distributional semantics, which can handle descriptive content but does not associate it to individuated referents. AMORE synthesizes the two approaches into a unified, scalable model of reference that operates with individuated referents and links them to referential expressions characterized by rich descriptive content. The model is a distributed (neural network) version of a formal semantic framework that is furthermore able to integrate perceptual (visual) and linguistic information about entities. We test it extensively in referential tasks that require matching noun phrases (“the Medicine student”, “the white cat”) with entity representations extracted from text and images.

AMORE advances our scientific understanding of language and its computational modeling, and contributes to the far-reaching debate between symbolic and distributed approaches to cognition with an integrative proposal. I am in a privileged position to carry out this integration, since I have contributed top research in both distributional and formal semantics.

Project End Date: **31-JAN-22**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
715605	**CONSCIOUSNESS**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. SIMON VAN GAAL**
Host Institution: Universiteit Van Amsterdam, NL

Towards a neural and cognitive architecture of consciousness

For decades the cognitive neuroscience community has expended significant effort identifying system-level neural correlates of human consciousness, broad neural signatures that distinguish conscious from unconscious processes at the level of whole brain regions. Meanwhile, within the field of neurobiology, rapid progress has been made in understanding the neurotransmitter systems underlying basic sensory processes (e.g. in mice, monkeys). This research has, however, been performed in relative isolation from studies of human consciousness, and clear opportunities to link the two levels of description remain largely unexplored. Here I will establish this link by combining state-of-the-art neuroimaging techniques with pharmacological interventions.

First, I will validate and refine existing theories of consciousness by isolating system-level neural correlates of consciousness that are invariant across experimental tasks and manipulations. Second, I will test the hypothesis that NMDA receptors play a crucial role in recurrent processing, the dynamic information exchange between brain regions, thought to give rise to consciousness. I will also test the hypothesis that rapid fluctuations in spontaneous network activity (modulating arousal levels), which are controlled by noradrenaline and acetylcholine neuromodulatory systems, determine the likelihood of sensory evoked recurrent processing, and hence consciousness, to occur. Third, I will test the hypothesis that recurrent processing provides the possibility for prolonged and flexible information processing, which could represent a potential function of consciousness.

In summary, the proposed research has the potential to gain fundamental insights in the neural causes, rather than simply correlates, of human consciousness, as has been the focus of most previous work. In so doing, the work will advance scientific understanding of the long-debated functional significance of consciousness for human cognition and behavior.

Project End Date: **30-APR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715618	**CALC**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. JOHANN-MATTIS LIST**
Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Computer-Assisted Language Comparison: Reconciling Computational and Classical Approaches in Historical Linguistics

By comparing the languages of the world, we gain invaluable insights into human prehistory, predating the appearance of written records by thousands of years. The traditional methods for language comparison are based on manual data inspection. With more and more data available, they reach their practical limits. Computer applications, however, are not capable of replacing experts' experience and intuition. In a situation where computers cannot replace experts and experts do not have enough time to analyse the massive amounts of data, a new framework, neither completely computer-driven, nor ignorant of the help computers provide, becomes urgent. Such frameworks are well-established in biology and translation, where computational tools cannot provide the accuracy needed to arrive at convincing results, but do assist humans to digest large data sets.

This project establishes a computer-assisted framework for historical linguistics. We pursue an interdisciplinary approach that adapts methods from computer science and bioinformatics for the use in historical linguistics. While purely computational approaches are common today, the project focuses on the communication between classical and computational linguists, developing interfaces that allow historical linguists to produce their data in machine readable formats while at the same time presenting the results of computational analyses in a transparent and human-readable way.

As a litmus test which proves the suitability of the new framework, the project will create an etymological database of Sino-Tibetan languages. The abundance of language contact and the peculiarity of complex processes of language change in which sporadic patterns of morphological change mask regular patterns of sound change make the Sino-Tibetan language family an ideal test case for a new overarching framework that combines the best of two worlds: the experience of experts
and the consistency of computational models.

Project End Date: **31-MAR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716230	**CoSaQ**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. JAKUB SZYMANIK**
Host Institution: Universiteit Van Amsterdam, NL

Cognitive Semantics and Quantities

At the heart of the multi-faceted enterprise of formal semantics lies a simple yet powerful conception of meaning based on truth-conditions: one understands a sentence if one knows under which circumstances the sentence is true. This notion has been extremely fruitful resulting in a wealth of practical applications. But to what extent can it also account for the human linguistic behavior? The past decade has seen the increasing interaction between cognitive science and formal semantics, and the emergence of the new field of experimental semantics. One of its main challenges is the traditional normative take on meaning, which makes semantic theories hard to compare with experimental data. The aim of this project is to advance experimental semantics by building cognitive semantics, that is semantics founded on cognitive representations instead of normative logical abstractions.

Numerical information plays a central role in communication. We talk about the number of students in a class, or the proportion of votes for a particular political party. In this project, I will focus on the linguistic expressions of quantities, known as quantifiers. Recent progress in the study of computational constraints on quantifier processing in natural language laid the groundwork for extending semantic theory with cognitive aspects. In parallel, cognitive science has furthered the study of non-linguistic quantity representations. This project will integrate formal models of quantifier semantics with cognitive quantity representations in order to obtain cognitive semantics of quantifiers, which is both logically precise and psychologically plausible. The theory will have significant repercussions, not only in the immediately related disciplines as semantics and psycholinguistics, but also beyond, e.g., in philosophy and in language technology.

Project End Date: **31-JAN-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724411	**TreeGraSP**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. LAURA KALLMEYER**
Host Institution: Heinrich-Heine-Universitaet Duesseldorf, DE

Tree rewriting grammars and the syntax-semantics interface: From grammar development to semantic parsing

The increasing amount of data available in our digital society is both a chance and a challenge for natural language processing. On the one hand, we have better possibilities than ever to extract and process meaning from language data, and recent techniques, in particular deep learning methods, have achieved impressive results. On the other hand, linguistic research has a much broader empirical basis and can aim at rich quantitative models of language. Unfortunately, theory and application interact too little in these areas of meaning extraction and grammar theory. Current semantic processing techniques do not sufficiently capture the complex structure of language while grammatical theory does not sufficiently incorporate data-driven insights about language.

TreeGraSP bridges this gap by combining rich linguistic theory with data-driven approaches to large scale statistical grammar induction and to semantic parsing. The novelty of its approach consists in putting semantics at the center of grammar theory, putting an emphasis on multilinguality and typological diversity, and adopting a constructional approach to grammar. TreeGraSP is interdisciplinary and innovative in serveral respects: It contributes to the field of linguistics by a) making theories of grammar explicit, b) providing a grammar implementation tool for typologically working linguists and c) developing means to obtain a quantitative grammar theory. And it contributes to the field of computational semantics by providing a probabilistic theory of meaning construal that can be used for textual entailment and reasoning applications. The challenge lies in the intended transfer between theoretical linguistics and statistical natural language processing.

Project End Date: **30-JUN-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725025	**AgeConsolidate**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. ANDERS MARTIN FJELL**
Host Institution: Universitetet I Oslo, NO

The Missing Link of Episodic Memory Decline in Aging: The Role of Inefficient Systems Consolidation

Which brain mechanisms are responsible for the faith of the memories we make with age, whether they wither or stay, and in what form? Episodic memory function does decline with age. While this decline can have multiple causes, research has focused almost entirely on encoding and retrieval processes, largely ignoring a third critical process– consolidation. The objective of AgeConsolidate is to provide this missing link, by combining novel experimental cognitive paradigms with neuroimaging in a longitudinal large-scale attempt to directly test how age-related changes in consolidation processes in the brain impact episodic memory decline. The ambitious aims of the present proposal are two-fold:

(1) Use recent advances in memory consolidation theory to achieve an elaborate model of episodic memory deficits in aging

(2) Use aging as a model to uncover how structural and functional brain changes affect episodic memory consolidation in general

The novelty of the project lies in the synthesis of recent methodological advances and theoretical models for episodic memory consolidation to explain age-related decline, by employing a unique combination of a range of different techniques and approaches. This is ground-breaking, in that it aims at taking our understanding of the brain processes underlying episodic memory decline in aging to a new level, while at the same time advancing our theoretical understanding of how episodic memories are consolidated in the human brain. To obtain this outcome, I will test the main hypothesis of the project: Brain processes of episodic memory consolidation are less effective in older adults, and this can account for a significant portion of the episodic memory decline in aging. This will be answered by six secondary hypotheses, with 1-3 experiments or tasks designated to address each hypothesis, focusing on functional and structural MRI, positron emission tomography data and sleep experiments to target consolidation from different angles.

Project End Date: **30-APR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725970	**NATVIS**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. MARIUS VINCENT PEELEN**
Host Institution: Stichting Katholieke Universiteit, NL

Characterizing neural mechanisms underlying the efficiency of naturalistic human vision

Our daily-life visual environments, such as city streets and living rooms, contain a multitude of objects. Out of this overwhelming amount of sensory information, our brains must efficiently select those objects that are relevant for current goals, such as cars when crossing a street. The visual system has developed and evolved to optimally perform tasks like these, as reflected in the remarkable efficiency of naturalistic object detection. Little is known about the neural mechanisms underlying this efficiency. NATVIS aims to fill this gap, presenting a comprehensive multi-method and hypothesis-driven approach to improve our understanding of the neural mechanisms underlying the efficient detection of objects in natural scenes. fMRI, MEG, and TMS will be used to study the neural basis of rapid attentional guidance based on scene context and episodic memory, resulting in a full characterization of when, where, and how context- and memory-based expectations interact with attentional templates in visual cortex and beyond. The powerful effects of scene context on object recognition will be studied by testing how context-disambiguated objects are represented in visual cortex, characterizing when context-based predictions bias object processing, and testing for causal interactions between scene- and object-selective pathways in visual cortex. NATVIS will study how the brain uses real-world regularities to support object grouping and reduce clutter in scenes, modelling the cortical representation and neural dynamics of multiple simultaneously presented objects as a function of positional regularity. Finally, advanced multivariate modelling of fMRI data will test the functional relevance and representational content of internally generated templates that are hypothesized to facilitate object detection in scenes. This program of research tackles the next frontier in the neuroscience of high-level vision and attention, embracing the complexity of naturalistic vision.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
726090	**COGTOM**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. MATE LENGYEL**
Host Institution: Kozep-Europai Egyetem, HU

Cognitive tomography of mental representations

Internal models are fundamental to our understanding of how the mind constructs percepts, makes decisions, controls movements, and interacts with others. Yet, we lack principled quantitative methods to systematically estimate internal models from observable behaviour, and current approaches for discovering their mental representations remain heuristic and piecemeal. I propose to develop a set of novel 'doubly Bayesian' data analytical methods, using state-of-the-art Bayesian statistical and machine learning techniques to infer humans' internal models formalised as prior distributions in Bayesian models of cognition. This approach, cognitive tomography, takes a series of behavioural observations, each of which in itself may have very limited information content, and accumulates a detailed reconstruction of the internal model based on these observations. I also propose a set of stringent, quantifiable criteria which will be systematically applied at each step of the proposed work to rigorously assess the success of our approach. These methodological advances will allow us to track how the structured, task-general internal models that are so fundamental to humans' superior cognitive abilities, change over time as a result of decay, interference, and learning. We will apply cognitive tomography to a variety of experimental data sets, collected by our collaborators, in paradigms ranging from perceptual learning, through visual and motor structure learning, to social and concept learning. These analyses will allow us to conclusively and quantitatively test our central hypothesis that, rather than simply changing along a single 'memory strength' dimension, internal models typically change via complex and consistent patterns of transformations along multiple dimensions simultaneously. To facilitate the widespread use of our methods, we will release and support off-the-shelf usable implementations of our algorithms together with synthetic and real test data sets.

Project End Date: **30-APR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
726114	**DEVOMIND**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. VICTORIA SOUTHGATE**
Host Institution: Kobenhavns Universitet, DK

How do infants mentalize? Bringing a neuroimaging approach to the puzzle of early mindreading.

Human social interaction and learning depends on making the right inferences about other people's thoughts, a process commonly called mentalizing, or Theory of Mind, a cognitive achievement which several decades of research concluded was reached at around age 4. The last 10 years has radically changed this view, and innovative new paradigms suggest that even preverbal infants can think about others' minds. This new developmental data has created arguably one of the biggest puzzles in the history of developmental science: How can infants be mentalizing when years of research have shown that a) pre-schoolers fail at mentalizing tasks and b) mentalizing depends on the development of cognitive control, language, and brain maturation? The key issue is whether behaviour that looks like infant mentalizing really is mentalizing, or might infants' success belie alternative processes? The most powerful strategy for resolving this puzzle is to look to brain activity. By applying the same methods and paradigms across infancy and early childhood, DEVOMIND will investigate whether infants' success on mentalizing tasks recruits the same network of brain regions, and neural processes, that we know are involved in success in older children and adults. In the second half of the project, we will use our neural indicators of mentalizing to test a completely novel hypothesis in which infants' success is possible because they have a limited ability to distinguish self from other. Although novel, this hypothesis deserves to be tested because it has the potential to explain both infants' success and preschoolers' failures under a single, unified theory. By bringing a neuroimaging approach to the puzzle of early mentalizing, DEVOMIND will allow us to move beyond the current impasse, and to generate a new theory of Theory of Mind.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
726251	**STYDS**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. BENCE NANAY**
Host Institution: Universiteit Antwerpen, BE

Seeing things you don't see: Unifying the philosophy, psychology and neuroscience of multimodal mental imagery

When I am looking at my coffee machine that makes funny noises, this is an instance of multisensory perception – I perceive this event by means of both vision and audition. But very often we only receive sensory stimulation from a multisensory event by means of one sense modality. If I hear the noisy coffee machine in the next room (without seeing it), then how do I represent the visual aspects of this multisensory event?

The aim of this research project is to bring together empirical findings about multimodal perception and empirical findings about (visual, auditory, tactile) mental imagery and argue that on occasions like the one described in the last paragraph, we have multimodal mental imagery: perceptual processing in one sense modality (here: vision) that is triggered by sensory stimulation in another sense modality (here: audition).

Multimodal mental imagery is rife. The vast majority of what we perceive are multisensory events: events that can be perceived in more than one sense modality – like the noisy coffee machine. And most of the time we are only acquainted with these multisensory events via a subset of the sense modalities involved – all the other aspects of these events are represented by means of multisensory mental imagery. This means that multisensory mental imagery is a crucial element of almost all instances of everyday perception, which has wider implications to philosophy of perception and beyond, to epistemological questions about whether we can trust our senses.

Focusing on multimodal mental imagery can help us to understand a number of puzzling perceptual phenomena, like sensory substitution and synaesthesia. Further, manipulating mental imagery has recently become an important clinical procedure in various branches of psychiatry as well as in counteracting implicit bias – using multimodal mental imagery rather than voluntarily and consciously conjured up mental imagery can lead to real progress in these experimental paradigms.

Project End Date: **28-FEB-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
726361	**IMPROVE**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. JELTE WICHERTS**
Host Institution: Stichting Katholieke Universiteit Brabant, NL

Innovative Methods for Psychology: Reproducible, Open, Valid, and Efficient

With numerous failures to replicate, common misreporting of results, widespread failure to publish non-significant results or to share data, and considerable potential bias due the flexibility of analyses of data and researcher's tendency to exploit that flexibility, psychological science is said to experience a crisis of confidence. These issues lead to dissemination of false positive results and inflate effect size estimates in meta-analyses. This leads to poor theory building, an inefficient scientific system, a waste of resources, lower trust in psychological science, and psychology's outcomes being less useful for society. After having contributed to the literature highlighting these problems the goal of my ERC project is to improve psychological science by offering novel solutions to five vexing challenges: (1) I want to counter misreporting of results by using our new tool statcheck in several studies on reviewers' tendency to demand perfection and by applying it to actual peer review. (2) I want to counter the biasing effects of common explorations of data (p-hacking) by professing and studying pre-registration and by developing promising new approaches called blind analysis and cross-validation using differential privacy that simultaneously allows for exploration and confirmation with the same data. (3) I want to counter the common problem of selective outcome reporting in psychological experiments by developing powerful latent variable methods that render it fruitless to not report all outcome variables in a study. (4) I want to counter the problem of publication bias by studying and correcting misinterpretations of non-significance. (5) I want to develop and refine meta-analytic methods that allow for the correction of biases that currently inflate estimates of effects and obscure moderation. The innovative tools I develop have the potential to improve the way psychologists (and other scientists) analyse data, disseminate findings, and draw inferences.

Project End Date: **31-MAY-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
742204	**ROCKY**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. YOAD WINTER**
Host Institution: Universiteit Utrecht, NL

Forests and Trees: the Formal Semantics of Collective Categorization

Languages have various ways of referring to collections like families, herds and forests. The grammatical properties of collective expressions critically determine how we understand them. The sentences “this forest is old” and “these trees are old” categorize an arboreal collection using a concept (“old”), while conveying different meanings. This semantic difference correlates with the difference in grammatical number between the sentences: singular vs. plural. Such effects of collective categorization in language are crucial for understanding the connections between grammar and the mind, as well as for artificial intelligence. However, currently little is known about the mechanisms underlying our linguistic ability to conceptualize collections. This project aims to develop a novel linguistic theory of this ability, applied to a wide range of empirical phenomena and interdisciplinary challenges in computational semantics and comparative linguistics, benefiting from the recent synergy between linguistics and the psychology of concepts. The idea is that when classifying a collection, speakers rely on two inferential principles with mental concepts: (i) geometric inferences: a forest is considered “far away” if all of its trees are far; (ii) symmetric inferences: two trees are “similar” if each of them is similar to the other. The leading hypothesis is that uniform interactions between these inferential principles and the grammar of collective expressions account for collective categorization in language. This hypothesis is explored in three work packages, each of which develops the semantic theory and evaluates it on a different interdisciplinary domain: human interaction with geographic information systems, behavioral linguistic experiments, and comparative linguistics. Together, the three components of the project are expected to lead to a theoretical breakthrough in semantic theory and to enrich its interdisciplinary connections with neighboring disciplines.

Project End Date: **31-OCT-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
742289	**InterAccent**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. JONATHAN HARRINGTON**
Host Institution: Ludwig-Maximilians-Universitaet Muenchen, DE

Human interaction and the evolution of spoken accent

If a group of people were stranded on a desert island with limited contact to outside communities for a period of time, then the group would develop its own characteristic way of speaking or spoken accent. A lack of suitable data as input to an evolutionary computational model has meant that we have but a poor understanding of how spoken accent emerges out of human interaction. Yet a breakthrough in this area is critical for explaining the various forces - including contact between individuals through increased migration - that shape spoken accent development ultimately leading to language diversification and change. The project remedies this deficiency by developing a model of how random, local interactions between individuals leading to group-specific spoken accents can push the sound patterns of languages between stable and changing states. The methodological innovation is that the model's predictions of how spoken accent evolves will be constrained by longitudinal observations about how it actually develops within a group of speakers over time. We seek to generalise from diverse types of data: from children growing up in remote rural communities as opposed to high-contact urban settings; from languages that differ markedly in their sound structure; and from groups of adults isolated together for several months during an Antarctic winter. The project's scientific impact is on developing a computational framework for unifying historical sound change with the cognitive mechanisms by which speech is communicated and adapted to different social settings. The further impact is on understanding how migration and exposure to other accents change the sounds of language. The long-term significance of the project is to build a computationally predictive model of the way that microscopic idiosyncrasies in how humans process speech in everyday conversations accumulate into group-level macroscopic spoken accent change leading to language diversification.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
742545	**WIDE**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. HARALD BAAYEN**
Host Institution: Eberhard Karls Universitaet Tuebingen, DE

Wide Incremental learning with Discrimination nEtworks

Although homo sapiens has been endowed with language for over 50,000 years, the invention of alphabet-like scripts 3,000 years ago dominates Western linguistic thinking. Training in literacy starts in early childhood, and because of this, words and letter-like sound units can naturally seem to be the building blocks of language. The Chinese writing system highlights the cultural-specificity of this approach: characters are juxtaposed without intervening spaces, and their interpretation is highly context-dependent. Words are not singled out. And although more frequent characters contain parts indicating pronunciation, it is syllables that are referred to, not letter-like sound units.

The research proposed here seeks to break the hold that the alphabet-centric approach has on our understanding of language by exploring the idea that instead of being phone and word-based, languages use low-level properties of the acoustic signal to directly reduce uncertainty about the messages encoded in the speech signal. My work with wide learning networks (two-layer networks with many thousands of units, using the simplest possible error-driven learning rule) provides remarkable support for this suggestion: For reading and speech comprehension, their performance closely matches both the strengths and the weaknesses of human processing. Especially at a time when machine learning and artificial intelligence are moving beyond human capacity, it is a methodological imperative to study and work with algorithms reflecting both the advantages and disadvantages of human learning.

I am requesting funding to take this radically novel research program to the next level by further developing our account of auditory comprehension, by modeling more typologically diverse languages, by extending this approach to speech production, and by developing a discrimination-based language theory.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757184	**moreSense**	**SH4** The Human Mind and Its Complexity

Principal Investigator:	**Dr. ECKART ZIMMERMANN**
Host Institution:	Heinrich-Heine-Universitaet Duesseldorf, DE

The Motor Representation of Sensory Experience

How do we experience the visual world around us? The traditional view holds that the retinal input is analyzed to reconstruct an internal image that generates our perceptual experience. However, a general theory of how visual features are experienced in space and time is lacking. The fundamental claim of this grant proposal is that only motor knowledge - i.e. the way we interact with the world - establishes the underlying metric of space and time perception. In this model view, the spatial and temporal structure of perception is embedded in the processing of neural motor maps. The project moreSense has four major objectives: First, it will unravel how neural motor maps provide the metric for the experience of visual space. It will be hypothesised that there is no central neural map of space or time but a weighted contribution of all maps. Novel experimental techniques are required to uncover the motor basis of perception, which are available by recent developments in head-mounted displays and online motion tracking. Second, it will provide a general understanding of time perception being implicitly coded in movement plans to objects in space. Third, results from the first two objectives will be applied to the long-standing mystery of visual stability and continuity across movements. A bayesian model, supported by quantitative measurements, will demonstrate how information combination from the various motor maps leads naturally to stable and continuous perception. Fourth, this new theory of space and time perception will be investigated in patients suffering from a breakdown of space perception. The results will establish causal evidence that space and time perception are generated by processing in motor maps. New rehabilitation procedures will be developed to re-establish spatial perception in these patients. The experiments in this grant proposal will unravel the fundamental spatiotemporal structure of perception which organizes our sensory experience.

Project End Date: **31-MAR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757295	**FraMEPhys**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. ALASTAIR WILSON**
Host Institution: The University Of Birmingham, UK

A Framework for Metaphysical Explanation in Physics

There is a growing consensus that causal explanation is not the whole story about explanation in science. Metaphysics has seen intense recent attention to the notion of grounding; in philosophy of physics, the focus has been on mathematical and structural explanation. But the grounding debate has been criticized for insularity and disconnection from scientific practice, while work on explanation in physics tends to overlook the sophisticated logical systems and conceptual distinctions developed in metaphysics. This situation hinders understanding of novel explanatory scenarios n philosophy of physics, where familiar models of causal explanation seem to break down. FraMEPhys addresses these challenges by combining new conceptual innovations and insights from both metaphysics and philosophy of physics to transform our understanding of the nature of explanation.

FraMEPhys will engage systematically with the best work on explanation within metaphysics and philosophy of science to develop a new general framework for understanding metaphysical explanation in physics, based around the structural-equations approach to causation. The guiding idea is that the conceptual and methodological tools of structural-equations modelling can be extended beyond their familiar application to causal explanation. This promising strategy, based on ground-breaking recent work by the PI, will be applied in FraMEPhys to model the explanatory structures involved in three case studies from philosophy of physics: geometrical explanations of inertial and gravitational motion, explanation in the presence of closed time-like curves, and the explanatory connection between entangled quantum systems. FraMEPhys will develop new concepts for understanding the varieties of explanation, will provide a uniquely systematic treatment of some key cases in philosophy of physics, and will push forward fruitful interactions at the intersection of metaphysics, philosophy of science and philosophy of physics.

Project End Date: **30-JUN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757583	**Brain2Bee**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. JENNIFER COOK**
Host Institution: The University Of Birmingham, UK

How dopamine affects social and motor ability - from the human brain to the honey bee

Parkinson's Disease is usually characterised by motor impairment, and Autism by social difficulties. However, the co-occurrence of social and motor symptoms is critically underappreciated; Parkinson's Disease patients exhibit social symptoms, and motor difficulties are common in Autism. At present, the biological basis of co-occurring social and motor impairment is unclear. Notably, both Autism and Parkinson's Disease have been associated with dopamine (DA) system dysfunction and, in non-clinical populations, DA has been linked with social and motor ability. These disparate strands of research have never been combined.

Brain2Bee will use psychopharmacology in typical individuals to develop a model of the relationship between DA, Motor, and Social behaviour – the DAMS model. Brain2Bee will use sophisticated genetic analysis to refine DAMS, elucidating the contributions of DA-related biological processes (e.g. synthesis, receptor expression, reuptake). Brain2Bee will then test DAMS' predictions in patients with Parkinson's Disease and Autism. Finally, Brain2Bee will investigate whether DAMS generalises to an animal model, the honey bee, enabling future research to unpack the cascade of biological events linking DA-related genes with social and motor behaviour.

Brain2Bee will unite disparate research fields and establish the DAMS model. The causal structure of DAMS will identify the impact of dopaminergic variation on social and motor function in clinical and non-clinical populations, elucidating, for example, whether social difficulties in Parkinson's Disease are a product of the motor difficulties caused by DA dysfunction. DAMS' biological specificity will provide unique insight into the DA-related processes linking social and motor difficulties in Autism. Thus, Brain2Bee will determine the type of dopaminergic drugs (e.g. receptor blockers, reuptake inhibitors) most likely to improve both social and motor function.

Project End Date: **30-JUN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758232	**SPEECHREPORTING**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. TATIANA NIKITINA**
Host Institution: Centre National De La Recherche Scientifique, FR

Discourse reporting in African storytelling

The project explores the role of discourse reporting in West African storytelling and the grammatical strategies used by storytellers to achieve their goals. It focuses on three phenomena characteristic of the narrative grammar of a number of West African languages:
- logophoricity, or the use of special markers to signal self-reference by characters other than the current narrator,
- the use of quotative markers (commonly described as "epistemic validators"),
- and the use of foreign language or modified versions of the native language to represent the speech of certain characters.

The different phenomena are argued to serve the same purpose: they help speakers manage the distance between the role of the current narrator and the roles of story characters that the same speaker performs. The use of specific discourse reporting strategies is therefore closely related to the modes of textual production and performance in the culture-specific narrative genres, and to the construction of deixis in relation to the event of narration.

The comparative part of the project analyses similarities and differences in the ways discourse reporting functions in several West African cultures with similar data from an unrelated cultural area: the Turkic-speaking areas of Central Russia. The comparison of the organization of the same functional domain in two typologically and culturally distinct areas will assist in advancing our knowledge of universal structural and cognitive motivations underlying typologically diverse and culture-specific systems of discourse reporting.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758540	**EXPRESS**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. LUCA INCURVATI**
Host Institution: Universiteit Van Amsterdam, NL

From the Expression of Disagreeement to New Foundations for Expressivist Semantics

Disagreement is a pervasive feature of human life, which finds linguistic expression in the speech-act of rejection. If you assert that Amsterdam is in Belgium, I can express my dissent by responding 'No', thereby rejecting your assertion.

In the study of human language, assertion has taken centre stage and the investigation of rejection traditionally regarded as a chapter in the study of assertion. Thus, the orthodox treatment of rejection equates it with negative assertion, so that rejecting that Amsterdam is in Belgium is tantamount to asserting that Amsterdam is not in Belgium. However, recent theories of truth have employed a notion of rejection not reducible to negative assertion. Moreover, linguistic evidence shows that rejections and negative assertions have different functions in discourse. So what is rejection? And how does it behave?

The EXPRESS project will articulate a full-fledged theory of rejection as a speech-act not reducible to negative assertion. This theory will be incorporated into extant models of conversation and used to develop a novel logic of rejection faithful to the linguistic phenomena. The basic logical framework is that of a calculus containing formulae accompanied by signs for assertion and rejection. This bilateral framework will be modified to accommodate both weak and strong forms of rejection and extended into a unified multilateral framework capable of also handling weak forms of assertion.

The theory and logical framework developed will be used to establish a novel approach to expressivist semantics which will be applied to the case of negation and epistemic modals. This approach will lead to distinctive hypotheses about language evolution which will be tested using computational methods.

Based at the ILLC and advised by a board of researchers from Europe and the US, EXPRESS will deliver momentous advances in speech-act theory, its logic and semantics.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759370	**NGBMI**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. SURJO SOEKADAR**
Host Institution: Charite - Universitaetsmedizin Berlin, DE

Building Next-Generation Brain/Neural-Machine Interfaces For Restoration of Brain Functions

Today, five out of ten diseases worldwide resulting in long-term disability are related to the central nervous system. Due to the immense complexity and inter-individual variability of the human mind and brain there are still no effective and side effect free treatment options for many serious neuropsychiatric disorders, such as major depression, dementia or schizophrenia. Recent advancements in sensor technology and computational capacities resulted in the development of brain/neural-machine interfaces (B/NMIs) that translate electric, magnetic or metabolic brain activity into control signals of external devices, robots or machines. Moreover, novel transcranial magnetic and electric brain stimulation (TMS/TES) systems were developed allowing for direct modulation of brain activity. However, current B/NMIs are limited by the low information extraction rate constraining fluent direct brain-machine interaction. Furthermore, as simultaneous assessment of brain oscillations during TES was regarded unfeasible due to stimulation artefacts, current TES systems can only deliver “open-loop” stimulation unrelated to the underlying dynamic brain states resulting in highly variable TES effects. Building on the applicant’s previous work that includes pioneering work on in vivo assessment of brain oscillations during TES (Soekadar et al. 2013, Nature Communications) and full restoration of daily living activities after quadriplegia using a novel B/NMI hand exoskeleton (Soekadar et al. 2016, Science Robotics), the NGBMI project will overcome these limitations by merging both techniques. After developing the first real-time B/NMI-TES system allowing for effective modulation of brain functions and fluent direct brain-machine interaction, the system will be tested in persons with impaired brain function (e.g. depression, dementia or stroke). Finally, the B/NMI-TES paradigm will be implemented in a wireless and wearable EEG-based system that can be used in everyday life environments.

Project End Date: **31-OCT-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759651	**HANDmade**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. VIVIANA BETTI**
Host Institution: Universita Degli Studi Di Roma La Sapienza, IT

How natural hand usage shapes behavior and intrinsic and task-evoked brain activity.

A seminal concept in modern neuroscience is the plasticity of the developing and adult brain that underpins the organismic ability to adapt to the ever-changing environment and internal states. Conversely, recent studies indicate that ongoing sensory input seems not crucial to modulate the overall level of brain activity, which instead it is strongly determined by its intrinsic fluctuations. These observations raise a fundamental question: what is coded in the intrinsic activity? This project tests the hypothesis that intrinsic activity represents and maintains an internal model of the environment built through the integration of information from visual and bodily inputs. The bodily inputs represent the physical and functional interaction that our body establishes with the external environment. In this framework, the hand has a special role, as it represents the primary means of interaction with the environment.

Do behavior and mental activity change as a function of the effector we use to interact with the external environment? In virtual settings, I test the resilience of the internal model to extreme manipulations of the body by replacing the hand with everyday tools. The hypothesis is that prior representations constrain novel behaviors and plastic changes of both intrinsic and task-related brain activities. This prediction is also tested on samples of acquired amputees. These subjects represent an interesting model because the hand loss might reflect loss of sensory representations and less constrain on task-related brain activation.

Throughout a combination of behavioral approaches, methods and techniques ranging from kinematics to functional neuroimaging (fMRI and MEG) and virtual reality, this project provides insights on how the synergic activity of body and environment shapes behavior and neural activity. This grant might open novel opportunities for future developments of robotic-assisted technology and neuroprostheses.

Project End Date: **31-JAN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759659	**SUGARCODING**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. VALENTIN RIEDL**
Host Institution: Klinikum Rechts Der Isar Der Technischen Universitat Munchen, DE

The neuroenergetics of memory consolidation – hybrid PET/MR imaging of the default mode network

Since its discovery more than a decade ago, the most studied network in the human brain remains a paradox. The default mode network (DMN) is most active during the resting state and deactivates once subjects engage in goal directed behavior. Although reported in hundreds of studies using functional magnetic resonance imaging (fMRI), the function of the DMN is still unknown. I hypothesize that memories are consolidated in the DMN during resting state, a process that is interrupted once we engage in cognitive processing. This hypothesis is based on two complementary and recent findings. First, brain regions involved in encoding of novel or retrieval of consolidated memories strongly resemble regions of the DMN. Second, the DMN consumes most glucose during resting state as revealed by positron emission tomography (PET). Importantly, energy in the brain is mainly dedicated to neuronal signaling and synaptic plasticity related to memory consolidation.
To test my hypothesis, I will use hybrid PET/MR imaging to simultaneously study fMRI activity and energy metabolism of the DMN during episodic memory processing. Integrating this novel imaging approach with my recently developed brain connectivity methods, I will (i) identify the metabolic baseline of fMRI-deactivations in the DMN, (ii) track the metabolic demand and directional connectivity in the DMN during memory consolidation, and (iii) evaluate non-invasive brain stimulation as a therapeutic option to modulate memory consolidation. The DMN is massively disturbed in psychiatric disorders such as Alzheimer's disease, anxiety and affective disorders. SUGARCODING aims at uncovering memory consolidation as a universal function of the DMN that seems to critically orchestrate the human mind and its pathological deviations.
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Project End Date: **30-JUN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771057	**WELL-BEING**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. MEIKE BARTELS**
Host Institution: Stichting Vu, NL

The dynamics underlying Well-being; Understanding the Exposome-Genome interplay

In light of major demographic trends, building and maintaining health and well-being amongst citizens is one of the most important societal challenges European countries face. People who feel well, function better, are less susceptible to mental illness, and thus are better able to retain competitive advantage and expand human capital. People who feel well also facilitate social capital by enjoying stronger and more-lasting relationships. Consequently, maintaining, facilitating, and building well-being (WB) would not only improve individual (health) outcomes, but also reduce economic and health care burdens. To sustainably facilitate and build WB, thorough understanding of its underlying dynamics, especially the interplay between an individual's genetic makeup, epigenetic make-up, and (social) environmental exposure, is crucial.

In this project, I will cross disciplinary boundaries to initiate the urgently needed integration of multiple layers of influence in the study of WB. The key objectives are to (1) identify, quantify, and integrate static and dynamic environmental and social exposures to build the well-being exposome, (2) understand the multi-layer interplay of the genome, the epigenome, and the exposome, and (3) integrate the empirical findings into a novel comprehensive framework of WB. I will employ an interdisciplinary approach, using association, real-life, and network methodology to assess the dynamics underling WB. To apply these state-of-the-art techniques, I will bring together longitudinal twin-family data, molecular genetic data, and big data from satellite positioning (GPS), bluetooth beacons, geographical information systems (GIS), ambulatory assessment, and social network linkage. This project will mark a shift in scientific approach and enables the development of interdisciplinary academic theories and health, social, and economic policies to maintain, facilitate, and build WB to withstand our demanding and rapidly changing world.

Project End Date: **31-MAY-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772953	**LIGHTUP**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. MARCO TAMIETTO**
Host Institution: Universita Degli Studi Di Torino, IT

Turning the cortically blind brain to see: from neural computations to system dynamics generating visual awareness in humans and monkeys

Visual awareness affords flexibility and experiential richness, and its loss following brain damage has devastating effects. However, patients with blindness following cortical damage may retain visual functions, despite visual awareness is lacking (blindsight). But, how can we translate non-conscious visual abilities into conscious ones after damage to the visual cortex? To place our understanding of visual awareness on firm neurobiological and mechanistic bases, I propose to integrate human and monkey neuroscience. Next, I will translate this wisdom into evidence-based clinical intervention. First, LIGHTUP will apply computational neuroimaging methods at the micro-scale level, estimating population receptive fields in humans and monkeys. This will enable analyzing fMRI signal similar to the way tuning properties are studied in neurophysiology, and to clarify how brain areas translate visual properties into responses associated with awareness. Second, LIGHTUP leverages a behavioural paradigm that can dissociate nonconscious visual abilities from awareness in monkeys, thus offering a refined animal model of visual awareness. Applying behavioural-Dynamic Causal Modelling to combine fMRI and behavioral data, LIGHTUP will build up a Bayesian framework that specifies the directionality of information flow in the interactions across distant brain areas, and their causal role in generating visual awareness. In the third part, I will devise a rehabilitation protocol that combines brain stimulation and visual training to promote the (re)emergence of lost visual awareness. LIGHTUP will exploit non-invasive transcranial magnetic stimulation (TMS) in a novel protocol that enables stimulation of complex cortical circuits and selection of the direction of connectivity that is enhanced. This associative stimulation has been proven to induce Hebbian plasticity, and we have piloted its effects in fostering visual awareness in association with visual restoration training.

Project End Date: **31-JUL-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787836	**NEUME**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. SHIHAB SHAMMA**
Host Institution: Ecole Normale Superieure, FR

Neuroplasticity and the Musical Experience

Experiencing music as a listener, performer, or a composer is an active process that engages perceptual and cognitive faculties, endowing the experience with memories, joy, and emotion. Through this active auditory engagement, humans analyze and comprehend complex musical scenes by invoking its cultural norms, segregating sound mixtures, and marshaling expectations and anticipation. These remarkable feats are beyond our understanding and far exceed the capabilities of the most sophisticated music analysis systems. The goal of the proposed research is to investigate how cortical neuroplasticity in humans and animal models facilitates the musical experience over multiple time-scales, to explain how we assimilate musical norms and scales with long-term exposure, and rapidly recruit auditory-motor associations when listening to musical rhythms. The proposed research exploits neuroscience and computational approaches developed and effectively applied by the PI to study the cortical processing of speech. It will harness the power of these ideas and techniques to delineate the role of cognitive functions and adaptive sensory processing in forming musical structure and perception. The project builds upon the internationally recognized leadership of the PI in the fields of auditory cognition, cortical physiology, and computational neuroscience, and his pioneering research into rapid neuroplasticity in the auditory cortex. The project recruits the necessary complementary expertise both to record high-resolution spatiotemporal cortical responses to music in behaving humans, and to frame the proposed experiments in a musical context by garnering insights from music theory, performance, and composition. These diverse approaches will provide new insights into brain function; they will also promote a novel view of musical perception and cognition that will mutually benefit this team and the intellectually vibrant landscape of the neuroscience of music cognition in Paris and Europe

Project End Date: **30-SEP-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788826	**RRTJDM**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. GORDON BROWN**
Host Institution: The University Of Warwick, UK

Relative Rank Theory: A Computational Model of Preferences, Choices, Attitudes and Opinions

People differ in their preferences and attitudes. But how do these preferences and attitudes relate to the choices people make and the opinions they express? People's behaviour is ubiquitously and systematically context-dependent, but cognitive and economic models of choice have failed to provide accounts that satisfactorily reconcile the context-dependence of choice with the existence of stable individual differences. In social psychology, the related person-situation debate remains largely uninformed by current cognitive models. We propose to develop a new and integrative computational model which reconceptualises the relation between preferences, choices, attitudes, and expressed opinions. We suggest that people's choices and expressed opinions cannot be understood in terms of stable underlying preferences and attitudes in the way that conventional models assume. We propose a radically different alternative, which brings insights from social psychology to bear on cognitive models of economic judgement and choice by distinguishing between underlying preferences and expressed preferences. Underlying preferences are stable characteristics of people, but do not inform everyday choices directly because people have no conscious access to the strength of their underlying preferences. Expressed preferences in contrast are learned, context-dependent, and do inform everyday choices directly. Bringing insights from cognitive models to social context effects, we implement a parallel distinction between underlying and expressed attitudes and quantify the concepts of authenticity preference and social extremeness aversion. Using agent-based modelling to link individual-level and network-level effects, we model effects of both choice context and social context within an integrative framework, and aim to account for individual choice as well as social network-level phenomena such as social norm influences, polarisation, and social contagion effects.

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Project End Date: **30-SEP-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
789058	**eHONESTY**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. SALVATORE MARIA AGLIOTI**
Host Institution: Universita Degli Studi Di Roma La Sapienza, IT

Embodied Honesty in Real World and Digital Interactions

Every day, everywhere, people make unethical choices ranging from minor selfish lies to massive frauds, with dramatic individual and societal costs.

Embodied cognition theories posit that even seemingly abstract processes (like grammar) may be biased by the body-related signals used for building and maintaining self-consciousness, the fundamental experience of owning a body (ownership) and being the author of an action (agency), that is at the basis of self-other distinction.

Applying this framework to morality, we hypothesize that strengthening or weakening participants' bodily self-consciousness towards virtual avatars or real others will influence dishonesty in real, virtual, and web-based interactions.

To test this hypothesis, we will measure:

i) individual dishonesty after modifying body ownership (e.g., by changing the appearance of the virtual body) and agency (e.g., by changing the temporal synchrony between participant's and avatar's actions) over an avatar through which decisions are made;

ii) intergroup dishonesty after inducing inter-individual sharing of body self-consciousness (e.g., blur self-other distinction via facial visuo-tactile stimulation);

iii) individual and intergroup dishonesty by manipulating exteroceptive (e.g., the external features of a virtual body) or interoceptive (e.g., changing the degree of synchronicity between participant's and avatar/real person's breathing rhythm) bodily inputs.

Dishonesty will be assessed through novel ecological tasks based on virtual reality and web-based interactions. Behavioural (e.g., subjective reports, kinematics), autonomic (e.g., heartbeat, thermal imaging) and brain (e.g., EEG, TMS, lesion analyses) measures of dishonesty will be recorded in healthy and clinical populations.

Our person-based, embodied approach to dishonesty complements cross-cultural, large-scale, societal investigations and may inspire new strategies for contrasting dishonesty and other unethical behaviours.

Project End Date: **31-OCT-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802553	**ContentMAP**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. JORGE ALMEIDA**
Host Institution: Universidade De Coimbra, PT

Contentotopic mapping: the topographical organization of object knowledge in the brain

Our ability to recognize an object amongst many others is one of the most important features of the human mind. However, object recognition requires tremendous computational effort, as we need to solve a complex and recursive environment with ease and proficiency. This challenging feat is dependent on the implementation of an effective organization of knowledge in the brain. In ContentMAP I will put forth a novel understanding of how object knowledge is organized in the brain, by proposing that this knowledge is topographically laid out in the cortical surface according to object-related dimensions that code for different types of representational content – I will call this contentotopic mapping. To study this fine-grain topography, I will use a combination of fMRI, behavioral, and neuromodulation approaches. I will first obtain patterns of neural and cognitive similarity between objects, and from these extract object-related dimensions using a dimensionality reduction technique. I will then parametrically manipulate these dimensions with an innovative use of a visual field mapping technique, and test how functional selectivity changes across the cortical surface according to an object's score on a target dimension. Moreover, I will test the tuning function of these contentotopic maps. Finally, to mirror the complexity of implementing a high-dimensional manifold onto a 2D cortical sheet, I will aggregate the topographies for the different dimensions into a composite map, and develop an encoding model to predict neural signatures for each object. To sum up, ContentMAP will have a dramatic impact in the cognitive sciences by describing how the stuff of concepts is represented in the brain, and providing a complete description of how fine-grain representations and functional selectivity within high-level complex processes are topographically implemented.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802998	**BRAINMINT**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. LARS T. WESTLYE**
Host Institution: Universitetet I Oslo, NO

Brains and minds in transition: The dark side of neuroplasticity during sensitive life phases

The potential and boundaries of the human mind is determined by dynamic interactions between the environment and the individual genetic architecture. However, despite several breakthroughs, the genetic revolution has not provided a coherent account of the development of the mind and its disorders, and the missing heritability is large across human traits. One explanation of this impasse is the complexity of the gene-environment interactions. Current knowledge about the determinants of a healthy mind is largely based on studies whose modus operandi is to treat the environment as a static entity, neglecting to consider the crucial fact that environmental inputs and their genetic interactions vary dramatically between life phases.

The objective of BRAINMINT is to provide this missing link by zeroing in on two major life transitions, namely adolescence and pregnancy. These phases are characterized by temporarily increased brain plasticity, offering windows for adaptation and growth, but also host the emergence of common mental disorders. I propose that a multi-level investigation with this dark side of brain plasticity as the axis mundi will add a mechanistic understanding of this link between growth and vulnerability. I will test the main hypothesis that mechanisms that boost neuroplasticity promote adaptation to a dynamic environment, but at the cost of increased risk of psychopathology if exposed to a combination of genetic and environmental triggers. To this end I will utilize cutting-edge longitudinal brain imaging, electrophysiology, rich cognitive and clinical data, immune markers, gene expression and genetics. I will leverage on massive imaging data (n>40,000) and novel tools to increase power and generalizability and improve brain- and gene-based predictions of complex traits. Aiming to help resolving one of the modern day enigmas, BRAINMINT is a pioneering and high risk/high gain effort to find mechanisms of brain plasticity that support and harm the brain.

Project End Date: **31-JUL-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803122	**MetAction**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. NATHAN FAIVRE**
Host Institution: Centre National De La Recherche Scientifique, FR

The motor hypothesis for self-monitoring: A new framework to understand and treat metacognitive failures

Humans can monitor their own mental lives and build representations that contain knowledge about themselves. This capacity to introspect and report one's own mental states, or in other words "knowing how much one knows", is termed metacognition. Although metacognition is crucial to behave adequately in a complex environment, metacognitive judgments are often suboptimal. Specifically for neurological and psychiatric diseases, metacognitive failures are highly prevalent, with severe consequences in terms of quality of life. This project proposes a new hypothesis to explain the determining factors of metacognitive failures: namely, that metacognition does not operate in a vacuum but relies on the monitoring of signals from the body, and more specifically, on motor signals involved during action execution. We suggest several experiments to test the motor hypothesis for self-monitoring, and propose a new remediation procedure to resolve metacognitive failures resulting from deficient action monitoring. We will start by assessing the contribution of motor signals to metacognition by identifying the behavioral and neural correlates for detecting self-committed vs. observed errors (WP1), and by using virtual reality and robotics to probe metacognition in a vacuum, operating in the complete absence of voluntary actions (WP2). Finally, we will use these results to develop and evaluate a method to train metacognition in healthy volunteers and individuals with schizophrenia in a bottom-up manner, using online feedback based on motor signals (WP3). This new metacognitive remediation procedure will be performed both in a clinical context and on mobile devices. The goal of this ambitious project is therefore twofold, theoretical in shedding new light on a cognitive process central to our most profound mental states, and clinical in establishing a new remediation method to tackle a major health and societal issue.

Project End Date: **29-FEB-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803684	**TRUST**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. JOHANNES STERN**
Host Institution: University Of Bristol, UK

Truth and Semantics

"Anne believes that Bob assumes that Anne believes that Bob's assumption is false. Does Anne believe that Bob's assumption is false?" Don't try too hard answering the question - any straightforward attempt will lead to paradox.

But what are we to make of sentences such as "Anne believes that Bob's assumption is false." Is the sentence true or false? On the face of it, it would seem that answering this question is a pressing problem for natural language semantics that assigns truth conditions to sentences of natural language. However, semanticists have largely ignored problems of this kind, leaving the field to philosophical logicians working on paradoxes, in particular, the paradoxes of truth such as the Liar paradox. But research on the paradoxes of truth has often focused on exploring the space of possible coherent "solutions" to the paradoxes thereby ignoring desiderata of natural language semantics. The project provides a unified perspective on natural language semantics, conceived of as truth-conditional semantics, and the research on the so-called semantic paradoxes in form of theories of self-applicable truth. A unified approach to truth and semantics will need to answer two principal challenges, which divides the research project into two interrelated parts. The first part, Truth in Semantics, aims at developing semantic accounts for rich fragments of natural language, that is, fragments in which, besides the notion of truth, we allow for, e.g., modal expressions, propositional attitudes but also natural language conditionals. The second part, Truth and the Foundations of Semantics, assumes a metasemantic perspective and explores the role of the notion of truth in the foundations of natural language semantics, conceived of as truth-conditional semantics. The project constitutes the first systematic study of truth and natural language semantics from such a combined perspective.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804388	**wHiSPER**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. ALESSANDRA SCIUTTI**
Host Institution: Fondazione Istituto Italiano Di Tecnologia, IT

investigating Human Shared PErception with Robots

Perception is a complex process, where prior knowledge is incorporated into the current percept to help the brain cope with sensory uncertainty. A crucial question is how this mechanism changes during interaction, when the brain is faced with two conflicting goals: either optimizing individual perception by using internal priors, or maximizing perceptual alignment with the partner, by limiting the reliance on individual priors. wHiSPER proposes to study for the first time how visual perception of space and time is modified during interaction, by moving the investigation to an interactive shared context, where two agents dynamically influence each other. To allow for scrupulous and systematic control during interaction, wHiSPER will use a humanoid robot as a controllable interactive agent. The research will be articulated along five main objectives: i) determine how being involved in an interactive context influences perceptual inference; ii) assess how perceptual priors generalize to the observation of other's actions; iii) understand whether and how individual perception aligns to others' priors; iv) assess how is it possible to enable shared perception with a robot and v) determine whether perceptual inference during interaction is modified with aging, when lowered sensory acuity could increase priors relevance. To these aims wHiSPER will exploit rigorous psychophysical methods, Bayesian modeling and human-robot interaction, by adapting well-established paradigms in the study of visual perception to a novel interactive context. In several experiments the humanoid robot and the participants will be shown simple temporal or spatial perceptual stimuli that they will have to perceive either to reproduce them or to perform a coordinated joint action (as passing an object). The measures of the reproduced intervals and of the kinematics of the actions will allow to quantify through Bayesian modeling how social interaction influences visual perception.

Project End Date: **29-FEB-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
816564	**ActionContraThreat**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. DOMINIK BACH**
Host Institution: University College London, UK

Action selection under threat: the complex control of human defense

Run away, sidestep, duck-and-cover, watch: when under threat, humans immediately choreograph a large repertoire of defensive actions. Understanding action-selection under threat is important for anybody wanting to explain why anxiety disorders imply some of these behaviours in harmless situations. Current concepts of human defensive behaviour are largely derived from rodent research and focus on a small number of broad, cross-species, action tendencies. This is likely to underestimate the complexity of the underlying action-selection mechanisms. This research programme will take decisive steps to understand these psychological mechanisms and elucidate their neural implementation.

To elicit threat-related action in the laboratory, I will use virtual reality computer games with full body motion, and track actions with motion-capture technology. Based on a cognitive-computational framework, I will systematically characterise the space of actions under threat, investigate the psychological mechanisms by which actions are selected in different scenarios, and describe them with computational algorithms that allow quantitative predictions. To independently verify their neural implementation, I will use wearable magnetoencephalography (MEG) in freely moving subjects.

This proposal fills a lacuna between defence system concepts based on rodent research, emotion psychology, and clinical accounts of anxiety disorders. By combining a stringent experimental approach with the formalism of cognitive-computational psychology, it furnishes a unique opportunity to understand the mechanisms of action-selection under threat, and how these are distinct from more general-purpose action-selection systems. Beyond its immediate scope, the proposal has a potential to lead to a better understanding of anxiety disorders, and to pave the way towards improved diagnostics and therapies.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833029	**LEARNATTEND**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. JAN THEEUWES**
Host Institution: Stichting Vu, NL

What to expect when you are not expecting it: How implicit regularities drive attentional selection

Extracting statistical regularities from the environment is one of the most fundamental abilities of any living organism. This type of learning is largely unconscious, unintentional, and implicit; it runs "in the background", both seeking and giving structure to the world around us; making it coherent, predictable and quickly manageable. Even though a lot is known about how statistical learning affects language acquisition, object recognition, motor learning, and decision making, only recently it became apparent that it plays a key role in attentional selection. Visual perception must be selective, as we are confronted with the massive amount of available sensory input. Statistical learning occurring often beneath the level of awareness provides structure to the environment uncovering the relations between objects in space and time.

The proposed research program investigates the mechanisms underlying visual statistical learning (VSL) focusing on how, when and what information is extracted by the visual system. Through brain imaging we seek to understand how learning taking place in the medial temporal lobe (hippocampus), affects attentional representations within putative priority maps across the visual hierarchy. By means of EEG, we seek to connect hippocampal activity to the activations within the spatial priority map which ultimately controls attentional selection. By means of single cell recording in humans we determine at a cell level how statistical learning develops over time. To understand the mechanism, we analyse individual differences in VSL and relate this to visual working memory capacity and attentional selection in psychopathy. The proposed research will have a large impact on the study of cognition, learning, and memory.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833504	**SPANUMBRA**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. GIORGIO VALLORTIGARA**
Host Institution: Universita Degli Studi Di Trento, IT

Number-space associations in the brain

Research in cognitive science has revealed that the temporal, spatial, and numerical features of a stimulus can interact with one another. An example is the tendency to map increasing numerical magnitudes with a left-to-right orientation. Numerical-spatial associations (NSA) are pervasive in human behaviour and have relevance to health (e.g., dyscalculia is thought to be related to improper understanding of the so-called «mental number line»). NSA have been shown to occur in human newborns and in non-human animals for non-symbolic numerousness. SPANUMBRA aims to investigate NSA in different animal models (domestic chicks, mice and zebrafish) and in human neonates and infants to provide a comprehensive and comparative perspective on the developmental, neural and genetic origins of this phenomenon. The project will be guided by a new hypothesis that links the direction of NSA to a differential role of the two sides of the brain to the perceived value (valence) of changes in magnitudes. The role of the experience (WP1) in the development of NSA will be investigated making use of early exposure to light in chicks' embryos to modulate brain asymmetry, and controlled-rearing experiments in which newly-hatched chicks will be exposed to correlated and anti-correlated discrete and continuous magnitudes. Development of NSA will be also studied in human neonates and infants (WP2) before, during, and after the exposure to culture-specific NSA associations (numbers organized in spatially oriented layouts) to investigate the role of culture in shaping/reinforcing NSA. The study of the neural basis of the NSA (WP3) will combine neurobiological techniques (immediate early gene expression in chicks and zebrafish), and non-invasive methods (EEG and fNIRS in human neonates). The genetic bases of NSA (WP4) will be investigated using transgenic lines of zebrafish and mice, in order to understand the role of some genes implicated in the development of lateralization and in dyscalculia.

Project End Date: **31-OCT-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834050	**CrossLingference**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. GERHARD JÄGER**
Host Institution: Eberhard Karls Universitaet Tuebingen, DE

Cross-Linguistic statistical inference using hierarchical Bayesian models

Historical linguistics and linguistic typology share the objective of explaining cross-linguistic variation. Their traditional research agendas have been largely disjoint though since historical linguistics strives for depth and typology for breadth. This tension has been replicated in current statistical and computational renderings of two sub-disciplines. Computational models of language change generally focus on individual language families, while statistical typology pays little attention to diachronic processes. CrossLingference will bridge this gap. Using Bayesian hierarchical models, the reach of modern phylogenetic linguistics will be extended to cross-family models, where each lineage is assumed to follow its own dynamics, but cross-family variation is constrained and data from one family are used to make inference about the processes in other families. At the same time, state-of-the-art generalized linear mixed models will be extended to control both for genealogical history and language contact. These model-based approaches will be complemented by agent-based simulations. CrossLingference will implement this general programme for the following domains of application, securing a lasting impact both on statistical typology and on computational historical linguistics:

- Sound laws in language change, enabling automatic reconstruction of proto-language vocabulary,
- Causal relationships between typological variables.
- Factoring of universal tendencies, historical contingencies and language contact in explaining variation in word-order types and inflectional paradigms.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
835263	**SPRINT**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. AMALIA ARVANITI**
Host Institution: University Of Kent, UK

Speech Prosody in Interaction: The form and function of intonation in human communication

Intonation, the modulation of voice pitch, is essential for communication as it conveys information that helps listeners make inferences about the pragmatic intent of the speaker. Despite increased understanding of intonation's importance, there is little agreement even about essential aspects of its structure and meaning. This is in large part because research has focused either on the form of intonation, often taking a reductive approach to meaning, or has concentrated on meaning but without full scrutiny of form. Crucially, most research has eschewed the study of intonational variability, seeing it as a problem, rather than a natural facet of speech production that needs to be understood and accounted for. Examining all three aspects in tandem is critical for understanding how intonation is structured and functions in communication: considering meaning in the study of intonational form (i.e. phonetics and phonology) can help delimit intonational categories and uncover the limits of within-category variability; in turn, a robust understanding of form will lead to insights into intonational pragmatics. The present proposal will take exactly this integrative approach, based on the PI's recent research, to examine intonational phenomena attested in English and Greek that have vexed researchers for some time (uptalk, high accents, question tunes). Two varieties per language will be studied, Standard Southern British, Bristol English, Standard Athenian, and Corfiot Greek. Their systematic differences with respect to the phenomena under investigation will allow me to examine cross-linguistic differences, and dialectal variation and its role in communication. The investigation will involve phonetic and pragmatic analysis and modelling, followed by series of behavioural and neurophysiological experiments. Together, these methods will shed light onto the realization, structure and function of intonation, and lead to a robust model of intonational phonology and pragmatics.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
848532	**OUTOFPAPUA**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. ANTOINETTE SCHAPPER**
Host Institution: Stichting Vu, NL

Papuans on the move. The linguistic prehistory of the West Papuan languages.

This project combines urgent documentation of endangered languages in Indonesia with rigorous investiga-tion of a linguistic puzzle that has important implications for our understanding of both Melanesian and Southeast Asian prehistory. Some two dozen Papuan languages, scattered over a 1000km on and around the Bird's Head of West Papua, show signs of sharing a common origin. The OUTOFPAPUA project uses cut-ting-edge methods in historical linguistics to test the hypothesis that these languages belong to a single West Papuan language family, and to investigate the possibility that their distribution reflects a migration of Papuan people, in relatively late prehistoric times, from the New Guinea mainland outward and westward into the Indonesian archipelago. The project will also address the question of what drove this putative expansion, in particular the possibility that it had to do with indigenous agricultural innovations. Thus, it contributes both to the difficult enterprise of uncovering genealogical relationships among the diverse languages of New Guinea, and to a growing body of research that questions the orthodox linguistic understanding of eastern Indonesia's prehistory in terms of an eastward expansion of Austronesian speakers at the expense of less dynamic Papuan populations. At a methodological level, the project furthers the development of techniques for establishing remote historical linguistic relationships in the absence of written records of relevant languages. The project will make innovative comparisons using a suite of techniques, including the application of new computational methods, the construction of a lexical database of unparalleled richness in Papuan linguistics, and by giving a prominent role to semantic shifts, paleolinguistics, and morphology and paradigms in the reconstructive project. This research aims at achieving a breakthrough in the study of human prehistory in one of world’s oldest areas of human settlement.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850404	**COGNITIVE THREADS**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. DIEGO VIDAURRE**
Host Institution: Aarhus Universitet, DK

Separating parallel threads of cognition to better explain behaviour

Our understanding of the neural basis of human cognition and its relation to behaviour is limited by the extent to which we can observe its underlying components. Neural activity elicited by a given stimulus can be decomposed in parallel threads of cognitive computation, each specialising on a different aspect of the stimulus. Conventional methods are fundamentally limited to tease apart these components within the stimulus-specific brain activity, therefore obscuring our understanding of the underlying mechanisms. I will build a framework to distil these threads by modelling their (trial-by-trial) distinct spatiotemporal trajectories and the interaction between them. Furthermore, I propose that the way our brains process stimuli, and in particular how these different components organise and relate to each other, can be critical to characterise subjects at the psychological and clinical level. However, it is unclear how to relate these complex models of stimulus processing to the subject phenotypes. I will develop principled algorithms to automatically discover which specific aspects of the modelled brain activity are most relevant to the traits under study. In summary, this multidisciplinary project brings together modelling and prediction across different data modalities to offer a novel temporal analytic account of how different threads of brain activity give rise to cognition, and how the nature of these elements relates to population variability.

I will tackle three important questions that are representative of the addressed methodological challenges: in the study of decision-making, the relation between value representation, decision-formation and attention; in sleep research, which specific aspects of the sleep cycle are most altered in insomniacs; in the field of pain perception, the disambiguation of nociception and salience, and how these diverge in chronic pain. Despite diverse, these questions are conceptually linked by ideas presented here.

Project End Date: **31-OCT-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850636	**MEMTICIPATION**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. FREEK VAN EDE**
Host Institution: Stichting Vu, NL

Preparing memories for action: how visual working memories are sculpted by their anticipated use

Visual working memory allows us to hold in the fore of our mind those visual representations that are anticipated to become most relevant for ensuing behaviour – guiding our perception as well as action. Thus, while working memories inherently regard the past, their purpose is to guide adaptive behaviour in the near future. Yet, conventional studies of visual working memory consider memory retention (how we remember) regardless of anticipated memory use (what we remember for), and neglect that representations that are held in memory concurrently often serve distinct purposes and afford specific actions.

I posit that the accessibility and neural recruitment of individual working memories are fundamentally determined, and dynamically sculpted, by their anticipated use – i.e. by our expectations of when we need individual memory items, and what we need them for. This opens the fundamental, yet largely overlooked, question of how visual working memories are 'prepared for action'.

To target this central question, this project will pioneer multiple innovative memory tasks and combine these with cutting-edge brain imaging approaches to dynamically track how working memories are optimised to be ready for the right action (theme 1), ready at the right time (theme 2), and ready for the right task (theme 3). Having made considerable progress, this project will then also asses the identified 'forward thinking' memory dynamics as a key novel dimension to charter relevant individual and group differences in working memory (theme 4).

Together, this is anticipated to uncover ground-breaking novel insights into the pro-active mechanisms that ensure adaptive memory-guided behaviour – and to change not only the way we view visual working memory, but also how we study and use this core cognitive construct.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850975	**TINTIN**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. NEIL COHN**
Host Institution: Stichting Katholieke Universiteit Brabant, NL

Visual narratives as a window into language and cognition

Drawn sequences of images are a fundamental aspect of human communication, appearing from instruction manuals and educational material to comics. Despite this, only recently have scholars begun to examine these visual narratives, making this an untapped resource to study the cognition of sequential meaning-making. The emerging field analysing this work has implicated similarities between sequential images and language, which raises the question: Just how similar is the structure and processing of visual narratives and language? I propose to explore this query by drawing on interdisciplinary methods from the psychological and linguistic sciences. First, in order to examine the structural properties of visual narratives, we need a large-scale corpus of the type that has benefited language research. Yet, no such databases exist for visual narrative systems. I will thus create innovative visual annotation tools to build a corpus of 1,500 annotated comics from around the world (Stage 1). With such a corpus, I will then ask, do visual narratives differ in their properties around the world, and does such variance influence their comprehension (Stage 2)? Next, we might ask why such variation appears, particularly: might differences between visual narratives be motivated by patterns in spoken languages, thereby implicating cognitive processes across modalities (Stage 3)? Thus, this proposal aims to investigate the domain-specific (Stage 2) and domain-general (Stage 3) properties of visual narratives, particularly in relation to language, by analysing both production (corpus analyses) and comprehension (experimentation). This research will be ground-breaking by challenging our knowledge about the relations between drawing, sequential images, and language. The goal is not simply to create tools to explore a limited set of questions, but to provide resources to jumpstart a budding research field for visual and multimodal communication in the linguistic and cognitive sciences.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851423	**STARFISH**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. GEORGE WALKDEN**
Host Institution: Universitat Konstanz, DE

Sociolinguistic typology and responsive features in syntactic history

The aim of this project is to develop and test a new theory of variation and change in syntactic complexity, building on Trudgill's (2011) theory of sociolinguistic typology and on the general architectural assumptions of Minimalist syntax. Trudgill (2011) makes the case that the distribution of simplicity and complexity across the world's languages is related to the historical circumstances involved, with intense short-term contact involving extensive adult second language acquisition leading to simplification. This project will establish which syntactic features are "responsive" - that is, are susceptible to change under such circumstances. In the process, the project will bring together theories of second-language acquisition, syntax, computational modelling, and historical corpus linguistics to submit Trudgill's sociolinguistic-typological hypothesis to its most rigorous empirical test to date, in the domain of syntactic change. Crucial questions, such as the proportion of L2 acquirers and population structure necessary for simplification, will be teased out and addressed using computational modelling. We will look for responsive features in the domains of negation, Case, and subject expression, using the new generation of parsed historical corpora containing dated and localized texts at a high temporal and geographical resolution (e.g. the Corpus of Historical Low German currently in development), and put our theory and model to the test in these domains. The impact of the project will be to establish a new synthesis of historical sociolinguistics and syntactic theory that makes developments in each accountable to the other.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851613	**EXTREME**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. RIK PEELS**
Host Institution: Stichting Vu, NL

The Epistemology and Ethics of Fundamentalism

Fundamentalism harms our societies. It consists of a complex set of actions, sentiments, and attitudes that have all sorts of detrimental effects regarding, for example, the education of fundamentalist minorities, the perception of public safety, and the general image of religions.

Scholars in fundamentalism studies have developed various models to better understand fundamentalism, such as the Radicalization Model. Increasingly, though, they are dissatisfied with these models, since they are often unable to explain why some individuals turn to fundamentalism while others do not. This project will provide a new normative-theoretical framework that is needed to better understand and assess one of the main reasons for fundamentalist behaviour: fundamentalist beliefs. In order to do this, I combine influential methods in analytic philosophy, like conceptual analysis and reflective equilibrium, with literature reviews of empirical and historical research and normative-theoretical analysis of case studies.

The epistemology and ethics of fundamentalism that I develop addresses five questions. First, what makes extreme beliefs fundamentalist beliefs, and how do they relate to other cognitively detrimental phenomena? Second, how does the social environment affect the rationality of fundamentalist beliefs? Third, what obligations regarding their beliefs do fundamentalists violate? Fourth, which circumstances, like indoctrination, excuse people for violating such obligations? Fifth, how does this epistemology and ethics of fundamentalist belief help to better understand and assess fundamentalism?

This project breaks new ground in epistemology and ethics by exploring responsibility for extreme beliefs and fundamentalist beliefs in particular. It is also beneficial to the academics fields involved in fundamentalism studies, because those fields are largely based on historical and empirical work rather than conceptual and ethical analysis.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851990	**LINGUINDIC**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. JOHN LOWE**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Linguistics from India: new ideas for modern linguistics from ancient India

This project aims to synthesize expertise and insights from the fields of ancient Indian and modern Western linguistics, to enable deeper understanding and innovation in linguistic theory.

An extensive and highly sophisticated linguistic tradition flourished in ancient India between c. 500 BC and 1700 AD. Panini's grammar the Astadhyayi is often recognized by generative linguists as the earliest generative grammar ever developed, more than 2000 years before Chomsky. Yet beyond this recognition, modern Western linguistics has very little knowledge of the millennia of linguistic insights and analyses developed in India. In the context of the academic enterprise - building on the achievements of our predecessors to advance human knowledge and understanding - this ignorance is a hindrance to the progress of linguistic science. The aims of this project are:

1. To systematically explore and analyse the neglected riches of ancient Indian linguistic thought;
2. To uncover lost linguistic insights and analyses;
3. To build on these insights to create innovative approaches to contemporary issues in modern Western linguistics.

The project will focus on ancient Indian contributions to linguistic thought in three broad areas: morphosyntax and formal language systems, semantics/pragmatics and the philosophy of language, and phonetics/phonology. In all three fields ancient Indian analyses provide new perspectives which challenge standard assumptions of modern Western linguistics.

This project will bring together expertise in modern linguistics and the ancient Indian linguistic tradition, enabling innovative interactions between traditions. This project is challenging, but the potential rewards for modern linguistics are significant. This project aims to be paradigm changing, redefining modern linguistics as a field which can and does draw and build on three thousand years of academic insights, rather than drawing merely on two hundred years of linguistic work in the West.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852352	**ELISA**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. CONNIE DE VOS**
Host Institution: Stichting Katholieke Universiteit Brabant, NL

The Emergence of Language in Social Interaction

During spontaneous sign language genesis, signers naturally come to integrate gestural material into their grammars. Researchers have been able to track this process in two famous cases: Nicaragua and Israel's Negev desert. This project addresses a third case: Kata Kolok (KK) arose six generations ago due to high incidences of deafness in a Balinese village. ELISA determines what the earliest stages of this language looked like and what mechanism have shaped its emergence.

Theories of sign language emergence have been based on comparisons of emergent signing varieties from geographically distinct areas and thus potentially very different gesture cultures. ELISA focuses on signing varieties within the context of Bali to enable direct comparison between the various stages of language emergence. Three potentially-interacting hypotheses are considered: gestural origins (the contribution of the spontaneous gestures used by speakers), time-depth (intergenerational transmission), and social interaction (community structure & quality of conversations).

This is achieved by

i) reconstructing the setting in which KK emerged by investigating the social interactions of homesigners and intergenerational homesign systems within the wider region;

(ii) documenting the communicative structures of these homesigners as they interact with their hearing communication partners, and by comparing these systematically to generations III-V of KK;

(iii) growing sign languages in the lab by asking hearing Balinese participants to describe events using silent gesture under various experimental conditions to test each of the hypotheses.

Through this comparative approach, ELISA brings together the fields of sign language emergence and cultural evolution and is effectively able to chart the birth and development of a modern human language over the course of a century. Given her empirical expertise in KK and rural sign languages, the PI is uniquely positioned to bring this project to fruition.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852570	**CoCoFlex**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. SENNE BRAEM**
Host Institution: Universiteit Gent, BE

What makes us cognitively flexible? A new learning perspective

Much of human behavior is characterized by the extraordinary ability to quickly reconfigure our mind, and switch between different tasks, often referred to as cognitive flexibility. While most psychologists agree on the kind of behaviors that fall under the term cognitive flexibility, we have only a poor understanding on what drives cognitive flexibility. When defining cognitive flexibility, its putative underlying processes are often distinguished from other functions of the brain by opposing them to low-level learning. In contrast, this project starts from the idea that cognitive flexibility is grounded in reinforcement learning and associative learning, and thus sensitive to the same rules that low-level learned behavior is subject to. Therefore, the first two aims of this project will be to demonstrate that the processes behind cognitive flexibility can be conditioned by reward and controlled by the context. This approach breaks with a traditional view on cognitive flexibility as originating from a vague, independent supervisory system. Instead, it allows us to get a grip on cognitive flexibility, and study its neural mechanisms more closely. To this end, a third aim will be to test the counterintuitive hypothesis that increased neural variability (or "noise") in control regions of the brain is what allows for cognitive flexibility. Finally, I will apply this fundamentally different way of understanding cognitive flexibility to the clinical domain. Autism spectrum disorder (ASD) has been linked to deficits in cognitive flexibility, but studies have shown mixed results. Accordingly, a fourth aim will be to further the understanding of the assumed deficits in cognitive flexibility related to ASD. Overall, this project intends to change the current way of thinking about cognitive flexibility, and cognitive control more generally, and to cause a paradigmatic shift in how we go about assessing its neural mechanisms and deficits in clinical conditions like ASD.

Project End Date: **30-APR-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852885	**INDIVISUAL**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. BENJAMIN DE HAAS**
Host Institution: Justus-Liebig-Universitaet Giessen, DE

Individual differences in human gaze behaviour and the visual system

Does visual perception vary between people? This question has fascinated philosophers for millennia, but largely evaded empirical vision science. Recent findings show that eye-movements towards complex, everyday scenes are drawn to important objects, like faces, but the attentional 'pull' of different objects reliably varies between people. We do not yet understand the causes and perceptual consequences of these individual salience biases. Understanding their basis in the individual brain has the potential to reveal general mechanisms of attentional selection. Uncovering their distribution in the general population is key to evaluate their potential as a biomarker.

We propose three sets of experiments to achieve these goals. First, we will use psychophysics, virtual reality and mobile eye tracking to probe which visual features are driving individual salience biases and how they affect task-driven and real-world behaviour. Second, we aim to understand the neural mechanisms of attentional selection. It is unclear how the brain selects peripheral targets based on semantic attributes, which are thought to be processed by foveal pathways. We will exploit individual differences and the latest developments in brain imaging to juxtapose competing hypotheses and test the relation of salience biases to fine-scale functional neuroanatomy and connectivity. Third, we will evaluate the diagnostic potential of salience biases. We will record the gaze of thousands of individuals in a public setting to establish a norm sample of free viewing in the general population and compare observers with autism spectrum disorder and schizophrenia to this norm.

This project will establish how and why natural gaze behaviour and perception vary between people. It will harness individual differences to uncover the general mechanisms that guide our eyes through the visual world. A norm sample of salience biases will lay the foundation to evaluate their use in clinical and applied settings.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
863732	**HOMEOSTASIS**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. STEFAN VAN DER STIGCHEL**
Host Institution: Universiteit Utrecht, NL

The mental economy: testing a dynamic trade-off between internal storage and external sampling

While interacting with the external world, the brain can only represent very little of this world in working memory (WM). WM is therefore generally referred to as a limited-capacity system. This limitation is not a problem in daily life, however, because the external world typically remains available and can be accessed relatively easily. The current dominant theory of WM does not explain how the brain balances between internal storage and external sampling, as this theory exclusively relates to situations in which the remembered information is no longer physically present. The HOMEOSTASIS project is motivated by the idea that WM should be studied in interaction with the world that is still within view.

HOMEOSTASIS will develop a new theoretical model of WM based on an internal mental economy: I propose that WM maintains a perceptual homeostasis by dynamically trading the costs of accurate internal storage against external sampling of the external visual world. Whereas current research on WM has a strong focus on its maximum capacity, this capacity may hardly be used as observers prefer to minimize internal storage due to the effortful nature of WM storage.

I will rigorously test the model's theoretical basis using novel experimental paradigms in which WM is studied in interaction with the physically present environment. To decode the current content of WM, I will adopt state-of-the-art electroencephalographic decoding techniques. To study WM in interaction with worlds of varying reliability and familiarity, I will employ virtual reality technology. Finally, I will investigate patients with restricted deficits to specific components of the model and use machine learning techniques to discover biometric signatures in eye movements.

This new model of WM will open a new window to diagnose WM disorders and for understanding how we interact with computer-manipulated virtual environments in an increasingly computer-dominated world.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865003	**DyNeRfusion**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. MARIOS PHILIASTIDES**
Host Institution: University Of Glasgow, UK

Dynamic Network Reconstruction of Human Perceptual and Reward Learning via Multimodal Data Fusion

Training and experience can lead to long-lasting improvements in our ability to make decisions based on either ambiguous sensory or probabilistic information (e.g. learning to diagnose a noisy x-ray image or betting on the stock market). These two processes are referred to as perceptual and probabilistic/reward learning, respectively. Despite considerable efforts to uncover the neural systems involved in these processes, perceptual and reward learning have largely been studied in separate lines of research using divergent learning mechanisms. The primary aim of this proposal is to develop a unified framework for integrating these lines of research and understand the extent to which they share a common computational and neurobiological basis. Specifically, we will test the proposition that both the perceptual and reward systems could be understood in a common framework of “reward maximization”, whereby a domain-general reinforcement-guided learning mechanism – based on separate prediction error representations – facilitates future actions and adaptive behavior. To offer a comprehensive spatiotemporal characterization of the relevant networks and their computational principles we will adopt a state-of-the-art multimodal neuroimaging approach to fuse simultaneously-acquired EEG and fMRI data, via machine-learning-inspired multivariate single-trial analysis techniques and computational modelling. The project’s ultimate goal is to empower a level of neuronal and mechanistic understanding that extends beyond what could be inferred with each of these modalities in isolation. We will achieve this goal by exploiting endogenous trial-by-trial electrophysiological variability to build parametric fMRI predictors that can offer additional explanatory power than what can already be achieved by stimulus- or behaviorally-derived predictors, allowing us to go over and beyond what has been reported previously in the literature.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865077	**MitO2Health**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. IRIS-TATJANA KOLASSA**
Host Institution: Universitaet Ulm, DE

Major depression as a metabolic disorder: The role of oxygen homeostasis and mitochondrial bioenergetics in depression etiology and therapy

MitO2Health aims to develop and empirically prove a radically new pathophysiological model of Major Depressive Disorder (MDD) as a systemic energy deficiency disease. Traditionally, MDD is conceptualized as a neurotransmitter deficiency in the brain. However, with pioneering methods my group has provided evi-dence for reduced mitochondrial energy production in MDD, characterizing it as a cellular-metabolic disorder with a lowered production of adenosine triphosphate (ATP). Reduced mitochondrial bioenergy production and impairments in oxygen (O2) homeostasis (reduced levels of erythrocytes, less hemoglobin and its lower O2-binding affinity due to oxidative stress), as well as oxidative stress and inflammation (the “MitO2Health parameters”) were consistently associated with an increased risk for MDD, but have been neglected so far in MDD research and therapy. In MitO2Health we will more comprehensively than ever before investigate the physiological mechanisms underlying MDD and will provide first longitudinal evidence on the mutual in-terplay between the MitO2Health parameters and MDD. Moreover, we will apply cognitive-behavioral therapy (CBT) as randomized treatment condition to test whether CBT-related MDD symptom reduction is coupled to a normalization of the MitO2Health parameters. We will treat 100 MDD patients with 6 months of CBT and compare them to 100 MDD patients of a waiting-list group and 100 healthy controls. Clinical and biological status will be assessed at four points over 18 months. We will thus characterize the biomarker pro-files of MDD treatment response and resistance as well as MDD symptom recurrence during a follow-up pe-riod. MitO2Health will not only establish a modern etiological model of MDD, but also identify biomarkers of individual therapy response and relapse. This will lead to new diagnostic standards and inspire personalized MDD treatment concepts that will fundamentally improve clinical outcomes in psychotherapy and psychiatry.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865568	**GutBrainGABA**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. BHISMADEV CHAKRABARTI**
Host Institution: The University Of Reading, UK

Mapping the impact of gut microbiota on brain and behaviour through the lens of GABA

Human beings are over 99% genetically identical. It seems striking therefore, that 1% of this genetic difference accounts for the large extent of individual variations seen in human behaviour and brain function. One promising alternative source of individual differences is the resident bacteria in the gastrointestinal tract, which is 40-90% distinct between different individuals. Bacteria in the human gut outnumber human cells, and account for nearly 10 times as much DNA as that from human cells. Some gut bacteria have been shown to produce Gamma Amino Butyric Acid (GABA) and serotonin (5-HT), molecules that function as neurotransmitters in the human brain. However, it is not known whether their production in the gut has any impact on behavioural and brain function. This project takes a biochemically informed approach to address this gap in knowledge through focussing on GABA, whose function as a neurotransmitter is well characterised, and which can be assayed directly or through proxy measures of brain and behaviour. The first work package of this project in human adults will investigate whether the population of gut bacteria capable of producing GABA can modulate brain levels of GABA (measured directly using Magnetic Resonance Spectroscopy), as well as performance in tasks that depend on GABA-ergic activity. The second work package will test the impact of ingesting bacteria known to produce GABA (packaged as a custom-made probiotic) over a period of four weeks, on the same brain and behavioural measures. Together, these studies will answer a fundamental question of whether the population of gut bacteria capable of producing GABA, as well as its modulation by probiotics, has any impact on the level GABA in the brain and its function. This interdisciplinary proposal brings together approaches from psychology, neuroscience, and gut microbiology to chart a new research frontier in understanding individual differences in human behaviour and brain function.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865715	**VIS-A-VIS**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. MARTIN ROLFS**
Host Institution: Humboldt-Universitaet Zu Berlin, DE

How visual action shapes active vision

A key component of visual perception is our ability to move: In a flick of the eye, we see the time on the watch, and we quickly turn around if we hear our name in the crowd. Whereas other movements aim to change the state of the world, visual actions shift our eyes, heads, and bodies to align the retina with currently relevant parts of the world. Although they vitally extend the scope of high-acuity vision, their immediate sensory consequences have challenged scientists for centuries: How do we not experience the brisk motion of the entire scene on the retina every time the eyes move (perceptual omission)? How does the brain keep track of objects' changing retinal locations across consecutive glances (object continuity). And how do we routinely attribute retinal motion to our own movements rather than to motion in the world (sense of agency). To explain these phenomena, research and theories across disciplines have focused on how the brain—using its knowledge about ongoing movement plans—predicts and compensates for undesirable side effects of visual actions. I pursue a radically new perspective based on a key insight: Visual actions follow distinct kinematic rules, and as every visual action translates directly into a movement of the world on the retinal image, these rules also directly govern the sensory input. Their sensory consequences can thus be distinguished from motion in the world based on the rules they follow. In embracing this idea, I challenge the long-standing idea that visual actions are a nuisance to sensory processing and propose instead that they support core functions in active vision. In an interdisciplinary team, we will leverage innovative technology, state-of-the-art psychophysical tools and robust experimental protocols to find out if and how the active visual system learns and exploits the lawful relation between visual actions and their sensory consequences, to establish perceptual omission, object continuity, and the sense of agency.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
884116	**Color3.0**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. KARL GEGENFURTNER**
Host Institution: Justus-Liebig-Universitaet Giessen, DE

An object-oriented approach to color

There have been tremendous advances in color science. The absorption of photons by three types of photoreceptors is known at the molecular genetic level. Human cone fundamentals are tabled to several decimal places and color opponency is understood at the neural and computational level. Yet, all this knowledge is based on extremely restrictive assumptions with a colored light in the dark (Color 1.0) or flat, matte surfaces in a uniformly colored context (Color 2.0). But which mechanisms mediate perception of colors in the real world– when looking at a field of flowers or searching for a certain product in the supermarket?

Arguably, the most important function of color is the processing of information about objects in scenes. It is the tight link to objects through which color helps us see things quicker and remember them better. This proposal, Color 3.0, is based on an active observer dealing with three-dimensional objects in natural environments. It deals with the dimensions relevant for the main purpose of color perception – intensity, hue and saturation. The goal is to fundamentally rethink color science around real world objects and natural tasks.

We will gain a deep understanding of the circuitry underlying color perception in real and virtual worlds, a Deep Neural Network model of color processing that can be traced through the brain, a new colorimetry based on natural object colors rather than flat, matte patches of light, and last but not least a better measure for luminous intensity that can deal with objects of different color. This could lead to a revision of how we study the early visual system, better color reproduction and better lighting systems. Our use of real-time raytracing in VR could cause a paradigm shift in vision science, away from a passively viewing observer pushing buttons, towards an active observer situated in a virtual world and performing a natural task.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681880	**ARTIVISM**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. MONIKA SALZBRUNN**
Host Institution: Universite De Lausanne, CH

Art and Activism : Creativity and Performance as Subversive Forms of Political Expression in Super-Diverse Cities

ARTIVISM aims at exploring new artistic forms of political expression under difficult, precarious and/or oppressive conditions. It asks how social actors create belonging and multiple forms of resistance when they use art in activism or activism in art. What kind of alliances do these two forms of social practices generate in super-diverse places, in times of crisis and in precarious situations? Thus, ARTIVISM seeks to understand how social actors engage artistically in order to bring about social, economic and political change. Going beyond former research in urban and migration studies, and beyond the anthropology of art, ARTIVISM focuses on a broad range of artistic tools, styles and means of expression, namely festive events and parades, cartoons and comics and street art. By articulating performance studies, street anthropology and the sociology of celebration with migration and diversity studies, the project challenges former concepts, which took stable social groups for granted and reified them with ethnic lenses. The applied methodology considerably renews the field by bringing together event-, actor- and condition-centred approaches and a multi-sensory framework. Besides its multidisciplinary design, the ground-breaking nature of ARTIVISM lies in the application of the core concepts of performativity and liminality, as well as in an examination of the way to advance and refine these concepts and to create new analytical tools to respond to recent social phenomena. We have developed and tested innovative methods that respond to a postmodern type of fluid and temporary social action: audio-visual ethnography, urban event ethnography, street ethnography, field-crossing, and sensory ethnography (apprenticeship). Therefore, ARTIVISM develops new methods and theories in order to introduce a multi-faceted trans-disciplinary approach to the study of an emerging field of social transformations that is of challenging significance to the social sciences.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714166	**NARMESH**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. MARCO CARACCIOLO**
Host Institution: Universiteit Gent, BE

Narrating the Mesh: Ecology and the Non-Human in Contemporary Fiction and Oral Storytelling

Today's ecological crisis prompts us to rethink our attitude towards physical and natural realities that have traditionally been seen as opposed to human subjectivity and agency. What emerges from this "non-human turn" is a sense of our interdependence on things like the bacteria in our intestines or the carbon atoms supporting life on Earth. Ecological theorist Timothy Morton uses the metaphor of the "mesh" to express this idea of human/non-human interconnectedness. This project will map the formal and thematic strategies through which contemporary narrative practices engage with the non-human and envisage this interconnectedness.

Storytelling is an indispensable tool for making sense of experience by establishing temporal and causal relations. But it is also biased towards the human-scale realities of action and social interaction. How can narrative overcome this bias? How does it convey phenomena that challenge our belief in the ontological and material self-sufficiency of the human?

Comparing fictional narratives in print (novels and short stories) and conversational storytelling, we will systematically explore the ways in which narrative can forge connections across levels of reality, weaving together the human and the non-human into a single plot. The assumption is that narrative is a field where fictional practices are in constant dialogue with the stories told in everyday conversation—and with the culture-wide beliefs and concerns those stories reflect.

Through its three sub-projects, the proposed research charts this complex dialogue while greatly advancing our understanding of how stories can be used to heighten people's awareness of the mesh and its significance. The project builds on a combination of methods (close readings of novels, qualitative analysis of interviews), aiming to open up a new field of study at the intersection of literary scholarship and the social sciences—with narrative theory serving as a catalyst for the interdisciplinary exchange.

Project End Date: **31-JAN-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714874	**DiGe**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. RENATA SÕUKAND**
Host Institution: Universita Ca' Foscari Venezia, IT

Ethnobotany of divided generations in the context of centralization

Understanding the logics of obtaining, managing and perceiving of local natural resources, particularly plants, is crucial for ensuring sustainability of human life, as the use of plants is a key for survival of humans. The proposed research will create an advanced understanding of the mechanisms of changes in ethnobotanical knowledge experienced by traditional societies/minor ethnic groups when authoritative regime, led by dominating group, try to unify and/or erode this practical knowledge. It will also evaluate the effects of the sudden cease to existence of such regime and centralization and following impact of the trial of revival of discontinued traditional etnobotanical knowledge. Research will evaluate the effect of several social, cultural and political factors on the evolution of ethnobotanical knowledge of four compact, but divided ethnic minorities that had experienced for shorter (25 years) or longer (70 years) period different influences affecting their plant use and very different social (including welfare and economy), and political conditions. As a long-term outcome, based on the result of present and consequent studies scientists will be able to predict the extent and depth of the changes occurring in the ethnobotanical knowledge and as a applied outcome learn to direct and educate people in the way that the knowledge necessary for sustainable maintenance and utilization of local plant resources will be constantly evolving in the way supporting health and well-being of different populations.

Project End Date: **31-JUL-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715146	**ENERGY ETHICS**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. METTE HIGH**
Host Institution: The University Court Of The University Of St Andrews, UK

The Ethics of Oil: Finance Moralities and Environmental Politics in the Global Oil Economy

In October 2014, the Chairman of the Bank of England Mark Carney warned that many oil reserves cannot be developed. If so, they would contribute so significantly to increased greenhouse gas emissions that international targets to avoid dangerous levels of global warming would be exceeded. However, stock valuations of oil companies assume that all proven and probable reserves can indeed be produced. Amounting to a potentially enormous debt overhang, the Bank of England has launched an enquiry into the threat of a crisis similar to the subprime mortgage crash, known as the 'carbon bubble'. This looming crisis with its 'stranded assets' raises urgent questions about the conflicting dynamics between finance moralities and environmental politics at a time of oil dependency and an uncertain climate future. Grounded in ethnographic fieldwork with oil companies in the US and Norway, energy analysts in the UK and the US, and fossil fuel divestment movements in Germany and the UK, ENERGY ETHICS will develop a new framework for understanding the relationship between oil, money and climate change that counters the prevalent tendency to interpret these issues through aggregated normative systemic analysis only. Taking its starting point in people's own perceptions of and direct involvement in the oil economy, it will offer a major step forward in understanding how people in positions of influence within the oil economy make financial and ethical valuations of oil. This will contribute to public stakeholder dialogue and wider transdisciplinary engagements. Focusing on oil and its financialization, ENERGY ETHICS has three main research objectives: 1) to examine how people positioned strategically in relation to the global production of oil conceptualise and influence the oil market; 2) to understand the linkages and frictions between these different valuations of oil; and 3) to investigate how oil valuations relate to political reforms and new climate economic initiatives.

Project End Date: **30-JUN-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724317	**ARCTIC CULT**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. RICHARD POWELL**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

ARCTIC CULTURES: SITES OF COLLECTION IN THE FORMATION OF THE EUROPEAN AND AMERICAN NORTHLANDS

The Arctic has risen to global attention in recent years, as it has been reconfigured through debates about global environmental change, resource extraction and disputes over sovereign rights. Within these discourses, little attention has been paid to the cultures of the Arctic. Indeed, it often seems as if the Circumpolar Arctic in global public understanding remains framed as a 'natural region' - that is, a place where the environment dominates the creation of culture. This framing has consequences for the region, because through this the Arctic becomes constructed as a space where people are absent. This proposal aims to discover how and why this might be so.

The proposal argues that this construction of the Arctic emerged from the exploration of the region by Europeans and North Americans and their contacts with indigenous people from the middle of the eighteenth century. Particular texts, cartographic representations and objects were collected and returned to sites like London, Copenhagen, Berlin and Philadelphia. The construction of the Arctic thereby became entwined within the growth of colonial museum cultures and, indeed, western modernity. This project aims to delineate the networks and collecting cultures involved in this creation of Arctic Cultures. It will bring repositories in colonial metropoles into dialogue with sites of collection in the Arctic by tracing the contexts of discovery and memorialisation. In doing so, it aspires to a new understanding of the consequences of certain forms of colonial representation for debates about the Circumpolar Arctic today.

The project involves research by the Principal Investigator and four Post Doctoral Researchers at museums, archives, libraries and repositories across Europe and North America, as well as in Greenland and the Canadian Arctic. A Project Assistant based in Oxford will help facilitate the completion of the research.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724914	**AlchemEast**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. MATTEO MARTELLI**
Host Institution: Alma Mater Studiorum - Universita Di Bologna, IT

Alchemy in the Making: From ancient Babylonia via Graeco-Roman Egypt into the Byzantine, Syriac and Arabic traditions (1500 BCE - 1000 AD)

The AlchemEast project is devoted to the study of alchemical theory and practice as it appeared and developed in distinct, albeit contiguous (both chronologically and geographically) areas: Graeco-Roman Egypt, Byzantium, and the Near East, from Ancient Babylonian times to the early Islamic Period. This project combines innovative textual investigations with experimental replications of ancient alchemical procedures. It uses sets of historically and philologically informed laboratory replications in order to reconstruct the actual practice of ancient alchemists, and it studies the texts and literary forms in which this practice was conceptualized and transmitted. It proposes new models for textual criticism in order to capture the fluidity of the transmission of ancient alchemical writings. AlchemEast is designed to carry out a comparative investigation of cuneiform tablets as well as a vast corpus of Greek, Syriac and Arabic writings. It will overcome the old, pejorative paradigm that dismissed ancient alchemy as a "pseudo-science", by proposing a new theoretical framework for comprehending the entirety of ancient alchemical practices and theories. Alongside established forms of scholarly output, such as critical editions of key texts, AlchemEast will provide an integrative, longue durée perspective on the many different phases of ancient alchemy. It will thus offer a radically new vision of this discipline as a dynamic and diversified art that developed across different technical and scholastic traditions. This new representation will allow us to connect ancient alchemy with medieval and early modern alchemy and thus fully reintegrate ancient alchemy in the history of pre-modern alchemy as well as in the history of ancient science more broadly.

Project End Date: **30-NOV-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
726371	**PAIXUE**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. NIELS GAUL**
Host Institution: The University Of Edinburgh, UK

Classicising learning in medieval imperial systems: Cross-cultural approaches to Byzantine paideia and Tang/Song xue

In the medieval Eurasian geopolitical space, Byzantium and China stand out as two centralised imperial orders that drew on seemingly unbroken, in fact purposely constructed, traditions of classicising learning. PAIXUE examines in tandem, with equal focus on structural parallels and divergences, the conscious revival and subsequent dialectics of classicising learning in middle and later Byzantium (c.800–1350) and Tang/Song China (618–1279). Initially tied into aristocratic culture, it became a tool by which the imperial state sought to monopolise prestige and access to power so as to effectively channel the activities of newly emerging burgeoning 'middling' strata into the service of empire. As time progressed, it was also the basis upon which these new elites constructed novel forms of subjectivity that claimed authority and agency increasingly independent of the imperial state.

PAIXUE traces this evolution of classicising learning in Byzantine and Tang/Song literati culture from two angles. The first examines the galvanising function of social performances that involved classicising learning in the imperial systems. The second places the individual literatus centre-stage and explores the transformations of self-awareness, ethos, and self-cultivation. Given PAIXUE's concern with examining phenomena cross-culturally in the longue-durée, rather than merely juxtaposing 'spotlight' impressions, a comparison of these two imperial systems does not only allow for deeper insights into the historical development of both China and Byzantium: it opens the possibility of studying cultural mechanisms behind the formation of institutions, practices and values. The project explores novel forms of collaboration in the humanities, including the co-authoring of research output between Byzantinists and Sinologists. Byzantium, frequently perceived as the 'Other' within western culture to the present day, serves here to build meaningful bridges to (pre-modern) China.

Project End Date: **31-JUL-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
741084	**HCG**	**SH5** Cultures and Cultural Production

Principal Investigator:	**Dr. DOUGLAS CAIRNS**
Host Institution:	The University Of Edinburgh, UK

Honour in classical Greece: esteem, status, identity, and society in ancient Greek literature, life, and thought

If 'honour' is an outmoded term, its modern analogues – esteem, respect, recognition, dignity, status, prestige, deference, face, image, etc. – still shape the dynamics of human social interaction. But modern understandings of honour in the societies and literatures of the past – especially the literature of ancient Greece – tend to present it as a single, specific, and more or less monolithic notion especially associated with zero-sum competition between alpha-males, a notion that is typically superseded by more co-operative, inclusive, and egalitarian values, whether in fifth-century BC Athenian democracy or in the eighteenth-century AD enlightenment. Where honour survives in popular perception as a characteristic of modern communities it is typically ghettoized in the world of inner-city gangs, in the Muslim East, or in the traditional machismo of the Mediterranean.

These and similar perceptions are erroneous, and their application to ancient Greek literature, society, and thought is deeply misleading. Using the findings of contemporary sociology and philosophy, with contributions from other disciplines from economics to literary studies, cognitive linguistics, and psychology, this project will lead to a root and branch transformation of the idées fixes that still mould the understanding of honour (Greek timê) in our ancient Greek sources. Far from being one value among many, timê is a pluralist, inclusive, and flexible notion, as important to ancient values of justice, friendship, and social solidarity as it is to the violence of heroic self-assertion and the pursuit of vengeance. It underpins not only the wrath of Achilles in the Iliad but also the community standards that seek to restrain and assuage that wrath. In Athenian law and politics it is as much about the rights that the law protects as it is about the pursuit of rivalry and competition through litigation. It pervades ancient Greek literature, thought, and society. This project will write its history.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
741374	**NOSCEMUS**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. MARTIN KORENJAK**
Host Institution: Universitaet Innsbruck, AT

Nova Scientia. Early Modern Scientific Literature and Latin

Fundamental changes occurred in the study of nature between the late 15th and 18th centuries, leading to the emergence of modern science as we know it. This process would have been impossible without Latin as the scientific lingua franca of the era, just as today's science is hard to imagine without English. At present, this crucial role of Latin is insufficiently acknowledged, and the hundreds of thousands of scientific texts written in Latin have largely remained neglected. This severely limits the scope of research into the history of early modern science, an otherwise thriving field.

The proposed project intends to decisively advance our understanding of the interrelation of Latin and science in early modern times. By applying the methods of Latin philology, yet at the same time reaching out to historians of science, it will establish early modern scientific literature in Latin as an interdisciplinary research field. This will be accomplished

(a) by examining and classifying the formal variety and range of content of this literature to create an overall picture

(b) by analysing its function as a medium of communication within and beyond the scientific community.

To realise the first of these objectives, a tripartite database for authors, early modern texts, and secondary literature will be compiled and a sourcebook with a selection of digitally searchable texts put together, both of which will be made available online. A monograph will provide an overview structured according to the literary genres of early modern scientific literature in Latin. The second objective will be achieved through a series of interlinked monographs, whose analyses will build on the system of ancient rhetoric, the most important communicative paradigm of the early modern age. On this basis, four key functions of Latin scientific texts will be assessed: naming new phenomena; describing and explaining them; convincing others of the views expressed; and promoting science.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
756487	**EVWRIT**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. KLAAS BENTEIN**
Host Institution: Universiteit Gent, BE

Everyday Writing in Graeco-Roman and Late Antique Egypt (I - VIII AD). A Socio-Semiotic Study of Communicative Variation

This five-year project aims to generate a paradigm shift in the understanding of Graeco-Roman and Late Antique communication. Non-literary, 'documentary' texts from Ancient Egypt such as letters, petitions and contracts have provided and continue to provide a key witness for our knowledge of the administration, education, economy, etc. of Ancient Egypt. This project argues that since documentary texts represent originals, their external characteristics should also be brought into the interpretation: elements such as handwriting, linguistic register or writing material transmit indirect social messages concerning hierarchy, status, and power relations, and can therefore be considered 'semiotic resources'. The project's driving hypothesis is that communicative variation – variation that is functionally insignificant but socially significant (e.g. there are ~ there's ~ it's a lot of people) – enables the expression of social meaning. The main aim of this project is to analyse the nature of this communicative variation. To this end, a multidisciplinary team of six researchers (one PI, one post-doc, and four PhD's) will apply recent insights form socio-semiotic and socio-linguistic theory to a corpus of Graeco-Roman and Late Antique documentary texts (I – VIII AD) by means of a three-level approach: (i) an open-access database of annotated documentary texts will be created; (ii) the 'semiotic potential' of the different semiotic resources that play a role in documentary writing will be analysed; (iii) the interrelationships between the different semiotic resources will be studied. The project will have a significant scientific impact: (i) it will be the first to offer a holistic perspective towards the 'meaning' of documentary texts; (ii) the digital tool will open up new ways to investigate Ancient texts; (iii) it will make an important contribution to current socio-semiotic and socio-linguistic research; (iv) it will provide new insights about humans as social beings.

Project End Date: **31-MAY-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758221	**MESG**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. MATTHEW MACHIN-AUTENRIETH**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

Past and Present Musical Encounters across the Strait of Gibraltar

MESG explores how the notion of a collective European-North African cultural memory has been articulated through music for different sociopolitical ends in colonial and postcolonial contexts. Based on the notion of convivencia (the alleged coexistence between Christians, Jews and Muslims in Islamic Spain), music has been employed as a means of social control and representation during French-Spanish colonialism in North Africa (1912–56) and as a model for multiculturalism among North African communities in Europe today. Current scholarship on musical exchange between Europe and North Africa is fragmented, often focusing on isolated geographical case studies. There is limited understanding of how a collective cultural memory has shaped musical practice and discourse in the colonial past and the postcolonial present. In contrast, MESG offers a comparative study of music and colonialism in the Maghreb. By examining colonial music scholarship, policy and education, and musical encounters between different cultural groups, MESG probes the social dynamics of musical interaction at this time, framed by issues of race, imperialism and cultural memory. Second, MESG explores how the idea of a collective cultural memory is invoked through musical collaboration today, by focusing on various genres such as Arab-Andalusian music and flamenco. Rather than separating these historical periods, however, MESG analyses how modern-day practices of musical exchange in the region are shaped by discourses and networks formed during colonialism. Musical exchange will be read against the wider context of multiculturalism, immigration and cultural diplomacy that underpins postcolonial relations between Europe and North Africa. Combining archival and ethnographic research, this groundbreaking project brings together for the first time different geographical, linguistic and musical specialisms, leading towards a fuller understanding of musical exchange in the region.

Project End Date: **31-MAR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758502	**COMICS**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. MAAHEEN AHMED**
Host Institution: Universiteit Gent, BE

Children in Comics: An Intercultural History from 1865 to Today

Owing to their visual essence and status as a popular, modern medium, comics – newspaper strips, comics magazines and graphic novels – provide valuable insight into the transformation of collective consciousness. This project advances the hypothesis that children in comics are distinctive embodiments of the complex experience of modernity, channeling and tempering modern anxieties and incarnating the freedom denied to adults. In testing this hypothesis, the project constructs the first intercultural history of children in European comics, tracing the changing conceptualizations of child protagonists in popular comics for both children and adults from the mid-19th century to the present. In doing so, it takes key points in European history as well as the history of comics into account.

Assembling a team of six multilingual researchers, the project uses an interdisciplinary methodology combining comics studies and childhood studies while also incorporating specific insights from cultural studies (history of family life, history of public life, history of the body, affect theory and scholarship on the carnivalesque). This enables the project to analyze the transposition of modern anxieties, conceptualizations of childishness, child-adult power relations, notions of liberty, visualizations of the body, family life, school and public life as well as the presence of affects such as nostalgia and happiness in comics starring children.

The project thus opens up a new field of research lying at the intersection of comics studies and childhood studies and illustrates its potential. In studying popular but often overlooked comics, the project provides crucial historical and analytical material that will shape future comics criticism and the fields associated with childhood studies. Furthermore, the project's outreach activities will increase collective knowledge about comic strips, which form an important, increasingly visible part of cultural heritage.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758732	**FLOS**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. EMILIANO FIORI**
Host Institution: Universita Ca' Foscari Venezia, IT

Florilegia Syriaca.
The Intercultural Dissemination of Greek Christian Thought in Syriac and Arabic in the First Millennium CE

FLOS will focus on the metamorphoses of Greek Christian thought in Syriac (Aramaic) and Arabic in Late Antiquity, within the timeframe of the first millennium CE. Syriac Christianity was a pivotal mediator of culture in the Late Antique epistemic space, but is little-known today. FLOS aims to bring to light for the first time a body of highly relevant Syriac and Christian Arabic sources that have hardly ever been studied before. At the end of the millennium, in Islamic-ruled Syria, Mesopotamia, and Iran, Syriac Christians strived to define their religious identity. One of their strategies was the production of florilegia, i.e. anthologies that they used to excerpt and reinvent the patristic canon, a corpus of Greek Christian works of the 2nd–6th centuries shared by European and Middle Eastern Christian cultures. A Greco-centric bias has prevented scholars from viewing these florilegia as laboratories of cultural creativity. FLOS will reverse the state of the art through two groundbreaking endeavours: 1) open-access digital editions of a set of Syriac florilegia of the 8th–10th centuries; 2) a study of many neglected writings of Syriac and Christian Arabic authors of the 8th–11th centuries. These tremendously important writings drew from Syriac patristic florilegia to pinpoint topics like incarnation and the Trinity against other Christians or Islam, showing how patristic sources were used to create new knowledge for the entangled environment of the Abbasid era. FLOS will thus dramatically improve our understanding of the cultural dynamics of Late Antiquity; patristic Christianity will emerge as a bridge between the intellectual history of Europe and of the Middle East. By studying how this shared patrimony was transformed in situations of interreligious interaction, especially with Islam, FLOS will facilitate the comprehension of Europe's current religious discourses, and the preservation of the endangered cultural heritage of the Syriac Christians.

Project End Date: **28-FEB-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
770816	**CATENA**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. HUGH HOUGHTON**
Host Institution: The University Of Birmingham, UK

Commentary Manuscripts in the History and Transmission of the Greek New Testament

Manuscripts which contain commentary alongside the biblical text are some of the most significant and complicated witnesses to the Greek New Testament. First compiled around the fifth century, the commentaries consist of chains of extracts from earlier writers (catenae). These manuscripts became the main way in which users encountered both the text and the interpretation of the New Testament; revised editions produced in the eleventh and twelfth centuries continued to hold the field until the invention of printing.

Recent advances have shown that commentary manuscripts play a much more important role than previously thought in the history of the New Testament. The number of known copies has increased by 20% following a preliminary survey last year which identified 100 additional manuscripts. A recent comprehensive textual analysis of the Catholic Epistles indicated that all witnesses from the third generation onwards (some 72% of the total) could stem from the biblical text of three commentary manuscripts occupying a key place in the textual tradition. Investigation of the catena on Mark has shown that the selection of extracts could offer a new approach to understanding the theology of the compilers and the transmission of the commentaries.

The CATENA Project will use digital tools to undertake a fuller examination of Greek New Testament commentary manuscripts than has ever before been possible. This will include the application of multispectral imaging to the oldest copy of a catena in order to recover otherwise illegible text; an exhaustive survey to establish a complete list of witnesses; a database of extracts to examine their principles of organisation and relationships; and electronic transcriptions to determine their role in the transmission of the biblical text. The results will have a direct impact on editions of the Greek New Testament, providing a new understanding of its text and reception and leading to broader insights into history and culture.

Project End Date: **31-MAY-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771292	**LUDEME**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. CAMERON BROWNE**
Host Institution: Universiteit Maastricht, NL

The Digital Ludeme Project: Modelling the Evolution of Traditional Games

The development of games goes hand in hand with the development of human culture. Games offer a rich window of insight into our cultural past, but early examples were rarely documented and our understanding of them is incomplete. While there has been considerable historical research into games and their use as tools of cultural analysis, much is based on the interpretation of partial evidence with little mathematical analysis. This project will use modern computational techniques to help fill these gaps in our knowledge empirically.

I will represent games as structured sets of ludemes (units of game-related information), which will allow the full range of traditional strategy games to be modelled in a single software system for the first time. This system will not only model and play games, but will evaluate reconstructions for quality and authenticity, and automatically improve them where possible. This will lay the foundations for a new field of study called digital archaeoludology, which will involve addressing technical challenges that could yield significant benefits in their own right, particularly in artificial intelligence.

The ludemic model reveals innate mathematical relationships between games, allowing phylogenetic analysis. This provides a mechanism for creating a family tree/network of traditional games, which could reveal missing links and allow ancestral state reconstruction to shed light on the gaps in our partial knowledge. Locating ludemes culturally provides a mechanism for creating interactive maps that chart the transmission of mathematical ideas across cultures through play. This project seeks to bridge the gap between historical and computational studies of games, to provide greater insight into our understanding of them as cultural artefacts, and to pioneer new tools and techniques for their continued analysis. The aim is to restore and preserve our intangible cultural heritage (of game playing) through the tangible evidence available.

Project End Date: **31-MAR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771509	**MetaScience**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. TUOMAS TAHKO**
Host Institution: University Of Bristol, UK

The Metaphysical Unity of Science

The Metaphysical Unity of Science project will pursue the question of what, if anything, unifies the natural sciences. The project studies the question from the perspective of metaphysics and philosophy of science by way of employing case studies from biology, chemistry, and physics.

What does it mean for one scientific phenomenon to be explained in terms of another? Under what conditions does scientific unification take place? In philosophy these questions are often discussed under the rubric of reduction. Typically, in asking whether one phenomenon reduces to another, we aim to understand what the ultimate or fundamental basis of the first phenomenon is. In the mid to late 20th century, there was a hope to reduce all higher level phenomena to fundamental physics. Yet, it was soon discovered that there are phenomena that cannot be easily reduced, so unification may not be available via this route.

The project's ambitious goal is to produce a novel account of unification. This is made possible by recent breakthroughs in the methodology of metaphysics, an area sometimes called "metametaphysics". The project's objectives are (1) to establish the criteria for scientific unification; (2) to conduct case studies of actual scientific reductions at the biology-chemistry and the chemistry-physics interfaces; (3) to study the role of dependence relations weaker than reduction.

A cross-disciplinarily applicable toolbox for unification would be enormously useful for identifying the kind of expertise needed for studying a given phenomenon. This is not merely a philosophical problem. If there are reasons to think that a given biological phenomenon reduces to chemical phenomena, then biologists studying that phenomenon had better be prepared to consult and collaborate with the chemists. If a unification can be achieved, we can determine when scientists ought to consult their colleagues in other sciences and also when this is likely to be a hindrance instead of an advantage.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771800	**Machine Vision**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. JILL WALKER RETTBERG**
Host Institution: Universitetet I Bergen, NO

Machine Vision in Everyday Life: Playful Interactions with Visual Technologies in Digital Art, Games, Narratives and Social Media

In the last decade, machine vision has become part of the everyday life of ordinary people. Smartphones have advanced image manipulation capabilities, social media use image recognition algorithms to sort and filter visual content, and games, narratives and art increasingly represent and use machine vision techniques such as facial recognition algorithms, eye-tracking and virtual reality.

The ubiquity of machine vision in ordinary peoples' lives marks a qualitative shift where once theoretical questions are now immediately relevant to the lived experience of ordinary people.

MACHINE VISION will develop a theory of how everyday machine vision affects the way ordinary people understand themselves and their world through 1) analyses of digital art, games and narratives that use machine vision as theme or interface, and 2) ethnographic studies of users of consumer-grade machine vision apps in social media and personal communication. Three main research questions address 1) new kinds of agency and subjectivity; 2) visual data as malleable; 3) values and biases.

MACHINE VISION fills a research gap on the cultural, aesthetic and ethical effects of machine vision. Current research on machine vision is skewed, with extensive computer science research and rapid development and adaptation of new technologies. Cultural research primarily focuses on systemic issues (e.g. surveillance) and professional use (e.g. scientific imaging). Aesthetic theories (e.g. in cinema theory) are valuable but mostly address 20th century technologies. Analyses of current technologies are fragmented and lack a cohesive theory or model.

MACHINE VISION challenges existing research and develops new empirical analyses and a cohesive theory of everyday machine vision. This project is a needed leap in visual aesthetic research. MACHINE VISION will also impact technical R&D on machine vision, enabling the design of technologies that are ethical, just and democratic.

Project End Date: **31-JUL-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772436	**RURALIMAGINATIONS**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. ESTHER PEEREN**
Host Institution: Universiteit Van Amsterdam, NL

Imagining the Rural in a Globalizing World

With globalization primarily considered an urban phenomenon, its impact on rural areas tends to be neglected. Tackling this blind spot is urgent as rural-urban divides persist and rural communities, notably in the 2016 Brexit vote and US election, claim their concerns about globalization's effects are being ignored. RURALIMAGINATIONS focuses on the crucial role played by cultural imaginations in determining what aspects of contemporary rural life do and do not become visible nationally and globally, which, in turn, affects how the rural can be mobilized politically. Using a distinctive humanities approach, it examines prominent cultural imaginations of the rural in film, television and literature in the UK, US, Netherlands, China and South Africa, asking: 1) to what extent do these imaginations render globalization's effects on the rural (in)visible? 2) what role do traditional rural genres and the feelings or desires they attach to the rural play in this making (in)visible? 3) how can new aesthetic repertoires highlighting the rural as a site of globalization and addressing rural-urban divides and inequalities be developed? The five subprojects conduct, in their national contexts, a narrative, visual and discursive analysis of post-2000 rural imaginations, guided by an innovative theoretical framework combining three concepts: the chronotope reveals what the imagined rural time-space renders visible and how it relates to urban and global time-space; spectrality gives access to what rural imaginations render invisible and to their haunting by traditional genres; and affect exposes how these imaginations attach feelings and desires to the rural, impacting its evaluation and political mobilization. The project synthesis compares the five contexts and examines how rural imaginations interact globally. Expert workshops in the national contexts forge collaborations between humanities scholars, social scientists and cultural producers to develop new rural imaginations.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
786314	**CRAACE**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. MATTHEW RAMPLEY**
Host Institution: Masarykova Univerzita, CZ

Continuity and Rupture in Central European Art and Architecture, 1918-1939

When new political elites and social structures emerge out of a historical rupture, how are art and architecture affected? In 1918 the political map of central Europe was redrawn as a result of the collapse of Austria-Hungary, marking a new era for the region. Through comparative analysis of the visual arts in 3 states built on the ruins of the Habsburg Empire (Austria, Hungary and [former] Czechoslovakia), this project examines how such political discontinuity affected art and architecture between 1918 and 1939. The project is organised into 4 themes, each resulting in a monograph:

1. Vernacular modernisms, nostalgia and the avant-garde
2. Presenting the state: world fairs and exhibitionary cultures
3. Piety, reaction and renewal
4. Contested histories: monuments, memory and representations of the historical past

It is the first systematic and comprehensive trans-national study of this type, based on the claim that the successor states to Austria-Hungary belonged to a common cultural space informed by the shared memory of the long years of Habsburg society and culture. The project focuses on the contradictory ways that visual arts of artists and architects in central Europe adapted to and tried to shape new socio-political circumstances in the light of the past. The project thus examines the long shadow of the Habsburg Empire over the art and culture of the twentieth century.

The project also considers the impact of the political and ideological imperatives of the three successor states on the visual arts; how did governments treat the past? Did they encourage a sense of historical caesura or look to the past for legitimation? How did artists and architects respond to such new impulses? In answering these questions the project analyses the conflicts between avant-gardes and more conservative artistic movements; the role of the visual arts in interwar memory politics; the place of art in the nexus of religion, national and state identity.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
786572	**NOTAE**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. ANTONELLA GHIGNOLI**
Host Institution: Universita Degli Studi Di Roma La Sapienza, IT

NOT A writtEn word but graphic symbols. NOTAE: An evidence-based reconstruction of another written world in pragmatic literacy from Late Antiquity to early medieval Europe.

The use of graphic symbols in documentary records from the 4th to the 10th c. has so far received scant attention. 'Graphic symbols' are graphic signs (including alphabetical ones) drawn as a visual unit in a written text and representing something other than a word. They therefore broadly cover the semantic spectrum of the Latin 'notae' (signs) as opposed to 'litterae' (letters of the alphabet). With the gradual introduction of signature and the increasing use of papyrus from the 4th. c., the presence of graphic symbols became widespread in legal documents as it already was in other written records, and continued in post-Roman kingdoms as part of the same historical process of reception of the late antique documentary practice. Drawing symbols had a major social impact, because, provided it was done in one's own hand, it placed on the same footing professional scribes, basic literates and illiterates. For illiterates, it certainly meant, both in the late Roman state (a Greek-Latin graphic and linguistic community) and in the post-Roman kindgdoms (as long as Latin functioned as language of vertical communication) a way of taking an active part in the writing process. A thorough investigation of this 'other side' of the written world can therefore provide precious insights about the spread of literacy as a whole. The available instances of graphic symbols, which number in their thousands, will be investigated in their contemporary context as well as diachronically, bringing together methods developed in the fields of palaeography, diplomatics and history. Archaeology, sociolinguistics, social anthropology and history of christianity will also provide important methodological angles. The census, description and images of these graphic symbols will be made available on the web through the relational and dynamic NOTAE-Database, which will be the main result of the project and, at the same time, the research tool for both the team members and all the interested scholars.

Project End Date: **30-JUN-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788960	**COSMOS**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. ELAINE CHEW**
Host Institution: Centre National De La Recherche Scientifique, UK

COSMOS: Computational Shaping and Modeling of Musical Structures

Music performance is considered by many to be one of the most breath taking feats of human intelligence. That music performance is a creative act is no longer a disputed fact, but the very nature of this creative work remains illusive. Taking the view that the creative work of performance is the making and shaping of music structures, and that this creative thinking is a form of problem solving, COSMOS proposes an integrated programme of research to transform our understanding of the human experience of performed music, which is almost all the music that we hear, and the creativity of music performance, which addresses how that music is made. The research themes are as follows: i) to find new ways to represent, explore, and talk about performance; ii) to harness volunteer thinking (citizen science) for music performance research by focussing on structures experienced and problem solving; iii) to create sandbox environments to experiment with making performed structures; iv) to create theoretical frameworks to discover the reasoning behind the structures perceived and made; and, v) to foster community engagement by training experts (including retired musicians) to provide feedback on structure solutions so as to increase public understanding of the creative work in music performance. Analysis of the perceived and designed structures will be based on a novel duality paradigm that turns conventional computational music structure analysis on its head to reverse engineer why a listener perceives or a performer chooses a particular structure. Embedded in the approach is the use of computational thinking to optimise representations and theories to ensure accuracy, robustness, efficiency, and scalability. The PI is an established performer and a leading authority in music representation, music information research, and music perception and cognition. The project will have far reaching impact, reconfiguring the way researchers and the general public view music performance.

Project End Date: **31-MAY-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802437	**RUSTRANS**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. MUIREANN MAGUIRE**
Host Institution: The University Of Exeter, UK

The Dark Side of Translation: 20th and 21st Century Translation from Russian as a Political Phenomenon in the UK, Ireland, and the USA

What is the dark side of translation? Translation is valued, taught, and often funded as a deterrent to monolingual nationalism and cultural parochialism. Yet the praxis of translation is highly politicized, often subverted by ideological prejudice or state interference. Translators have a personal agenda, as do editors, publishers, and other agents. Every translation is an act of cultural appropriation. This may not be detrimental to the culture of origin; even inaccurate translations can confer prestige on the former. The 'dark side' of translation – its immanent politics – often allows subaltern nations to assert cultural parity with larger neighbours.

RusTRANS investigates how individuals, and governments, exploit this 'dark side' to reap cultural capital by translating their own literature into global languages (and the reverse). The PI and postdoctoral research assistant will research four case studies about translators of Russian literature, and their networks, in Anglophone contexts (Ireland, the UK, and the USA). Three doctoral students will study the transmission of Russian literature in other European cultures. We will also commission new translations of contemporary Russian writing in order to observe the dynamics of translator (and publisher) networks today.

RusTRANS offers two key innovations. First, we explore an obscure, paradoxical, yet crucial function of translation: as a means of self-promotion and cultural consolidation for emergent nation-states. By focussing on literary translation, and on the transmission of a single language (Russian), we create a coherent paradigm for historians of the cultural reception of national literatures in translation. Second, our diachronic approach to translation praxis allows us to contrast past translation networks and strategies with cultural agents in the ever-more volatile context of modern Russia, as we document the political pressures placed on contemporary authors, translators, and publishers.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804881	**NEUROEPIGENETHICS**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. KRISTIEN HENS**
Host Institution: Universiteit Antwerpen, BE

Epigenetics, Experience and Responsibility: Implications for neurodevelopmental disorders

In folk psychology and in bioethical discussions, the central dogma of genetics is often taken for granted: humans are seen as defined in a genetic blueprint. The conceptualization of psychiatric conditions as innate or acquired, biological or psychosocial, genetic or environmental, influences the ascription of both capacity responsibility (the capacity to adapt or adjust one's own behavior) and normative responsibility of individuals or the society towards those diagnosed. But findings in the field of epigenetics indicate that the social and physical environment influence how genes are expressed. Indeed, epigenetics may shed a new light on distinctions such as innate/acquired, genetic/environmental, biological/psychosocial: a far more complex view on neurodevelopmental disorders may emerge, with ethical implications. However, the implications of epigenetics for discussions on the scope and extent of normative responsibility have not been adequately addressed.

NEUROEPIGENETHICS aims to investigate the ethical implications of epigenetics for neurodevelopmental disorders. We will use theoretical and empirical methods to investigate how certain concepts (innate/biological/genetic) affect the ways in which professionals and stakeholders (persons with a neurodevelopmental disorder and their families) conceive of responsibility. We will evaluate how the emerging field of epigenetics alters the ascription of capacity responsibility and normative responsibility. We will research how individuals with Autism Spectrum Disorder (ASD), Tourette Syndrome (TS) and Attention Deficit Hyperactivity Disorder (ADHD)and their families experience the interaction between their condition and their biological and social environment. Finally, we will define moral responsibility in light of the emerging field of epigenetics in the area of neurodevelopmental disorders and child psychiatric practice.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804920	**CAFYR**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. VANESSA JOOSEN**
Host Institution: Universiteit Antwerpen, BE

Constructing Age for Young Readers

Constructing Age for Young Readers (CAFYR)

CAFYR starts from the observations that Europe has recently witnessed a few pertinent crises in intergenerational tension, that age norms and ageism frequently go unchecked and that they are part of children's socialization. It aims at developing pioneering research for understanding how age is constructed in cultural products. CAFYR focuses on fiction for young readers as a discourse that often naturalizes age norms as part of an engaging story and that is endorsed in educational contexts for contributing to children's literacy, social and cultural development. The effect of three factors on the construction of age in children's books is studied: the age of the author, the age of the intended reader, and the age of the real reader.

CAFYR aims to lay bare whether and how the age and aging process of children's authors affect their construction of the life stages in their works. It will show how various crosswriters shape the stages in life differently for young and adult readers. It considers the age of young readers as varied in its own right, and investigates how age is constructed differently for children of different ages, from preschoolers to adolescents. Finally, it brings together readers of various stages in the life course in a reception study that will help understand how real readers construct age, during the reading process and in dialogue with each other. CAFYR also aims to break new theoretical and methodological ground. It offers an interdisciplinary approach that enriches children's literature research with concepts and theories from age studies. It combines close reading strategies with distant reading and tools developed for digital text analysis. It provides a platform to people of different stages in life, contributing to their awareness about age, and facilitating and investigating dialogues about age, with the aim of ultimately fostering them more.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
805436	**WINK**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. CARME FONT PAZ**
Host Institution: Universidad Autonoma De Barcelona, ES

Women's Invisible Ink: Trans-Genre Writing and the Gendering of Intellectual Value in Early Modernity

Literature scholars have succeeded in recovering texts by early modern women from different languages, genres, and sociopolitical contexts. Still, compared to their male counterparts, few women writers feature in national canons, or they compose a separate set of 'early modern women writers'. A nuanced qualitative approach to their textual production reveals forms of self-taught, intellectually-minded trans-genre discourse (traversing poetry, drama, prose, novels) traditionally deemed irrelevant as it did not conform to a practice of scholarly male-dominated discourse. Thus, much original thinking by women has remained intact even if their texts are available to us.

The proposed research locates, identifies and examines the invisible written production of women in early European modernity in order to modify the single-gender paradigm of intellectual value. It surveys sources in six languages through a methodology based on trans-genre writing rather than on close genre types, allowing patterns of persuasive argumentation to emerge as intellectual input, while exposing the rhetorical models that have impinged on the social and cognitive processes identifying intellectual value as being androcentric.

The main research unfolds in three strands: 1) Synergies, examining religious and life-writing themes that shaped into ethical discourses on the common good. 2) Cloud intertextualities, tracing fragmented chains of intuitive argument in discursive narrative. 3) Textual porosity, understanding patterns of knowledge transference and authorial attribution in the management of sources.

The research outcomes will render co-authored articles, a virtual space environment as the reservoir and task field for comparative textual analysis, and a four-volume collection on the cultural history of textual misogyny. WINK approaches intellectual value as a category of gender analysis, bringing to light transformative thinking from understudied and underrepresented women authors.

Project End Date: **29-FEB-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
805498	**BIOUNCERTAINTY**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. TOMASZ ZURADZKI**
Host Institution: Uniwersytet Jagiellonski, PL

Deep uncertainties in bioethics: genetic research, preventive medicine, reproductive decisions

Uncertainty is everywhere, as the saying goes, but rarely considered in ethical reflections. This project aims to reinterpret ethical discussions on current advances in biomedicine: instead of understanding bioethical positions as extensions of classical normative views in ethics (consequentialism, deontologism, contractualism etc.), my project interprets them more accurately as involving various normative approaches to decision making under uncertainty. The following hard cases in bioethics provide the motivation for research:

1) Regulating scientific research under uncertainty about the ontological/moral status (e.g. parthenogenetic stem cells derived from human parthenotes) in the context of meta-reasoning under normative uncertainty.

2) The value of preventive medicine in healthcare (e.g. vaccinations) in the context of decision-making under metaphysical indeterminacy.

3) Population or reproductive decisions (e.g. preimplantation genetic diagnosis) in the context of valuing mere existence.

The main drive behind this project is the rapid progress in biomedical research combined with new kinds of uncertainties. These new and “deep” uncertainties trigger specific forms of emotions and cognitions that influence normative judgments and decisions. The main research questions that will be addressed by conceptual analysis, new psychological experiments, and case studies are the following: how do the heuristics and biases (H&B) documented by behavioral scientists influence the formation of normative judgments in bioethical contexts; how to demarcate between distorted and undistorted value judgments; to what extent is it permissible for individuals or policy makers to yield to H&B. The hypothesis is that many existing bioethical rules, regulations, practices seem to have emerged from unreliable reactions, rather than by means of deliberation on the possible justifications for alternative ways to decide about them under several layers and types of uncertainty.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818366	**CLIC**	**SH5** Cultures and Cultural Production

Principal Investigator:	**Dr. ISABELLE TORRANCE**
Host Institution:	Aarhus Universitet, DK

Classical Influences and Irish Culture

The hypothesis of this project is that Ireland has a unique and hitherto underexplored history of cultural engagement with models from ancient Greece and Rome. Unlike Britain and mainland Europe, Ireland was never part of the Roman Empire. Yet the island has an extraordinarily vibrant tradition of classical learning that dates back to its earliest recorded literature, and is unparalleled in other northern European countries. Research for this project will address why this is the case, by examining sources through nine significant diachronic themes identified by the PI: language; land; travel and exile; Troy; satire; Neoplatonism; female voices; material culture; and global influence. This multi-thematic approach will enable analysis of what is remarkable about classical reception in Ireland. It will also provide a heuristic framework that generates dialogue between normally disparate fields, such as classical reception studies, Irish and British history, English-language literature, Irish-language literature, medieval studies, postcolonial studies, philosophy, material culture, women's studies, and global studies. The project will engage with contemporary preoccupations surrounding the politics and history of the divided island of Ireland, such as the current decade of centenary commemorations for the foundation of an independent Irish state (1912-1922, 2012-2022), and the on-going violence and political divisions in Northern Ireland. These issues will serve as a springboard for opening new avenues of investigation that look far beyond the past 100 years, but are linked to them. The project will thus shed new light on the role of classical culture in shaping literary, social, and political discourse across the island of Ireland, and throughout its history.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818702	**TEXTEVOLVE**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. HECTOR PATMORE**
Host Institution: Katholieke Universiteit Leuven, BE

A New Approach to the Evolution of Texts Based on the Manuscripts of the Targums

TEXTEVOLVE will study the Targums. Targums are Jewish Aramaic paraphrases of the Hebrew Bible. They are important because they provide a unique insight into what Jews believed God was saying to them through their sacred texts at transformative moments in Jewish history, particularly the aftermath of the First Jewish-Roman War (66–74 CE). The state of the art in the study of the Targums is defined by 1) methodology, and 2) the primary sources that are available. TEXTEVOLVE will go beyond the state of the art in both areas.

Methodology — We do not possess the author's original copy of any Targum. Rather, in most cases we have multiple copies preserved in much later manuscripts, all of which differ one from another. Existing methodology aims to reconstruct the earliest possible form of the text. But changes made by later copyists also yield important insights into evolving Jewish culture, theology, and praxis. Therefore TEXTEVOLVE reframes the dominant research question in the field so that neither the importance of the original wording nor the significance of subsequent changes is neglected. It asks: How did the text of the Targums evolve over time and why? TEXTEVOLVE will develop a new methodology, called Evolutionary Philology, that is capable of addressing this core question. It will use techniques from evolutionary biology that have not previously been applied to texts to achieve this. This will have implications across disciplines that work with historical texts.

Primary Sources — To ensure the most robust possible dataset, TEXTEVOLVE will expand the pool of primary sources available for analysis. TEXTEVOLVE will find Targum manuscripts that have been 'lost' in un-catalogued or poorly catalogued collections, and will analyse for the first time recently discovered manuscripts from the 'European Genizah'. Since the available primary sources define the boundaries of any discipline, this is the second major way in which TEXTEVOLVE goes beyond the state of the art.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819043	**REAL**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. ADINA PREDA**
Host Institution: The Provost, Fellows, Foundation Scholars & The Other Members Of Board Of The College Of The Holy & Undivided Trinity Of Queen Elizabeth Near Dublin, IE

Rights and Egalitarianism

REAL opens up new perspectives in moral and political philosophy by closing the rift between analytical theories of rights and egalitarian theories of distributive justice. There is a perception in both the academic and public discourse that pursuing egalitarian economic policies is incompatible with a commitment to rights. Socialist thinkers have traditionally been sceptical of rights, and contemporary egalitarian theories are often silent about them. At the same time, theories that take rights seriously either neglect the distributive dimension or suggest that egalitarian redistribution may infringe on individual rights. Egalitarianism and rights thus appear to be inhospitable to each other. This project seeks first, to understand what explains this divide and second, to demonstrate that it can be bridged.

REAL is motivated by the thought that a theory of justice, including economic justice, would be more action-guiding if it could translate its recommendations into moral and subsequently legal rights. It thus aims to show that egalitarianism is not only compatible with a commitment to rights but that they are mutually supportive. The project has three main objectives:

- to refute the idea that the concept of rights rules out egalitarian commitments
- to uncover the reasons why egalitarianism is inhospitable to rights and show that they are inconclusive
- to propose a rights-friendly egalitarian theory of justice

The project will critically examine theories of rights and egalitarian theories of justice and adopts an analytical approach that blends arguments from political and legal philosophy, normative ethics and axiology in order to provide a novel and solid framework that integrates the two and advances current debates in these areas.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819459	**NovelEchoes**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. KOEN DE TEMMERMAN**
Host Institution: Universiteit Gent, BE

Novel Echoes. Ancient Novelistic Receptions and Concepts of Fiction in Late Antique and Medieval Secular Narrative from East to West

This project offers the first comprehensive reconstruction and interpretation of receptions of ancient novels (1st-4th cent. AD) in (Greek, Arabic and western vernacular) secular narrative from Late Antiquity and the early Middle Ages. Novel Echoes follows up from the ERC Starting Grant project Novel Saints (on hagiography). It does so by taking ancient novelistic receptions towards entirely new, unexplored horizons.

Our knowledge about the early history of the novel is incomplete. Receptions of ancient novels have been studied for periods from the 11th and 12th cent. onwards but not systematically examined for preceding eras – much to the detriment of the study of both narrative (then and later) and the history of fiction. This project pursues the hypothesis that different secular, narrative traditions in this period were impacted (directly or indirectly) by ancient novelistic influences of different kinds and adopted (and adapted) them to various degrees and purposes; and that, since the ancient novel is a genre defined by its own fictionality, its reception in later narrative impacts notions of truth and authentication in ways that other (often more authoritative) literary models (e.g. Homer and the Bible) do not.

Novel Echoes strikes a balance between breath and depth by envisaging three objectives:
1. the creation of a reference tool charting all types of novelistic influence in secular narrative from the 4th to the 12th cent.;
2. the in-depth study of particular sets of texts and the analysis of their implicit conceptualizations of truth, authentication, fiction and narrative;
3. the reconstruction of routes of transmission in both the West and the East.

Given the project's innovative focus, it will enhance our understanding of both the corpus texts and the early history of the novel; place the study of corpus texts on an improved methodological footing; and contribute to the theoretical study of the much-vexed question of how to conceptualize fiction.

Project End Date: **30-APR-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819649	**FACETS**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. MASSIMO LEONE**
Host Institution: Universita Degli Studi Di Torino, IT

Face Aesthetics in Contemporary E-Technological Societies

FACETS studies the meaning of the face in contemporary visual cultures. There are two complementary research foci: widespread practices of face exhibition in social networks like Facebook, Instagram, Snapchat, and Tinder; and minority practices of occultation, including the mask in anti-establishment political activism (e.g., Anonymous) and in anti-surveillance artistic provocation (e.g., Leonardo Selvaggio). Arguably, the meaning of the human face is currently changing on a global scale: through the invention and diffusion of new visual technologies (e.g., digital photography, visual filters, as well as software for automatic face recognition); through the creation and establishment of novel genres of face representation (e.g., the selfie); and through new approaches to face perception, reading, and memorization (e.g., the 'scrolling' of faces on Tinder). Cognitions, emotions, and actions that people attach to the interaction with one's and others' faces might soon be undergoing dramatic shifts. In FACETS, an interdisciplinary but focused approach combines visual history, semiotics, phenomenology, visual anthropology, but also face perception studies and collection, analysis, and social contextualization of big data, so as to study the cultural and technological causes of these changes and their effects in terms of alterations in self-perception and communicative interaction. In the tension between, on the one hand, political and economic agencies pressing for increasing disclosure, detection, and marketing of the human face (for reasons of security and control, for commercial or bureaucratic purposes) and, on the other hand, the counter-trends of face occultation (writers and artists like Banksy, Ferrante, Sia, or Christopher Sievey / Frank Sidebottom choosing not to reveal their faces), the visual syntax, the semantics, and the pragmatics of the human face are rapidly evolving. FACETS carries on an innovative, cross-disciplinary survey of this phenomenon.

Project End Date: **31-MAY-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819757	**ProtMind**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. THOMAS DOUGLAS**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Protecting Minds: The Right to Mental Integrity and The Ethics of Arational Influence

Unlike most traditional forms of behavioural influence, such as rational persuasion, incentivisation and coercion, many novel forms of behavioural influence operate at a subrational level, bypassing the targeted individual's capacity to respond to reasons. Examples include bottomless newsfeeds, randomised rewards, and other 'persuasive' technologies employed by online platforms and computer game designers. They also include biological interventions, such as the use of drugs, nutritional supplements or non-invasive brain stimulation to facilitate criminal rehabilitation.

The ethical acceptability of such arational influence depends crucially on whether we possess a moral right to mental integrity, and, if so, what kinds of mental interference it rules out. Unfortunately, these questions are yet to be addressed. Though the right to bodily integrity is well-established, the possibility of a right to mental integrity has attracted little philosophical scrutiny.

The purposes of this project are to (1) determine whether and how a moral right to mental integrity can be established; (2) develop a comprehensive and fine-grained account of its scope, weight, and robustness, and (3) determine what forms of arational influence infringe it, and whether and when these might nevertheless be justified. It will deploy a tripartite methodology comprising a bottom-up, casuistic approach, drawing on reflective responses to particular interventions; a horizontal approach, in which lessons for mental integrity will be drawn from analyses of the related phenomena of coercion, manipulation, and bodily integrity; and a top-down approach, drawing on theories of moral rights.

The analysis will establish arational influence as a new area of enquiry and yield guidance on controversial novel forms of arational influence including persuasive digital technologies, salience-based nudges, treatments for childhood behavioural disorders, and biological interventions in criminal rehabilitation.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
832940	**WE**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. DAN ZAHAVI**
Host Institution: Kobenhavns Universitet, DK

Who are we? Self-identity, Social Cognition, and Collective Intentionality

What does it mean to feel, think, and act as part of a we? During the last few decades, the topic of collective intentionality or we-intentionality has been much debated. However, the following foundational issues continue to remain underexplored and unresolved:

• How is the we related to the self?

• What does the fact that one can adopt a we-perspective tell us about the fluid character of selfhood?

• What type of social cognition is required in order to identify with and share a perspective with others?

• What kinds of interpersonal relations are at play in different we-formations?

• What is the relation between a transient we and a persisting we, and between a we that connects particular individuals who are known to each other, and a we that involves identification with a more anonymous and impersonal group?

The working hypothesis of WE is that a systematic account of the we must be embedded in a more comprehensive investigation of selfhood and social cognition. This hypothesis draws inspiration from and will engage with seminal contributions by figures in classical phenomenology.

The project will combine systematic theorizing with historical scholarship, and will challenge existing disciplinary boundaries by interweaving work on self-identity, social cognition, and collective intentionality. It will break new theoretical ground by developing a systematically convincing, phenomenologically valid, and empirically relevant account of the complex interrelation between the we, the you, and the I. In doing so, it will offer a clarification of foundational issues in the humanities and social sciences, and facilitate a much-needed cross fertilization between philosophy and theoretical considerations in the social sciences.

Given the recent upsurge of ethno-nationalism and identity thinking, a renewed critical reflection on the ontological and epistemological status of the we is of urgent societal significance.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834033	**AN-ICON**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. ANDREA PINOTTI**
Host Institution: Universita Degli Studi Di Milano, IT

An-Iconology: History, Theory, and Practices of Environmental Images

Recent developments in image-making techniques have resulted in a drastic blurring of the threshold between the world of the image and the real world. Immersive and interactive virtual environments have enabled the production of pictures that elicit in the perceiver a strong feeling of being incorporated in a quasi-real world. In doing so such pictures conceal their mediateness (their being based on a material support), their referentiality (their pointing to an extra-iconic dimension), and their separateness (normally assured by framing devices), paradoxically challenging their status as images, as icons: they are veritable “an-icons”.

This kind of pictures undermines the mainstream paradigm of Western image theories, shared by major models such as the doctrine of mimesis, the phenomenological account of image-consciousness, the analytic theories of depiction, the semiotic and iconological methods. These approaches miss the key counter-properties regarding an-icons as "environmental" images: their immediateness, unframedness, and presentness. Subjects relating to an-icons are no longer visual observers of images; they are experiencers living in a quasi-real environment that allows multisensory affordances and embodied agencies.

AN-ICON aims to develop “an-iconology” as a new methodological approach able to address this challenging iconoscape. Such an approach needs to be articulated in a transdisciplinary and transmedial way: 1) HISTORY – a media-archaeological reconstruction will provide a taxonomy of the manifold an-iconic strategies (e.g. illusionistic painting, pre-cinematic dispositifs, 3D films, video games, head mounted displays); 2) THEORY – an experiential account (drawing on phenomenology, visual culture and media studies) will identify the an-iconic key concepts; 3) PRACTICES – a socio-cultural section will explore the multifaceted impact of an-iconic images, environments and technologies on contemporary professional domains as well as on everyday life.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834759	**DEMOSERIES**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. SANDRA LAUGIER**
Host Institution: Universite Paris I Pantheon-Sorbonne, FR

Shaping Democratic Spaces: Security and TV Series

In France, the UK, Germany, the US, and Israel, a growing number of films and television series are set 'behind the scenes' of democratic regimes faced with terrorist threats. These works reveal a moral state of the world. They may be analysed as 'mirrors' of society, or as ideological tools. But they can also be understood as new resources for the education, creativity, and perfectibility of their audiences; as the emergence of a form of 'soft power' that can serve as a resource for public policies and democratic conversation.

Because of their format (weekly/seasonal regularity, home viewing) and the participatory qualities of the Internet (tweeting, sharing, liking, chat forums), series allow for a new form of education by expressing complex issues through narrative and characters.

As a result, TV series are increasingly recognised in current research. However, their aesthetic potential for visualising ethical issues and their capacity at enabling a democratic empowerment of viewers has not yet been analysed ; nor their power for confronting cultural and social upheavals underway, and developing a collective inquiry into democratic values and human security.

DEMOSERIES brings together a team of scholars of moral philosophy, film studies, digital media and cultural data, sociology, law and political science, to explore a corpus of TV 'security series' from conception to reception. Doing so requires a particularist ethics based on attention to multi-faceted situations, paired with qualitative methods (interviews with security experts, showrunners, viewers; analyses of images, tropes, words; ethnography of reception) and quantitative methods (tweets and web analytics).

By elucidating how these series are conceived by their creators and audiences, DEMOSERIES thus aims to understand if and how they might play a crucial role in building the awareness necessary for the safety of individuals and societies, and in creating shared and shareable values in the EU and beyond.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
847428	**TiNT**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. GARRICK ALLEN**
Host Institution: Dublin City University, IE

Titles of the New Testament: A New Approach to Manuscripts and the History of Interpretation

The problem this project addresses is that operative modes for interpreting the Greek New Testament (NT) rely upon critical editions, not manuscripts. NT editions are scholarly abstractions that focus on reconstructing an "original" text, and that fail to account for a rich manuscript tradition that preserves evidence for key disciplinary questions. Instead of asking how manuscripts help reconstruct a text, this project examines what manuscripts say about the ways the NT was interpreted by the communities that produced them. This is accomplished by comprehensively analysing the forms and wordings of the title preserved in all non-lectionary NT manuscripts (c. 3500). Titles are malleable paratexts that provide a substantive vector to rethink approaches to the NT by seriously considering contexts of production and interpretation ranging from 2rd century Egypt to modern Mt. Athos, moving beyond the 1st century Roman world. Titles demonstrate that material and paratextual variance in form and design are constitutive aspects of the NT. Adopting New Philology as a methodology, the project critiques dominant approaches by taking each manuscript seriously as evidence for specific reading events, using titles as primary evidence. Titular analysis informs a range of topics, including authorship, locales of production, contexts of use, bibliography, and literary interpretation. The NT is best understood as an omnibus of manuscripts that constitute specific reading events, reflecting the interpretations of the communities that used them. The NT has never been a single reconstructed text, but a collection of texts in specific material and paratextual contexts. Despite the value inherent in the manuscripts, scholarship has focused almost exclusively on the NT's original context of composition. Resisting this trend, the project argues that titles are a rich resource for mapping the interpretation of the NT in contexts overlooked by critical scholarship: its own manuscript matrix.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
850760	**LAWHA**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. NADIA VON MALTZAHN**
Host Institution: Stiftung Deutsche Geisteswissenschaftliche Institute Im Ausland - Dgia, DE

Lebanon's Art World at Home and Abroad: Trajectories of artists and artworks in/from Lebanon since 1943

This project takes an ambitious approach to investigating the trajectories of artists and their works in and from Lebanon since its independence in 1943. In the absence of an institutionalised local art history, artists are often stereotyped according to the agendas of labelling institutions. The project proposes a shift of perspective in approaching Lebanon's art world by placing emphasis on the multi-dimensionality of artists' individual trajectories. It investigates (1) the forces that have shaped the emergence of a professional field of art in their local, regional and global contexts, (2) how to rethink the impact of the political, social and economic environment on the art world and its protagonists, Lebanon often being defined by its experience of violence and conflict, (3) how artists are represented in relation to the nation, and (4) how the trajectories of individuals shape the field. The focus will be on artists in and from Lebanon using the forms of painting (Arabic: lawha), sculpture and new media art. The specificity of Lebanon's history after gaining independence from France in 1943 makes it particularly worthwhile to study the power-relations between artists and institutions at home and abroad. The project's objectives are to (1) develop a new approach to rethink artistic production from a cultural-political perspective while placing the trajectory of artists and their works at the centre, (2) re-evaluate the impact of war and migration on a country's artistic production, (3) build a collaborative digital platform and database (DDP) to create a central and open-access repository and innovative tool for future research and preserving Lebanon's cultural heritage, and (4) to connect the scientific cultures of academic research and museums/art institutions. The project's five thematic clusters and DDP will identify new methods on how to interrelate context and artistic production, serving as a model for revisiting art histories in post-colonial contexts.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851043	**PROGRESS**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. HANNO SAUER**
Host Institution: Universiteit Utrecht, NL

The Enemy of the Good: Towards a Theory of Moral Progress

According to the currently dominant account of moral progress, the story of moral progress goes something like this: once, moral recognition used to be the privilege of a select few. Full moral status was only accorded to people of a certain class, age, gender, ethnicity, or religion. Over time, the moral franchise was gradually extended, however imperfectly, to include human beings of all races, creeds, or genders. Eventually, even species membership is recognized as morally irrelevant, and the moral circle is extended towards non-human animals as well. Many influential ethicists call this the "expanding circle" of moral concern. Moral progress, on this account, consists in further expansions of the moral realm beyond ethically arbitrary features. This account, however, faces a serious feasibility problem: our moral concern is limited due to features of our evolved psychology. Empathy is parochial; altruism remains tied to friends and kin. This project will develop an alternative theory of moral progress. By focusing on different forms of moral progress other than the expanding circle, different moral attitudes which are not subject to the same evolutionary constraints, and smart institutions that can bypass the limits of our inherited psychology, it will be shown that the prospects of moral progress have been severely underestimated.

Project End Date: **31-OCT-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851466	**EJCM**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. JOSEPH SANZO**
Host Institution: Universita Ca' Foscari Venezia, IT

Early Jewish and Christian Magical Traditions in Comparison and Contact

This interdisciplinary project will contribute to the study of both Mediterranean magic and Jewish–Christian relations during late antiquity (III–VII CE) by providing a comparative analysis of the Jewish and Christian magical texts and objects (e.g., amulets and incantation bowls) that is informed by an innovative, synthetic interpretative framework. This project will investigate the contacts between Jewish and Christian practitioners as well as the dynamics of religious assimilation, cooperation, and differentiation in the everyday lives of ancient Jews and Christians.

Although scholarly study of the early Jewish and Christian practices, rituals, and texts deemed "magical" has blossomed over the past few decades, this research has tended to be divided along disciplinary lines, with historians of Judaism studying Jewish magic and historians of Christianity studying Christian magic. Independent from this line of inquiry there is a long history of scholarship devoted to early Jewish–Christian relations which has detailed the diverse ways Jews and Christians interacted in the ancient world. However, the study of early Jewish–Christian relations has not taken into serious consideration the "magical" evidence. In short, despite these respective lines of scholarship within and across early Jewish and Christian studies, there has not yet been a sustained analysis of early Jewish and Christian magical traditions in comparison and in contact.

An interdisciplinary team (PI, 1 Postdoc, and 2 PhD students) will address this scholarly gap by examining local and global features of the magical artefacts – and the literary traditions about magic – from late-antique Jewish and Christian communities. In particular, this group will focus on the similarities, differences, and contacts between these traditions in four central areas of their magical practices: biblical texts and traditions; sacred names and titles; the word-image-material relation; and references to illicit rituals.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852190	**COFUTURES**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. BODHISATTVA CHATTOPADHYAY**
Host Institution: Universitetet I Oslo, NO

CoFutures: Pathways to Possible Presents

This project investigates future fictions from five distinct traditions: Afrofuturism, Sinofuturism, Arab/Gulf-futurism, Latin@futurism, and Indofuturism. All these fictions respond to the burning issues of the present, the transnational discourses of demographic change, climate change, and technological change, but they imagine different, localized ways of engaging with these transnational discourses.

Research Questions

What contributions can contemporary future fictions make to our understanding of global issues?

The project is split into three sub-questions to structure the enquiry:

1. What are the cultural and scientific bases for the development of different geography based future fictions?
2. What are the future changes – societal and technological – imagined in these future fictions?
3. How can we understand the response to global challenges – demographic change, climate change and technological change – in the local changes imagined in these futures?

Based on this, the project will develop a theory of "COFUTURES" (Co: Complex –Coexisting – Comparative).

Context

The project studies the recent proliferation of fiction based on ethnic, cultural, or national identity as take-off points for imagining possible futures even if their locations of production are globally spread. While many of these have older histories, these fictions have come together in this decade as alternative visions of the future that are resistant to perceived colonial or neo-colonial hegemony and are read as new forms of self-assertion. No methodologies have been developed to study all these together as shared phenomena, and no theories exist that can even make sense of them as similar yet distinct phenomena. There have also been no attempts to understand the specific sources for these futures in terms of the kinds of scientific and technological developments they project and the societal developments they imagine as localized responses to global challenges. This is the COFUTURES aim.

Project End Date: **31-DEC-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852216	**STAGING-ABJECTION**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. RUSTEM ERTUG ALTINAY**
Host Institution: Kadir Has Universitesi, TR

Staging National Abjection: Theatre and Politics in Turkey and Its Diasporas

Nation-building processes comprise not only of creating a collectivity but also of defining its borders through abjection. This research will analyse how theatre has served the processes of national abjection, and how abjected minorities have used theatre to negotiate the politics of belonging in Turkey and its diasporas. Employing a rigorous transdisciplinary theoretical and methodological framework, the project will study the key role theatre has played in the constitution of "the Turkish nation" and its Others.

Staging National Abjection covers the period from the rise of European-style theatre in the Ottoman Empire in the mid-nineteenth century to contemporary productions. Using both mainstream and alternative archives and ethnographic research methods, the project will investigate topics of vital importance that have received limited academic attention: theatre productions involving Armenians after the Genocide; negotiation of sexuality and national identity in queer dramas; Islamic theatre in Turkey and its European diasporas; Sephardic Jewish theatre in Turkey and diasporic productions in Israel and Europe; and Alevi theatre in Turkey and Europe. These case studies will bring different perspectives to the issue of national abjection, and provide insights into the political economy of contemporary Turkish theatre responding to pressures of a conservative neoliberal government.

Using the case of Turkey as a vantage point, this project will ask critical questions of broader theoretical significance about the role of theatre in regulating the politics of belonging in the nation-state, and about the relationship between artistic performance and the everyday performance of citizenship. This research will illustrate the political tensions that define Turkey and its growing diasporas, advance our understanding of diasporic and refugee theatre in Europe, and provide ground-breaking insights into cultural politics in post-Imperial contexts and illiberal democracies.

Project End Date: **30-APR-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
862367	**SoundKnowledge**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. BIRGIT ABELS-EISENLOHR**
Host Institution: Georg-August-Universitaet Goettingen Stiftung Oeffentlichen Rechts, DE

Sound Knowledge: Alternative Epistemologies of Music in the Western Pacific Island World

SoundKnowledge aims to rethink, for the first time, music in terms of the procedural knowledge inherent in and specific to music-making by exploring music-making as knowledge practices in Micronesia, Western Pacific Island world. This knowledge, formed in the performance of musical practice, may prove to be key to survival in the complex postcolonial predicament of Micronesia. I will address the issues of climate change, social alienation and postcolonial trauma in specific parts of Micronesia by fleshing out the nature and dynamics of that knowledge both conceptually and ethnographically. The systematic analysis of music as knowledge will allow me to identify strategies to foster resilience in the face of these urgent crises. At the same time, it will offer a first-of-its-kind theorization of the procedural knowledge inherent in and specific to music-making.

The knowledge of music is self-referential and forms multilayered connections and ruptures with pasts, presents and futures and surrounding orders of knowledge. SoundKnowledge asks what Western Pacific musical practices know and how do they know it, how music-making makes this knowledge operable and how humans mobilize upon this knowledge in coping with their life-world through music. The project, therefore, explores how music functions as a distinct epistemic form that is often referred to as the proverbial power of music. Music research has the tools to unlock this power, and SoundKnowledge intends to plough a path here.

SoundKnowledge provides insights into the specific knowledge of Western Pacific music in its entanglement with pressing cultural and social issues of the early 21st century. In contributing to the theoretical debate on the knowledge of music, the project probes vital questions of knowledge resources and human futures. SoundKnowledge will also instigate change: In collaboration with local institutions, the research results will be used towards the development of community action strategies.

Project End Date: **31-MAR-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864189	**MUSAiC**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. BOB STURM**
Host Institution: Kungliga Tekniska Hoegskolan, SE

Music at the Frontiers of Artificial Creativity and Criticism

Artificial intelligence (AI) is an especially disruptive technology, impacting a growing number of domains in ways both beneficial and detrimental. It is even showing surprising impacts in the Arts, provoking questions fundamental to philosophy, law, and engineering, not to mention practices in the Arts themselves. MUSAiC is an interdisciplinary research venture confronting questions and challenges at the frontier of the AI disruption of music. It aims to analyze, criticize and fundamentally broaden the AI transformation of three interrelated music practices: 1) listening, 2) composition and performance, and 3) analysis and criticism. For each practice, and grounded in two specific music traditions (Irish and Swedish), MUSAiC will document and critically analyze the impacts of and ethical issues surrounding AI. MUSAiC will formulate and implement the first music pedagogy for AI, the lack of which continues to result in the creation of AI systems that have only a surface knowledge of music. From this pedagogy, MUSAiC will develop new holistic methods for understanding and benchmarking AI, and improving them and their application. It will implement and test novel AI systems that dynamically adapt to specific users as “digital apprentices”, thus bringing human-AI music partnerships to new levels of fruitfulness. The outcomes of MUSAiC will facilitate applications of AI to music in robust and responsible ways, impacting a wide variety of stakeholders. It will not only prepare music practitioners and audiences of the present (human and artificial) for new ways of listening, working, appraising, and developing the art form, but will also pave the way for analyzing, criticizing and broadening the AI transformation of the other Arts. The PI, a leading figure in music AI and music informatics, is employed at a world-leading research department at the top-rated technical university in Sweden. He is also a composer, frequently illustrating his research outcomes through music.

Project End Date: **30-NOV-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864420	**Neurolive**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. GUIDO ORGS**
Host Institution: Goldsmiths' College, UK

The Neurocognition of Liveness

What makes live experiences special? Liveness is not just central to the performing arts, but to political rallies, sporting events, virtual reality and distance learning in higher education. NEUROLIVE is an inherently interdisciplinary research project, that combines theoretical concepts from theatre and performance studies, artistic research in performance making, psychological experimentation and mobile neuroimaging to understand how liveness is generated and experienced. NEUROLIVE proposes that the live experience can be conceptualized and quantified as a form of sustained entrainment, in which the minds, brains and bodies of performers and spectators are linked. Across three research streams we will combine artistic research (I) and cognitive neuroscience (II) to delineate the contextual, experiential and neurocognitive components of liveness, resulting in four live performance experiments (III). These live performances will be co-developed by performing artists and cognitive scientists with a view to establish an empirically testable, ecologically valid, multidimensional measure of liveness. NEUROLIVE combines dynamic experience sampling with psychophysiology, and mobile EEG. Advanced modelling techniques from machine learning will be used to integrate information from the different experiential, physiological and neural signals. This new measure will be grounded in the aesthetic principles of contemporary live performance, yet should be applicable across artistic and non-artistic performance situations, and to digital liveness in augmented and mixed realities. In this way, NEUROLIVE implements a conceptually and methodologically novel approach to understanding what makes live experiences special.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864635	**FEATHERS**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. NADINE AKKERMAN**
Host Institution: Universiteit Leiden, NL

FEATHERS (FE / MALES AND THEIR SCRIBES): Authorship and the Mediation of Voices, c. 1558-1642

When we look at a text, we think we know who wrote it. Indeed, Paradise Lost was authored by John Milton; the warrant of execution for Mary, Queen of Scots by Elizabeth I. The writers of these texts, the pen wielders, however, were Deborah Milton, and W. Davidson with Burghley. Manuscript production was a collaborative or 'socialised' enterprise that often involved secretaries and scribes who physically wrote what the author dictated.

Sometimes, however, they contributed rather more. Google, MS Word and even dictation software help us write emails – a traditional secretary silently corrects grammatical errors, suggests changes and even creates texts from notes ready for the employer's authorising signature: the early modern scribe fulfilled some or all of these roles.

To distinguish between authorial and scribal voices the project will analyse 3 distinct manuscript types: Historical letters, Legal documents, and Literary works. In doing so it will address 3 questions: who were these scribes; what was their role or function, and where did their influence end and their employer's begin?

Experiences of scribal publication differed along gender and class lines as while high-born men were drawn to it, women and the lower-born were mostly confined to it, rarely holding a pen themselves for reasons as diverse as seemliness and illiteracy. Impacting the fields of literature, cultural history, and digital humanities, this cutting edge project will forever change the way we think about early modern authorship, adding many texts to the canon by authors hitherto marginalised, such as women and the lower-born.

The project will create a model applicable to multiple political periods and countries by concentrating on England between 1558 and 1642 (the beginning of Elizabeth I's reign to the English Civil War), a time when the centres of power were stable enough to allow for relatively constant employment, making individual scribes easier to identify, and with that their influence.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865863	**AdriArchCult**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. JASENKA GUDELJ**
Host Institution: Universita Ca' Foscari Venezia, IT

Architectural Culture of the Early Modern Eastern Adriatic

During the 15th century, the political process of reducing the Eastern Adriatic, here considered as encompassing what is now littoral of Slovenia, Croatia and Montenegro, to a thin strip of border territories substantially separated from the continental massive to which they belong, reached its conclusion. The insularity of its large natural archipelago, i.e. almost exclusive dependence on the maritime communications, became characteristic even of mainland coastal towns, with lasting consequences. The project explores the impact of this change in the area between 15th and 18th c., focusing on architecture as the most evident materialization of a culture and its transformations. The goal is to examine the architectural culture in question in terms of both consumption and production. Factors such as political and economic consolidation of Venetian and Dubrovnik Republics as well as Habsburg Empire in the area, war and commerce with the Ottomans, but also the quick spread of revival of antiquity and the Catholic Revival, all fuelled the need for architectural creation with certain functional and symbolic characteristics, setting the cultural standards. On the other hand, the economics of production of architecture consisted of interrelated systems of the provision of materials (esp. Istrian stone) and organisation of construction sites, which, given the ease of the sea transport, resulted in an active market for architectural goods. This approach will provide an original contribution to the understanding of cultural practices that not only produced specific buildings, the most significant among which are now listed as World Heritage sites but also put into circulation ancient and modern models, techniques and materials for a European-wide audience. Moreover, it will investigate the trans-border and trans-confessional character of the architectural market, thus providing an innovative model for a study of such phenomena across Europe.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865971	**APOCRYPHA**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. HUGO LUNDHAUG**
Host Institution: Universitetet I Oslo, NO

Storyworlds in Transition: Coptic Apocrypha in Changing Contexts in the Byzantine and Early Islamic Periods

This project proposes the first systematic study of Coptic apocrypha covering the entire timespan of Coptic literary production, and it aims to do so with unprecedented methodological sophistication. Apocrypha is here defined as (1) texts and traditions that develop or expand upon characters and events of the biblical storyworld; (2) and/or contain a claim to authorship by a character from that storyworld or a direct witness to it. A great number of such apocryphal texts and traditions has been preserved in Coptic manuscripts from the fourth to the twelfth centuries. Most of these texts are attributed to apostles or other important early Christian figures, and over time such materials were also increasingly embedded in pseudepigraphical frames, such as in homilies attributed to later, but still early, heroes of the Church. The manuscripts in which this literature has been preserved were almost exclusively produced and used in Egyptian monasteries. Although the use of such apocrypha were at times controversial, the evidence clearly indicates the widespread use of such literature in Coptic monasteries over centuries, and this project will investigate the contents, development, and functions of apocrypha over time, as they were copied, adapted, and used in changing socio-religious contexts over time. The period covered by the project saw drastic changes in the religious landscape of Egypt, from its Christianity having a dominant position in the fourth century, through the marginalization of Egyptian Christianity in relation to the imperial Chalcedonian Church after 451, to a period of increasing marginalization in relation to Islam following the Arab conquest of Egypt in the mid-seventh century. The project will investigate how these changing contexts are reflected in the Coptic apocrypha that were copied and used in Egyptian monasteries, and what functions they had for their users throughout the period under investigation.

Project End Date: **31-JUL-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866043	**QaSLA**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. HOLGER ZELLENTIN**
Host Institution: Eberhard Karls Universitaet Tuebingen, DE

The Qur'an as a Source for Late Antiquity

The Qur'an's message to the populations of Mecca and Medina can only be fully understood in the context of its sustained and critical engagement with the Jewish and the Christian traditions. QaSLA complements and redevelops this approach from the ground up by utilizing the Qur'an across disciplines as witness to the history of Judaism and Christianity. Its innovation is twofold. The Qur'an, firstly, will become the primary literary source allowing us to sketch the religious landscape of the Arabian Peninsula, for which no comparable late antique witness exists. Secondly, the Qur'an's testimony to the religious culture of its contemporaries will enable us to approach the development of Jewish and Christian traditions throughout Late Antiquity from a new perspective.

QaSLA's main innovation consists in turning the table on the predominant hermeneutics of Western approaches to the Qur'an, which tend to focus on the question of how the Qur'an is influenced by Judaism and Christianity. By taxonomizing the religious profiles reflected in the demonstrable interface between the Qur'an and its Jewish and Christian contemporaries, the project first reorients and then revamps this approach. QaSLA initially analyses the affinity between the Qur'an and known forms of Judaism and Christianity surrounding Arabia in order to identify which biblical, exegetical, homiletic, legal, narrative, ritual, and poetic discourses and practices circulated within the peninsula. It then employs the Qur'an as a new vantage point from which to reconsider broader late antique religious trends across the Middle East. QaSLA combines expertise across disciplines to create a novel local Arabian and an enhanced longitudinal Middle Eastern understanding of Rabbinic Jewish and Syriac, Ethiopic and Arabic Christian cultures. In a final step, the project then returns to portray the Qur'an in sharper contradistinction to more clearly defined forms of Judaism and Christianity.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866239	**SST**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. JULIAN HENRIQUES**
Host Institution: Goldsmiths' College, UK

Sonic Street Technologies (SST): their diaspora and what they tell us about technology and scientific knowledge

This project claims that 'sonic street technologies' (SST) provide a new, productive and urgently required understanding of the social, cultural and political nature of technology. Jamaican reggae sound systems, Brazilian mobile carnival trio electrico, Mexican sonideros and Colombian los picos are examples of such 'street' technologies. In the global south they are played out of doors and are an essential part of popular culture. These are re-purposed, hacked, DIYed, pirated, customized and creolized assemblages that generate intensive auditory experience for their audience by playing recorded music.

This project investigates the sophisticated practices and techniques by which SST are designed, produced and operated, as well as their social and cultural purposes in the communities in which they originate. SST are subaltern achievements operating in the ghettos and favelas at the margins of the cities and societies whose mass-produced machinery they often cannibalise.

This project maps what is describes as the 'technological diaspora' of the SST themselves. A cultural studies approach compares different local SST, their social and economic circumstances, and the presence or absence of Jamaican or African influence. A practice-as-research methodology gives local SST practitioners a share in the research process with workshops, conferences and an online resource. This helps to establish the alternatives to conventional ideas of design and production processes, as well as scientific knowledge itself.

By de-colonizing technology, the project addresses the pressing need to understand how technology actually works in practice. This is ever more urgent with the 'existential' threat of AI and killer robots, together with technology's imbrication in climate catastrophe and digital social media's erosion of democratic processes and privacy. Instead SST low-tech innovations generate solutions for individual and community well-being and self-determination.

Project End Date: **31-DEC-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866350	**BOAR**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. LUDEK BROZ**
Host Institution: Etnologicky Ustav Akademie Ved Ceske Republiky Vvi - Institute Of Ethnology Of The Academy Of Sciences, CZ

Veterinarization of Europe? Hunting for Wild Boar Futures in the Time of African Swine Fever

This project proposes a collaborative, ethnographic investigation of the relationship between three understudied subjects in anthropology: veterinary medicine, European hunting and wild boars. In recent decades, the wild boar has proliferated, (re)conquering the natural, rural and urban landscapes of Europe, and increasingly clashing with human practices and worlds. Classified as a game animal, the boar is primarily killed and managed by recreational hunters. Yet, hunters are proving incapable of stemming the tide of this intelligent, adaptable being, an interspecies relation that challenges hunting's value and legitimacy in European society. This tension has amplified with the arrival of African Swine Fever (ASF) to the continent: a fatal virus that travels between wild boar and domestic pig, forest and farm, and threatens to infect and ruin the pig industry. In the name of biosecurity, and informed by veterinary knowledge, some States have intervened and conducted mass culls, erected dividing fences across Schengen space, or instituted no-go zones. During this crisis we witnessed how veterinary medicine's role can extend beyond mediating human-animal relations, and work to structure and govern human lives in general. At the intersection of boars, hunting, ASF and veterinary medicine, this project has two main objectives: first, to examine how European hunting and porcine futures are intertwined, and the role of veterinarians in shaping these futures, and; second, through human-boar relations, study how society is becoming increasingly veterinarized and thus shape the conceptual and methodological development of the emerging field of veterinary anthropology. This project will further contribute to anthropology by opening a novel empirical and theoretical niche for the anthropology of hunting, and experiment with ethnography as a tool of engagement with near futures. The emerging and uncertain impact of ASF in Europe is an excellent moment to conduct such a project.

Project End Date: **30-JUN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
882588	**PAGES**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. MICHELA ROSELLINI**
Host Institution: Universita Degli Studi Di Roma La Sapienza, IT

Priscian's Ars grammatica in European Scriptoria. A Millennium of Latin and Greek Scholarship

Written at the beginning of the 6th century AD in the bilingual context of Constantinople, the Ars Prisciani, in 18 books, is the last and greatest Latin grammar handbook of Antiquity. Bringing together the inheritance of Latin and Greek grammatical traditions, it stands as a milestone in the history of linguistic speculation and is an important source of fragments of lost literary works. The deep impact of this text on European culture falls beyond its original scope. Conceived to teach Latin to Greek speakers, in the early Middle Ages (8th-10th centuries) and during the Renaissance (15th-16th centuries) the Ars turned out, due to its great amount of Greek passages, to stimulate the study of Greek by Western scholars.

The peculiar East-Western transmission of the Ars can now be exploited and thoroughly illustrated thanks to the progress of digital philology. PAGES aims both to supersede Hertz's outdated and unreliable edition (1855-59) and, in a broader perspective, to reconstruct Priscian's key role not only in the revival of Latin in 9th-century Europe but also in the practice of Greek script and language in Carolingian scriptoria, in the renaissance of Greek philological studies in the Humanistic Age, and in the history of linguistic education in Europe. The project tackles these challenges with a multidisciplinary approach, gathering experts in textual criticism, digital humanities, palaeography and multispectral imaging, history of linguistics, and medieval and humanistic scholarship.

PAGES will build an open source digital scholarly resource on the text, the tradition, and the reception of Priscian. The infrastructure will make available the results of the systematic census of medieval manuscripts and early printed editions, including the comprehensive inquiry about the Greek script and glosses in Priscian's 8th-10th-centuries manuscripts as well as about the emendations and interpolations in 15th-16th-centuries manuscripts and printed editions.

Project End Date: **31-DEC-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
884951	**VICTEUR**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. GERARDINE MEANEY**
Host Institution: University College Dublin, National University Of Ireland, Dublin, IE

European Migrants in the British Imagination: Victorian and Neo-Victorian Culture

What can the large scale literary datasets now available tell us about the ways in which national cultures develop and the role of migration in that development? This project seeks to push beyond the frontiers of current understanding of the role of migration and migrants in the dynamics of cultural change and continuity, examining intra-European migration in the Victorian period through the 'macroscope' of text mining and the microscopes of literary scholarship. During the Victorian period Britain was the target destination for large numbers of migrants from across Europe fleeing war, political turmoil and/or economic deprivation. While this period and process has attracted considerable attention from historians, literary studies have primarily focussed on colonial racist and imperialist attitudes or representations of single ethnic groups. VICTEUR will focus on how the intra-European cultural exchange triggered by this movement of population is embedded in Victorian fiction. It will identify persistent and residual narratives and attitudes to a cross-section of European migrants by members of the host community and the cultural output of these migrants across a very large literary data set, the 35,918 volumes of fiction in the British Library Nineteenth Century Corpus operationalised for text mining via UCD's Curatr data interface. VICTEUR will trace the residual impact of these cultural representations in neo-Victorian fiction, film and television, focussing on the period 2011-2016, combining methodologies from text mining, transmedia and cultural memory studies. The project will examine in detail the relationship between gender and national and ethnic identities within the texts and the impact of authorial gender on representations of migrants by British and migrant writers. It will develop a new transhistorical and intra-national model for understanding migration as a key driver of cultural development at the interface of gender, ethnicity and demography.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
885273	**PlatoViaAristotle**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. JAN OPSOMER**
Host Institution: Katholieke Universiteit Leuven, BE

Not another history of Platonism. The role of Aristotle's criticisms of Plato in the development of ancient Platonism

The conventional historiography of ancient Platonism follows patterns that ultimately go back to Antiquity itself. While these traditional doxographical accounts are not per se inaccurate, they do overlook continuities across different phases of this thousand-year history as well as some unexpected discontinuities. The reason for these shortcomings lies in the fact that certain philosophical debates are being ignored. Some omissions could be detected by searching for the philosophical reasons explaining doctrinal developments.

This project chooses an unorthodox approach in that it does not try to reflect the issues emphasised in the sources, but instead selects one particular angle of approach: Aristotle's critical discussion of Platonic views. By analysing Platonic responses to Aristotle's criticisms and using these as a heuristic tool, the project pursues a twofold aim: to uncover debates that have hitherto not been picked up in scholarship; and to examine the philosophical reasons for doctrinal varieties and developments. The research hypothesis guiding this project is that Aristotle's criticism of Platonic philosophy was a driving force for many developments in Platonism.

The aims of the project can only be achieved through a large-scale investigation spanning the entire history of Platonism, searching for Platonic responses in all relevant philosophical domains. Since scholarship has been selective in its choice of topics, it cannot be predicted whether we can find sufficient traces of pertinent discussions in all subdomains. Despite the methodological difficulties and the uncertainty of the results the project is more than worth pursuing, as the pay-off is highly significant: it will radically change the way in which we understand the history of Platonism and add a whole new dimension to our historiographical accounts. If successful, it will uncover new debates and allow us to understand philosophical justifications for many philosophical developments.

Project End Date: **31-DEC-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677576	**HARVEST**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. AMANDA HENRY**
Host Institution: Universiteit Leiden, NL

Plant foods in human evolution: Factors affecting the harvest of nutrients from the floral environment

Plant foods comprise the majority of most human diets, yet the potential importance of these foods in human evolution is often overlooked. Using a behavioral ecology framework, the HARVEST project explores fundamental questions: Why did hominins choose to eat certain plants? What were their foraging goals? We will focus on two objectives: 1) Reconstructing the diets of fossil hominins and 2) Exploring the costs and benefits of plant foods.

To understand the factors driving food choice by ancient hominins, we must know what they ate. Analyses of plant remains, proteins, DNA and other residues preserved in dental calculus are cutting-edge methods for reconstructing diets, and provide information about food, processing techniques, and oral microbiota. With a sequential sampling approach, we will combine these analyses to identify foods consumed by hominin groups for which plants are thought to be of great importance.

The decision to consume a particular plant depends on its inherent properties (nutrients and antifeedants) and on the biological and technological abilities of the consumer, so that each potential food has a different cost and benefit. We will study the variation in plant properties among microhabitats in African environments similar to those used by hominins, to better model their food choices. Separately, our study of the food choices among living African foraging and farming groups will reveal if plants are chosen for calories, micronutrients or cultural preferences, while analysis of their gut microbiota and studies of their food processing behaviors will indicate how they acquire nutrients from these foods. Finally, we will assess how the costs of fire might influence food processing choices.

Results from these studies will help fill important lacunae in our understanding of hominin diets, broaden our knowledge of hominin behaviors in a variety of environments, and help generate hypotheses about the relationships between diet and human evolution.

Project End Date: **31-JAN-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679097	**UrbanOccupationsOETR**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. M. ERDEM KABADAYI**
Host Institution: Koc University, TR

Industrialisation and Urban Growth from the mid-nineteenth century Ottoman Empire to Contemporary Turkey in a Comparative Perspective, 1850-2000

This project aims to overcome historiographical and disciplinary limitations in social and economic history, historical geography and urban studies for the Ottoman Empire and the Republic of Turkey. The chosen long-term Ottoman/Turkish perspective is intended to facilitate comparative approaches so as to overcome the limitations of national historiographies. By extending the analysis up to 2000 the project also challenges the disciplinary divide between economic history, economics and urban studies in research on Turkey. To pursue these multiple goals the project will adopt both an inter-disciplinary approach and a comparative perspective. Throughout the project the focus will be on the dynamics of industrialisation, urbanisation and their accompanying changes in occupational structures and residential and migration patterns.

To be able to contextualise and compare changes in occupational structure and urban growth trajectories across time and space, solid and detailed datasets of occupational structure and historical demographics for a very large part of the Ottoman Empire in the 19th century and for the entire Turkey in the 20th century will be constructed. This project is an attempt at bringing Ottoman/Turkish history into the newly emerging field of digital humanities. It will use advanced techniques of spatial data and multiple correspondence analysis in conjuncture to answer long debated research questions and to formulate and work on new ones by taking an unprecedented step forward toward establishing a digital research infrastructure for the social and economic history of the Ottoman Empire and the Republic of Turkey. This project will re-define industrialisation in its connection with urbanisation from a spatiotemporal analytical perspective for Anatolia and the Southeast Europe to ask time and space specific questions about, simultaneity and geographical convergence of Eurasian economic development since 1850.

Project End Date: **31-MAR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681510	**MMS-II**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. JO VAN STEENBERGEN**
Host Institution: Universiteit Gent, BE

The Mamlukisation of the Mamluk Sultanate II: historiography, political order and state formation in fifteenth-century Egypt and Syria

MMS-II pursues the hypothesis that the Mamluk sultanate was a cultural product constructed in the interaction between state formation and historiography. MMS-II follows up from the ERC-project MMS' focus on the social production of power networks in the Syro-Egyptian sultanate between the 1410s and 1460s, but it does so by directing the themes of political history and Arabic historiography towards entirely new, unexplored horizons. Current understanding of the late medieval Middle East continues to rely heavily on the rich Arabic historiographical production of the period. However, the particular nature, impact and value of this highly politicized historiography remains hugely underexplored and underestimated. MMS-II aims to remedy this, by arguing with and beyond instead of against or outside of this historiography's subjectivities. It wants to understand its texts as products of particular socio-cultural practices and, at the same time, as a particular type of actors in such practices. Analytically, state formation will be prioritised as one extremely relevant patterned set of effects of such practices. Heuristically, the project will focus on practices related to claims of historical truth and order, asking how Arabic historiographical texts written between the 1410s and the 1460s related to the regularly changing social orders that were produced around the different sultans of these decades. My main hypothesis is that of these texts' active participation in the construction of a particular social memory of one longstanding sultanate of military slaves ('Mamlukisation'). MMS-II has three specific objectives: the creation of a reference tool for Arabic historiographical texts from the period 1410-1470; the in-depth study of particular sets of these texts; the analysis of political vocabularies in these texts. By thus exploring the inter-subjective re/production of Arabic historiography MMS-II will generate a welcome cultural turn in late medieval Islamic history.

Project End Date: **31-DEC-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694656	**RomaInterbellum**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. ELENA MARUSHIAKOVA**
Host Institution: The University Court Of The University Of St Andrews, UK

Roma Civic Emancipation Between The Two World Wars

Over the past two decades the Roma issue has become one of the most current topics in European public space and also became especially relevant in academia. Despite of this there are still not researched topics, such as history of the Roma in the period between WWI and WWII, and the appearance and development of social and political projects proposed by Roma. The present proposal has the ambitious goal to fill in this gap. The departing point of the research is the circumstances that Roma are not a hermetically isolated social and cultural system. They exist in two dimensions, both as separate ethnic communities and as a part of the macro-society in which they live within the respective nation-states. Together with members of the macro-society they experienced breakdowns of old Empires and the establishment of national states. On the vast territories of that what would became the Soviet Union they were included in the building of a new political system. In this time span Roma started to be politically institutionalized and subjected to a variety of controversial policy practices. The project looks at Roma not only as passive recipients of policy measures but also as active architects of their lives, so the aim is together with studying evidences reflecting state policies in regard to Roma to collect written heritage of Roma visionaries whose published and unpublished texts reflect the main stages in the development of the Roma movement and represent its different aspirations. The project is looking at Roma as an inseparable part of the mainstream history and Roma socio-political visions as part of the history of modern political thought in Europe. It will create a publicly accessible database of sources and manuscripts representing social and political endeavors of Roma. This will be a major contribution to the study of the history of Roma movements and state measures towards them in the Interwar period.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714033	**MEDEA-CHART**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. JOAQUIM GASPAR**
Host Institution: Fciencias.Id - Associacao Para A Investigacao E Desenvolvimento De Ciencias, PT

The Medieval and Early Modern Nautical Chart: Birth, Evolution and Use

Of all the technical and scientific developments that made possible the early modern maritime expansion, the nautical chart is perhaps the least studied and understood. This fact is very surprising as it was through those charts that the newly discovered world was first shown to the amazed eyes of the European nations. Although the History of Cartography is a well-established academic discipline and old charts have been examined for many years, their detailed technical study is still in its infancy. What is the origin of the pre-Mercator nautical chart, how charts evolved technically over time and how they were used at sea are all critical questions that remain to be answered. I intend to approach these challenges in a truly interdisciplinary way, by using innovative and powerful tools as a complement to the traditional methods of historical research: analytical cartometric methods, numerical modelling and the examination of the manuscripts through special lighting. By applying these tools to a large sample of charts of various periods and origins, I aim to unveil hidden graphic content related to their construction and use, to characterize their main geometric features, to establish meaningful connections with contemporary navigational methods and exploration missions, and to numerically simulate their construction by taking into account the explanations given in the textual sources. The effectiveness of those techniques has already been demonstrated in my previous studies, such as in the solution of an historical enigma which had been alive for more than a century: the construction of the Mercator projection, in 1569. Now, I propose to handle a broader and more complex set of questions, which has eluded the historians of cartography for even a longer period. The clarification of these issues will have a ground-breaking impact, not only in the strict field of the History of Cartography, but also in the context of the intellectual history at large.

Project End Date: **31-MAY-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714569	**Lawforms**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. NANDINI CHATTERJEE**
Host Institution: The University Of Exeter, UK

Forms of Law in the Early Modern Persianate World, 17th-19th centuries

This project will study concepts and practices of law across the early modern Persianate world, investigating how this specific cultural milieu structured understanding of law, legal expression and efforts to secure rights and justice. It will do so by focusing on the ordinary users of law, rather than on specialists, and by using legal documents written in Persian and associated languages produced in five major linguistic-cultural zones stretching from the Indian subcontinent to Iran and the northern and western Indian Ocean. Working with the surviving record of everyday transactions (legal deeds); formularies that standardised such legal forms; extant adjudication records and relevant jurisprudential literature, we shall pay particularly close attention to language – exploring how translation, multi-lingualism, orality and literacy facilitated processes of vernacularisation of Islamic law, and was actuated through the social and material world of writing.

The findings of this project will make significant contributions to several fields, such as: the history of Islamic law and its vernacularisation in various political, cultural and demographic contexts, the history of law and commerce in the Indian Ocean, the history of legal pluralism in Islamic and European empires.

This ambitious project will be pursued by an international team of distinguished scholars working under my direction. Together, we will access untapped historical records from archives and collections in India, Pakistan, Tajikistan, Iran, Kuwait, Bahrain, Oman and Tanzania; and read and analyse texts in variations of Persian, in combination with Hindi, Marathi, Bengali, Rajasthani, Gujarati and Arabic.

Outputs proposed are: 2 intensive workshops; 2 collective publications including 2 articles by each of the core project team members (1 for the PI); 1 monograph by the PI; and a major digitisation project which will enhance an existing database of Persian-language legal documents.

Project End Date: **30-APR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714842	**PALAEOSILKROAD**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. RADU IOVITA**
Host Institution: Eberhard Karls Universitaet Tuebingen, DE

A Silk Road in the Palaeolithic: Reconstructing Late Pleistocene Hominin Dispersals and Adaptations in Central Asia

In antiquity and the early Middle Ages, a network of trade routes known as the Silk Road connected east Asia and the Middle East. The Silk Road was not just an economic link, but also the avenue for cultural and even genetic exchanges between these regions. Recent genetic discoveries have hinted that such connections might have begun much earlier, during the Pleistocene. The Pleistocene period is of fundamental importance for human history. It is then that our ancestors evolved and colonised the entire Old World, surviving a suite of major extinction events – and they did so against a dramatic backdrop of ice ages and warmer interglacial phases which substantially altered their habitats. Conquering the extreme environments of arid central Asia to eventually settle the entire Asian mainland and beyond is one of the most impressive feats in this story. Unfortunately, there are too few known Pleistocene archaeological sites in central Asia to allow us to piece together when and how this happened. PALAEOSILKROAD will resolve this deficit by surveying central Asian mountain foothills as both corridors for human and animal movements and archives of past climate change. The project will discover new sites in the Tian Shan, Dzungar, and southern Altai foothills (Kazakhstan) and use them to examine if and how 1) humans were able to survive in the foothills throughout the last glacial cycle (110-11 500 years ago), and 2) periodic advances of mountain glaciers motivated dispersals, population segmentation, and behavioural adaptations. To address these questions, PALAEOSILKROAD will take an ambitious approach rooted in archaeology and contextualised by palaeoenvironmental reconstruction. The results of this project will change the way we understand human dispersals on a global scale and the resilience of early humans in the face of environmental challenges, providing a major missing link to explain how Homo sapiens became the only surviving species of our genus.

Project End Date: **31-MAY-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715423	**BRASILIAE**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. MARIANA DE CAMPOS FRANCOZO**
Host Institution: Universiteit Leiden, NL

Indigenous Knowledge in the Making of Science: Historia Naturalis Brasiliae (1648)

This project is an interdisciplinary study of the role of indigenous knowledge in the making of science. Situated at the intersection of history and anthropology, its main research objective is to understand the transformation of information and practices of South American indigenous peoples into a body of knowledge that became part of the Western scholarly canon. It aims to explore, by means of a distinctive case-study, how European science is constructed in intercultural settings.

This project takes the book Historia Naturalis Brasiliae (HNB), published in 1648 by Piso and Marcgraf, as its central focus. The HNB is the first product of the encounter between early modern European scholarship and South American indigenous knowledge. In an encyclopedic format, it brings together information about the natural world, linguistics, and geography of South America as understood and experienced by indigenous peoples as well as enslaved Africans. Its method of construction embodies the intercultural connections that shaped practices of knowledge production in colonial settings across the globe, and is the earliest example of such in South America. With my research team, I will investigate how indigenous knowledge was appropriated and transformed into European science by focusing on ethnobotanics, ethnozoology, and indigenous material culture.

Since the HNB and its associated materials are kept in European museums and archives, this project is timely and relevant in light of the growing concern for the democratization of heritage. The current debate about the societal role of publicly-funded cultural institutions across Europe argues for the importance of multi-vocality in cultural and political processes. This project proposes a more inclusive interpretation and use of the materials in these institutions and thereby sets an example of how European heritage institutions can use their historical collections to reconnect the past with present-day societal concerns.

Project End Date: **31-DEC-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716375	**PATRIMONIVM**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. ALBERTO DALLA ROSA**
Host Institution: Universite Michel De Montaigne- Bordeaux 3, FR

Geography and economy of the imperial properties in the Roman World (from Augustus to Diocletian).

PATRIMONIVM aims at conducting the first comprehensive and multidisciplinary socio-economic study of the properties of the Roman emperors from Octavian/Augustus to Diocletian (44 BC – AD 284) using a complete documentary base for the entire Roman world. Imperial properties were extended throughout the empire and included residences, cultivated land, pastureland, woods, mines, quarries, luxury items and slaves. This immense richness was a key element for the maintenance of the position of supreme power, since the emperor could use it to carry out all sort of public expenditure and to confer benefactions to individuals and communities. Moreover, large imperial possessions (vast landed estates, quarries) had relevant local economic repercussions. Since their owner was both the head of the empire and a global economic player, we can trace a tendency to trans-regional uniformity in the patterns of exploitation and a positive effect on the economic and, in a certain way, cultural integration of peripheral areas. No major survey of the available documentation has been produced since the beginning of the 20th century and many questions about the acquisition and use of the properties remain unanswered. The project aims at filling this gap creating a powerful online relational database of all published sources; every record will contain geodata and will be related to separate databases of all known persons (administrators, peasants etc.), regions and bibliographic references. A multidisciplinary and comparative study, developed through the project's rich scientific activity, will allow to understand the role of the properties as a structuring factor of Roman economy and as a vector of human mobility and socio-cultural transformation. Innovative hypotheses on imperial investments, the role of the emperor's freedmen and other aspects will be tested. A series of five books, among which an authoritative history of the imperial properties, will disseminate the project's results.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
723718	**Mideast Med**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. LIAT KOZMA**
Host Institution: The Hebrew University Of Jerusalem., IL

A regional history of medicine in the modern Middle East, 1830-1960

The purpose of this project is to write a long-term regional history of medicine in the Middle East and North Africa from a transnational and multi-layered perspective. A regional approach will enable tracing both global influences and local specificities, while a long-term perspective (1830-1960) will allow tracing continuity and change from the late Ottoman Middle East through the colonial to the post-colonial periods. Combining archival and published sources in Arabic, French, English, Hebrew, English, German and Ottoman Turkish, it will offer a unique perspective into the formation of the modern Middle East.

Research for this project will revolve around five main cores: First, the global context: global vectors of disease transmission, alongside the transmission of medical knowledge and expertise. Second, the international aspect: how international conventions and international bodies affected the region and were affected by it. Third, the regional flow of both health challenges and proposed solutions, the regional spread of epidemics and the formation of regional epistemic communities. Fourth, the colonial aspect, noting both inter- and intra-colonial influences, and the encounter between colonial bodies of knowledge and locally produced ones. Fifth, the role played by doctors in various national projects: the nahda, namely the Arabic literary revival from the mid-nineteenth century onwards; the Zionist project; Egyptian and Syrian interwar nationalism and, later, Arab nationalism.

This project will portray an intersection between the corporal, the social, the cultural and the technological and trace these interconnections across time and space. Health, medicine and hygiene will be a prism through which to explore large processes, such as colonization and decolonization, national identity and state-building. The scientific development of medicine and the globalization of health-risks and medical knowledge in this period make medicine an ideal case study.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724544	**AveTransRisk**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. MARIA FUSARO**
Host Institution: The University Of Exeter, UK

Average - Transaction Costs and Risk Management during the First Globalization (Sixteenth-Eighteenth Centuries)

This project focuses on the historical analysis of institutions and their impact on economic development through the investigation of a legal instrument – general average (GA) – which underpins maritime trade by redistributing damages' costs across all interested parties. This will be pursued through the comparative investigation of GA in those European countries where substantial data exists: Italy, Spain, England, France and the Low Countries (1500-1800). Average and insurance were both created in the Middle Ages to facilitate trade through the redistribution of risk. Insurance has been widely studied, average – the expenses which can befall ships and cargoes from the time of their loading aboard until their unloading (due to accidents, jettison, and unexpected costs) – has been neglected. GA still plays an essential role in the redistribution of transaction costs, and being a form of strictly mutual self-protection, never evolved into a speculative financial instrument as insurance did; it therefore represents an excellent case of long-term effectiveness of a non-market economic phenomenon. Although the principle behind GA was very similar across Europe, in practice there were substantial differences in declaring and adjudicating claims. GA reports provide unparalleled evidence on maritime trade which, analysed quantitatively and quantitatively through a novel interdisciplinary approach, will contribute to the reassessment of the role played by the maritime sector in fostering economic growth during the early modern first globalization, when GA was the object of fierce debates on state jurisdiction and standardization of practice. Today they are regulated by the York-Antwerp Rules (YAR), currently under revision. This timely conjuncture provides plenty of opportunities for active engagement with practitioners, thereby fostering a creative dialogue on GA historical study and its future development to better face the challenges of mature globalization.

Project End Date: **30-JUN-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
740611	**CLCLCL**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. JOHN HUDSON**
Host Institution: The University Court Of The University Of St Andrews, UK

Civil Law, Common Law, Customary Law: Consonance, Divergence and Transformation in Western Europe from the late eleventh to the thirteenth centuries

A highly significant division in present-day Europe is between two types of legal system: the Continental with foundations in Civil Law (law with an ultimately Roman law basis), and English Common Law. Both trace their continuous history back to the twelfth century. The present project re-evaluates this vital period in legal history, by comparing not just English Common Law and Continental Civil Law (or "Ius commune"), but also the customary laws crucially important in Continental Europe even beyond the twelfth century. Such laws shared many features with English law, and the comparison thus disrupts the simplistic English:Continental distinction. The project first analyses the form, functioning and development of local, national, and supra-national laws. Similarities, differences, and influences will then be examined from perspectives of longer-term European legal development. Proper historical re-examination of the subject is very timely because of current invocation of supposed legal histories, be it Eurosceptic celebration of English Common Law or rhetorical use of Ius commune as precedent for a common European Law.

F. W. Maitland wrote that 'there is not much "comparative jurisprudence" for those who do not know thoroughly well the things to be compared'. A comparative project requires collaboration – PI, senior researcher, post-doctoral and doctoral researchers, and Advisory Board. It also needs an integrated approach, through carefully selected areas, themes, and sources. The purpose is not just to provide geographical and thematic coverage but to assemble scholars who overcome divisions of approach in legal historiography: between lawyers and historians, between national traditions, between Common Law and Civil Law. The project is thus very significant in developing methods for writing comparative legal history - and legal history and comparative law more widely - in terms of uncovering patterns, constructing narratives, and testing theories of causation.

Project End Date: **30-APR-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
741182	**MAP**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. CORINNE BONNET**
Host Institution: Universite Toulouse Ii-Jean Jaures, FR

Mapping Ancient Polytheisms
Cult Epithets as an Interface between Religious Systems and Human Agency

Writing the history of ancient religions usually starts with the gods, considered as personifications linked by kinship or affinity. Yet this oversimplified approach overlooks the fact that gods are multifaceted powers, not individuals. MAP proposes to exploit the epithets attributed to the gods as the most efficient indicator of their multiple powers and modes of action, as well as their connection to places where humans interact with them. Epithets identify the god(s) invoked and thus enhance the effectiveness of ritual communication. With the great number of combinations produced by epithets, their entire repertoire results in a highly complex system of divine networks.

The volume and complexity of the data is beyond the limits of what traditional methods can handle. Today, thanks to Big Data and Social Network technologies, which deal with large related groups, we can map the divine and understand how human societies modified these ensembles of names and epithets to meet their needs. MAP intends, for the first time, to compile all attestations of divine epithets in context to enable large-scale analyses. It adopts a comparative approach to two areas: the Greek world and the Western Semitic world during the first millennium BC.

Methodologically, MAP innovates by linking the systematic compiling of epithets with Social Network Analysis in order to map the groups, links and polarities of the networks that divine epithets reveal, and interprets them in the light of historical dynamics. Understanding the interface between systems and contexts is one of the major gains of MAP. Religion is explored as an area of social experimentation between norms and inventiveness. MAP also revisits the relationship between religious thought and practice, and between polytheistic and monotheistic systems, questioning the relevance of these categories. The results promise considerable advances in our understanding of ancient religions.

Project End Date: **30-SEP-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
741340	**Rural Riches**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. FRANS THEUWS**
Host Institution: Universiteit Leiden, NL

Rural Riches. The bottom-up development of Post-Roman Northwestern Europe (450-640)

The question as to how Europe emerged from the collapse of the Roman state in the West has been the subject of academic debate for over a century. Most modern authors agree on the idea that the post-Roman economic development was the result of the initiatives and the demand of the elite. This paradigm of elite control of production and (long-distance) trade seems to be at odds with the vast amounts of objects, often precious and of exotic origin, that are found in the thousands of richly furnished cemeteries of even the smallest rural communities.

This project will analyse the importance of the rural population as consumers with access to global trade networks to the post-Roman economic development in northwestern Europe. It is of great importance to analyse the early economic development of this region because it became ever more important in the economic development of Europe as a whole in the Middle Ages and the Modern Period. With this ambitious archaeological project we aim to contribute substantially to the age-old debate on the origins of the European economy and to a general debate on the role of the mass of the population in economic processes in the past.

The project consists of five subprojects aimed at studying the 'lay of the land', the development of burial rite, the circulation of objects and the exchange mechanisms in place, the development of production and how it was embedded in social contexts and related to cosmology, and the presence and character of the elite. The main body of data will be the cemeteries and the vast amount of objects they contained. Sophisticated analyses of the objects' deposition contexts and distribution patterns, using GIS and data from the 'lay of the land' project will be carried out to better understand these 'Rural Riches'. An intensive programme of scientific research will contribute to understanding exchange, production and the use of objects in the communication and internalisation of shared values in rituals.

Project End Date: **31-AUG-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
755504	**ENTPAR**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. IVAN SABLIN**
Host Institution: Ruprecht-Karls-Universitaet Heidelberg, DE

Entangled Parliamentarisms: Constitutional Practices in Russia, Ukraine, China and Mongolia, 1905–2005

The project addresses the entangled histories of deliberative decision making, political representation and constitutionalism on the territories of the former Russian and Qing Empires and focuses on the cases of Russia, Ukraine, China and Mongolia between 1905 and 2005. Employing the perspectives of the New Imperial History and Transcultural Studies, the project overcomes narrow state-centered approaches and takes advantage of multidisciplinary methodology crossing history and political science. The project traces parliamentary developments, the interactions among imperial and post-imperial intellectuals and their engagement in global discussions, shared imperial legacies, mutual borrowings and references, imperial and post-imperial political practices and translatability of concepts. It seeks to refute the stereotypes about inclinations towards democracy in particular national contexts by tracing relevant transnational practices and interactions and providing a nuanced political and intellectual history of parliamentarism. The team of five researchers (the PI, three PhD students and a post-doctoral researcher), will discuss and develop five individual and three cooperative studies. The PI will write a global history of parliaments and quasi-parliamentary institutions in Russia's imperial formations (the State Duma of the Russian Empire, the congresses of soviets and the Federal Assembly of the Russian Federation). The three PhD students with relevant language skills will focus on parliamentary developments in the Ukrainian, Chinese (including Hong Kong and Taiwan) and Mongolian contexts. The post-doctoral researcher will explore the translatability of concepts between Russian, Chinese, Mongolian, Ukrainian and English. The three cooperative projects will focus on traditional institutions of deliberative decision making in the abovementioned contexts; the Communist International and institutional exchange; and the role of parliaments in major social transformations.

Project End Date: **31-MAR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758015	**N-T-AUTONOMY**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. BÖRRIES KUZMANY**
Host Institution: Universitaet Wien, AT

Non-Territorial Autonomy as Minority Protection in Europe: An Intellectual and Political History of a Travelling Idea, 1850-2000

Over the past 150 years, non-territorial autonomy has been one of three models for dealing with linguistic or ethnic minorities within several European states. Compared with the other two, i.e. the recognition of minority rights as individual rights and territorial self-rule, non-territorial autonomy has received little attention. This project proposes to write the first history of non-territorial autonomy as an applied policy tool in minority protection and as an intellectual concept with a chequered history across Europe. Intellectuals, politicians, and legal scholars across the political spectrum from the far left to the far right supported this idea, although they were aware of the risks of strengthening national differences by promoting such a collective approach to minority protection. The project explores how this idea of granting cultural rights to a national group as a corporate body within a state, as a means of integrating diverse nationalities, travelled and transformed throughout the Habsburg Empire from 1850 to the present. We propose to 1) trace the development/circulation of theoretical conceptions and political applications of non-territorial autonomy within the Habsburg Empire, by mapping the networks of scholars as well as politicians who advocated for it; 2) explain the continuities in the development of the idea, and its manifestations in policies adopted by interwar Central and Eastern European nation states, where communists, socialists, liberals and fascists alike were able to translate elements of non-territorial autonomy into their ideologies and programs; 3) analyse the treatment of non-territorial autonomy, which was advocated by minority lobby groups, in international minority protection in the 20th century despite strong opposition to practices based on it by international organisations. We rely on a mixture of historiographical methods developed in nationalism studies to analyse the idea's translation in entangled transnational spaces.

Project End Date: **31-MAR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759800	**RAINDROPS**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. CARLA LANCELOTTI**
Host Institution: Universitat Pompeu Fabra, ES

Resilience and Adaptation in Drylands. Identifying past water management practices for drought-resistant crops

RAINDROPS will investigate cultivation practices that support human resilience and adaptation in drylands, by developing an innovative and reliable methodology for the identification of water management practices from archaeobotanical remains. Irrigation, river floods or permanent water sources are often deemed necessary for cultivation to be practised in drylands. However, there are modern examples that testify to the existence of successful rain-fed cultivation systems, even in hyper-arid environments. Quantification of the extent of these practices in the past has the potential to dramatically change our understanding of human adaptation and agriculture. By establishing a protocol for the accurate identification of rain-fed cultivation, RAINDROPS will pave the way for the investigation of this practice in the past. Highly controlled data on phytolith ratios, and carbon, oxygen and silicon isotopes from macro- and micro-remains from experimental fields of finger millet [Eleusine coracana (L.) Gaertn.] and sorghum [Sorghum bicolor (L.) Moench] will be validated with ethnographic evidence before being applied to selected key archaeological case studies.
RAINDROPS will advance research in: (a) archaeobotanical methodology; (b) resilience theory; (c) physiology of drought-resistant crops; and (d) TEK of cultivation systems in drylands. This will for the first time allow a thorough evaluation of the relative importance of different water management practices in dryland cultivation in the past, and their significance for human adaptation to arid environments. The experimental work on finger millet and sorghum, at present two of the most important dryland crops, will provide valuable information on cultivation practices and plant physiology that will also inform current research on improvements of drought-resistant species – thereby contributing to work on improving the livelihood for over two billion people currently at risk from arid or changing environmental conditions

Project End Date: **31-DEC-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
770402	**FORCe**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. WILLEMIJN RUBERG**
Host Institution: Universiteit Utrecht, NL

Forensic Culture. A Comparative Analysis of Forensic Practices in Europe, 1930-2000

In television series like CSI and Criminal Minds forensic scientists can solve even the trickiest cases within a few hours. Technologies such as blood-spatter analysis, DNA and autopsies aid in reconstructing the crime and psychiatric classifications like 'psychopath' help to identify the perpetrator. Science and technology's impartial and unambiguous results seem to ensure that justice is done equally for everyone. In reality, however, the role and impact of forensic science depend on where the court is located.

Scholars have attributed this regional variance to either the availability of technology or the different legal systems. These explanations have not been backed up by empirical or comparative research and do not sufficiently explain why scientific experts are powerful in some national courtrooms, but dismissed in others.

Moreover, they neglect a third, vital factor: culture. This project will demonstrate the cultural influences that determine how forensic science was accepted in Europe (1930-2000) by focusing on historically and nationally variable political ideology, media representations and norms on gender and sexuality. The project's hypothesis is that cultural ideas and practices have been major determinants in the position of science in the courtroom. To test this, I will use criminal cases in which gender plays an important role: rape, murder and infanticide. Because these often play out in the media as well as the courtroom, they can best unveil the power of culture. The forensic practices of four countries with differing legal systems and ideologies will be compared (the Netherlands, England, Spain and Russia). FORCe will analyse the entangled relationships between forensic science, medicine and psychiatry, using an innovative comparative cultural-historical approach. The results will explain how scientific expertise works in practice and impacts the administration of justice.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
770548	**HRP-IAEA**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. MARIA RENTETZI**
Host Institution: Technische Universitat Berlin, DE

Living with Radiation: The Role of the International Atomic Energy Agency in the History of Radiation Protection

This project addresses the central question of how the International Atomic Energy Agency, a diplomatic and political international organization, came to dominate scientific institutions with a long tradition in radiation protection. Despite the importance of international organizations for the development of postwar science there is no work on the history of radiation protection in relation to the development of the IAEA. The project addresses this lacuna in a groundbreaking way: it analyses what is usually treated as a strictly techno-scientific issue—how best to protect us from ionized radiation—using methods from history, philosophy, and sociology of science, and in the context of international history. The main hypothesis is that scientific knowledge about radiation protection has been shaped by diplomatic, social, economic, and political concerns. This approach casts new light on important aspects of postwar history of science, combining attention to state actors, science diplomacy, and the roles played by international organizations. Given the enormous interest in radiation protection the time is ripe for providing a comprehensive social, historical, and political study of the role of the IAEA in the field.

The main objectives of the project are:

• to retrace the international history of radiation protection after World War II, focusing especially on the Technical Assistance Programs of the IAEA;

• to investigate the role of the IAEA in sponsoring knowledge production in the field of radiation protection in competition with other regulatory agencies; and

• to analyze the standardization of instruments, objects, procedures, and technical vocabulary as the main strategy used by the IAEA for guiding radiation protection worldwide.

The project advocates a "diplomatic turn": diplomacy becomes analytical category in history of science. Highly interdisciplinary it brings together expertise from several disciplines, promising a significant advancement across them.

Project End Date: **30-JUN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771453	**DREAM**	**SH6** The Study of the Human Past

Principal Investigator:	**Dr. LEYLA DAKHLI**
Host Institution:	Centre National De La Recherche Scientifique, FR

Drafting and Enacting the Revolutions in the Arab Mediterranean. In search of Dignity, from the 1950's until today

DREAM, Drafting and Enacting the Revolutions in the Arab Mediterranean, seeks to write the history of the revolutions in the Arab Mediterranean since the independences. It aims to write a transnational history of often forgotten struggles, recall facts and original forms of resistance. We know very few about the revolts that occurred in this period, and even less about the memory that they left in the societies, the way these memories circulated. This rediscovery of revolutions in the shadows must be done through the collection of original material, specifically "poor archives" of the ordinary and the production of Archives – through a combination of classical interviews and innovative methods that involve researchers, archivists, artists and the actors themselves.

The objective is to write a history that focuses on emotions and paths of revolts, telling us more about the link between all dimensions of human lives in these territories (religion, gender, social positions) and the articulation of these dimensions in the revolutionary projects. DREAM aims to write a history that doesn't produce heroes or big figures, doesn't discuss success or failure, but tries to understand the motivations and the potentialities that were at stake in different episodes and moments, during the uprisings and in between them.

It aims to explore the historical signification and the concrete aspects of the call for dignity (Karama/sharaf) in a space that, after liberating itself from the colonial domination, was trapped into the illusion of a common faith (being it the Arab nation or the Islamic umma) and the concrete oppression of authoritarian regimes. This period needs urgently to be explored and history, with its modern tools and patterns, can embrace and trace the particular conditions in which Arab people lived for more than six decades, and specifically the frames of their dreams and projections.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771589	**DEBATE**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. MONICA BRINZEI**
Host Institution: Centre National De La Recherche Scientifique, FR

Debate: Innovation as Performance in Late-Medieval Universities

The switch from parchment to paper had a fundamental impact on later medieval universities, equivalent to the shift to Open Access today, hindering some intellectual practices while encouraging others. The DEBATE project identifies a neglected genre of latin texts that flourished on paper, the Principia, which record the public confrontations between candidates (socii) for the title of doctor. These debates, imposed by university statutes throughout Europe as annual exercises linked to lectures on the Sentences (the medieval parallel to our PhD thesis), forced the candidate to reveal his innovative theories (sheets of papers were exchanged among the socii beforehand), display his erudition and prove his intellectual prowess before a large audience. The futuristic discussion usually exceeded the confines of one discipline and allowed the bachelor to indulge his interdisciplinary interests, employing science, theology, mathematics, politics, literature, and rhetoric in his polemics against his colleagues. Principia thus reveal the cutting edge method of fostering science in later medieval universities. The DEBATE team intends to identify new manuscripts, edit the texts, establish authorship for anonymous fragments and propose an interpretation that will help explain how innovation was a primordial target in medieval academia. Putting together all the surviving texts of Principia produced in various cultural contexts, this project will provide a wealth of material that will bring about a basic change in our understanding of the mechanism of the production of academic knowledge in the early universities all around Europe.The project is designed to promote erudition by combining a palaeographical, codicological, editorial and hermeneutical approach, aiming to open an advanced area of inquiry focusing on an intellectual practice that bound together medieval universities from different geographical and cultural regions: Paris, Bologna, Vienna, Prague, Krakow and Cologne.

Project End Date: **31-JUL-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772264	**NEPOSTRANS**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. GÁBOR EGRY**
Host Institution: Politikatorteneti Intezet Kozhasznu Nonprofit Kft, HU

Negotiating post-imperial transitions: from remobilization to nation-state consolidation. A comparative study of local and regional transitions in post-Habsburg East and Central Europe

The project's goal is to provide a new, overall narrative of how the Habsburg Empire was replaced by nation states at the end of WWI and reconsider in the light of its results categories and concepts like state and statehood, local, regional and national, transition and transformation. A novel combination of historical comparison and histoire croisée enables the in-depth analyses of a set of local transitions in diverse regions (agrarian, industrial, commercial, urban, rural, multi-and mono-ethnic, borderland and mainland, litoral) and the combination of these results with the existing literature on other localities.

The team addresses four main themes: state, elites, identities and discourses. The focus is always local, the question is how these societies faced the momentous changes and found their place within empire and nation-state(s). It will look at interactions, cultures and especially rupture and continuity of people, norms, practices, institutional cultures in order to discover patterns of transitions and the social factors influencing them. Besides a typology of transitions, it also aims at gaining a new perspective on empire and nation state from this crucial moment of collapse and state-building.

The project is informed by New Imperial history, the idea of phantom boundaries, everyday ethnicity, integrated urban history. At the methodological level it builds on a symmetrical comparison of the selected cases and on an asymmetrical one with the existing literature, while the object of comparison is the transition that we conceptualize as an "intercrossing". Through analysing this 'transformation from below' and connecting for the first time what has remained scattered both in historiography and in the social representations, the project aims to write a new history of modern Eastern Europe as a common legacy for an integrated European history.

Project End Date: **28-FEB-23**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772989	**KITAB**	**SH6** The Study of the Human Past

Principal Investigator:	**Dr. SARAH BOWEN SAVANT**
Host Institution:	The Aga Khan University (International) In The United Kingdom, UK

Exploring Cultural Memory in the Pre-Modern Islamic World (700–1500): Knowledge, Information Technology, and the Arabic Book

KITAB (an acronym that also means "book" in Arabic) undertakes a highly innovative and transregional study of the Arabic book (700–1500) and its role in shaping cultural memory in the Islamic world. One of the most spectacularly prolific traditions in human history, the medieval Islamic world witnessed a literary outpouring surpassing the textual output of classical Antiquity and medieval Europe. Our knowledge of the Arabic book, however, is restricted and anecdotal along linguistic and historical lines. This project will be the first to treat holistically this medieval tradition as a cultural phenomenon, and will offer a major new investigation of historical texts as mediators of memory. Its ingenuity derives from the application of pioneering digital technology which detects how Arabic texts were repurposed to suit an evolving present and imagined future. The project will provide the first open-access platform for studying the reuse of historical texts in Arabic and this platform can be then redeveloped for any other language in any other time period. The result will be the first ever comprehensive view of no less than 6,350 Arabic texts that narrate the human past in the Islamic world and that belong to an Islamic historiographical tradition that continues to shape the identity of Muslims worldwide today, including in the European Union. A multi-disciplinary team of 8 researchers and software developers, plus a user group of 12 peer historians, will carry out the research and build upon the successful British Academy-sponsored pilot carried out in 2015 and 2016.

Project End Date: **30-APR-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787015	**CIRGEN**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. MONICA BOLUFER**
Host Institution: Universitat De Valencia, ES

Circulating Gender in the Global Enlightenment: Ideas, Networks, Agencies

Research on the role played by women as actors and by gender as a cultural category has crucially contributed to historiographical revision of the Enlightenment and its legacy to the modern world. However, the perspective adopted has been national or, if comparative, mostly radial. A leap forward is urgent because current circulationist approaches to the Enlightenment tend to forget its key gender dimension and to underplay contributions from Southern Europe. This projects offers, for the first time in the field, a systematic,truly transnational and transatlantic approach, which knits together cultural, intellectual, gender and postcolonial history, literary, philosophical and visual studies. It looks at the cultural transfer of gender notions in global perspective around five axes: translation, learned sociability, travel, reading and sensibility, to be explored through textual and iconographic analysis and archival research. Adopting the vantage point of Spain and its empire will allow to question approaches based either on the "national context" or the centre-periphery dichotomy, to reassess the role of the Catholic Enlightenment in the making of modernity and to highlight the mediating roles played by local actors, male and female, in processes of sociocultural change.

CIRGEN's specific objectives are: to challenge dichotomous visions of Enlightenment discourses of gender by stressing their plural (and often conflictive) contribution to modernity; to decenter customary radial perspectives by stressing multilateral dialogues both within Europe and beyond; to better understand the role played by gender in the cultural geography of Enlightenment, particularly in the construction of the South/North symbolic divide; to produce empirically grounded evidence of the practical and iconic role of women in the making of modern reading publics; to foster innovative scholarship on the gendering of emotions in defining national identities and moral standards of civilization.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787264	**MENTICA**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. ROGER MATTHEWS**
Host Institution: The University Of Reading, UK

The Middle East Neolithic Transition: Integrated Community Approaches

Our world is marked by 'disruption', major re-orderings of society through changing circumstances, including abrupt climate change, impacting on social and economic life. What lessons can we learn from the prehistoric past about disruption, and human engagement with it? One of the first global disruptions faced by human societies was the Neolithic transition from mobile forager-hunter to settled farmer-herder in the Epi-Palaeolithic and Early Neolithic periods of the Middle East, 17,000-7000 BCE. Human communities worked through this disruption, including climate change, to enable complex societies to thrive and to form the basis for later cities, empires and civilisations. In this project, I will address key 'Grand Challenges' for archaeology including human responses to climate change, and societal transformation and resilience.

I will lead an inter-disciplinary team in investigating the Early Neolithic transition in a greatly under-researched region, the eastern Fertile Crescent of western Iran and eastern Iraq, a core zone for early developments, including domestication of animals and crops such as goat and barley. From this zone, early farmers disseminated herding and cultivation practices across Iran into Central and South Asia and Transcaucasia. But as yet we know little about the early stages in the development of farming life-ways in the eastern Fertile Crescent, because this upland area of the Zagros mountains in Iran and Iraq has been challenging for research teams to work in. As the only scholar directing research in both western Iran and eastern Iraq, I am in a unique position to lead this high-risk, trans-border project, on a major ancient route-way (later the Silk Road) from the highlands of Iran to the plains of Mesopotamia. I will direct a programme of six integrated Work Packages examining climate, plants and animals, built environment, food-ways, death and burial, and craft, within a theoretical framework of community networks and identities.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787282	**B2C**	**SH6** The Study of the Human Past

Principal Investigator:	**Dr. MATTHEW COLLINS**
Host Institution:	Kobenhavns Universitet, DK

Beasts to Craft: BioCodicology as a new approach to the study of parchment manuscripts

The intention of Beasts to Craft (B2C) is to document the biological and craft records in parchment in order to reveal the entangled histories of animal improvement and parchment production in Europe from 500-1900 AD.

B2C will lay the foundations for a new approach to the the study of parchment manuscripts — biocodicology— which draws evidence from the overlooked first stages in production, the raising of livestock and the preparation of the skins.

1. Parchment is an extraordinary but overlooked high resolution zooarchaeological record and a molecular archive. Livestock genetics is revealing breed diversity and markers of character traits such as fleece quality. B2C will exploit this new-found knowledge, using progressively older dated archival (sheep) parchments to study the history of improvement 1300 - 1900. Visual examination of the skins will search for direct evidence of disease and fleece quality.

2. Craft skills can be read from parchment and, when combined with chemical data and comparison with modern analogues, will produce the first European wide record of the craft from 500-1900. The size and scope of this the parchment archive means it is one of the largest and most highly resolved records of a specialist medieval craft. We will explore how these skills develop and when and where regional patterns appear and decline.

These two remarkable records requires a large interdisciplinary team. However biocodicology draws from and informs upon a wide and diverse spectrum of existing scholarship in conservation, the arts and sciences. A third strand of the project will (i) furnish manuscript scholars with some of the information available to the scribe at time of production (ii) inform and shape attitudes to parchment conservation (iii) provide high resolution biological data on animal management, movement and health and (iv) explore methods to link datasets and promote data reuse.

Project End Date: **30-NOV-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787522	**AMBH**	**SH6** The Study of the Human Past

Principal Investigator:	**Dr. STEFAN HAGEL**
Host Institution:	Oesterreichische Akademie Der Wissenschaften, AT

Ancient Music Beyond Hellenisation

From medieval times, Arabic as well as European music was analysed in terms that were inherited from Classical Antiquity and had thus developed in a very different music culture. In spite of recent breakthroughs in the understanding of the latter, whose technicalities we access not only through texts and iconography, but also through instrument finds and surviving notated melodies, its relation to music traditions known from later periods and different places is almost uncharted territory.

The present project explores relations between Hellenic/Hellenistic music as pervaded the theatres and concert halls throughout and beyond the Roman empire, Near Eastern traditions – from the diatonic system emerging from cuneiform sources to the flourishing musical world of the caliphates – and, as far as possible, African musical life south of Egypt as well – a region that maintained close ties both with the Hellenised culture of its northern neighbours and with the Arabian Peninsula.

On the one hand, this demands collaboration between Classical Philology and Arabic Studies, extending methods recently developed within music archaeological research related to the Classical Mediterranean. Arabic writings need to be examined in close reading, using recent insights into the interplay between ancient music theory and practice, in order to segregate the influence of Greek thinking from ideas and facts that must relate to contemporaneous 'Arabic' music-making. In this way we hope better to define the relation of this tradition to the 'Classical world', potentially breaking free of Orientalising bias informing modern views. On the other hand, the study and reconstruction, virtual and material, of wind instruments of Hellenistic pedigree but found outside the confinements of the Hellenistic 'heartlands' may provide evidence of 'foreign' tonality employed in those regions – specifically the royal city of Meroë in modern Sudan and the Oxus Temple in modern Tajikistan.

Project End Date: **31-AUG-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787842	**ARTSOUNDSCAPES**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. A. MARGARITA DIAZ-ANDREU**
Host Institution: Universitat De Barcelona, ES

The sound of special places: exploring rock art soundscapes and the sacred

The ARTSOUNDSCAPES project deals with sound, rock art and sacred landscapes among past hunter-gatherers and early agricultural societies around the world. The potential of sound to stimulate powerful emotions makes it a common medium for conferring places with extraordinary agency. Ethnographic and ethnohistorical sources indicate that these sites are often endowed with a sacred significance and, in many cases, they also receive special treatment, including the production of rock paintings. Despite the aural experience being an integral component of the human condition and a key element in ritual, archaeology has largely been unable to study it systematically. Rock art landscapes are no exception and, although some studies have been made, they have largely been reproached for their lack of scientific rigour and subjectivity. ARTSOUNDSCAPES will fully address this weakness by investigating the perception of sound in rock art landscapes from an interdisciplinary approach. Borrowing methods developed in acoustic engineering, the project will assess, from an objective and quantitative perspective, the acoustic properties of rock art landscapes in selected areas around the world: the Western/Central Mediterranean in Europe, Siberia in Asia, and Baja California in North America. Human experiences associated with altered or mystical states invoked by the identified special sonic characteristics of these landscapes will be further tested by exploring the psychoacoustic effects these soundscapes have on people and their neural correlate to brain activity. The project will also thoroughly survey ethnographic attitudes to sacred soundscapes based on both current premodern societies and ethnohistorical sources. The groundbreaking combination of this array of interdisciplinary approaches will facilitate the ultimate aim of the project: to propose a phenomenological understanding of sacred soundscapes among late hunter-gatherers and early agriculturalists around the world.

Project End Date: **30-SEP-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802210	**PASSIM**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. SHARI BOODTS**
Host Institution: Stichting Katholieke Universiteit, NL

Patristic sermons in the Middle Ages. The dissemination, manipulation and interpretation of late-antique sermons in the medieval Latin West

PASSIM will study the medieval reception of the Latin sermons preached by the Early Church Fathers, using a digital network of manuscripts.

The sermons of Augustine, Gregory the Great and other patristic preachers were transmitted throughout medieval Europe in the form of sermon collections, preserved in thousands of manuscripts. Nearly every manuscript contains a new combination of sermons, attesting to a continuous, widespread engagement with the authorities of the Early Church. The dynamic tradition of reorganising and rewriting the patristic heritage is largely overlooked by scholars of medieval religious practices, who concentrate on medieval preachers, and by scholars of Early Christianity, whose focus is the patristic context.

Medieval collections of patristic sermons were part of the liturgical life of the monastery, but also of an intellectual tradition. They offer unique insights into medieval attitudes toward authority, techniques of appropriation, church organisation, monastic networks and knowledge exchange. PASSIM will execute the first large-scale analysis of the formation and spread of patristic sermon collections in medieval Europe. The project will develop a digital network of manuscripts, using well-tried principles from the field of textual criticism. Building on this network, PASSIM will pursue three lines of inquiry: the customizing of standard liturgical collections as indicative of individual purposes and contexts, the impact of transmission on the popularity of patristic sermons, and pseudo-epigraphic sermons as revelatory of medieval perceptions of the Church Fathers.

PASSIM will bridge two disciplinary divides, between patristic and medieval sermon studies and between textual criticism and reception studies. Developing an interdisciplinary methodology with a wide applicability in the study of intellectual history, this project will introduce patristic preaching as a vibrant strand in the tapestry of the medieval religious tradition.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802424	**CLaSS**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. DAN LAWRENCE**
Host Institution: University Of Durham, UK

Climate, Landscape, Settlement and Society: Exploring Human-Environment Interaction in the Ancient Near East

Over the last 8000 years, the Fertile Crescent of the Near East has seen the emergence of cities, states and empires. Climate fluctuations are generally considered to be a significant factor in these changes because in pre-industrial societies they directly relate to food production and security. In the short term, 'collapse' events brought about by extreme weather changes such as droughts have been blamed for declines in population, social complexity and political systems. More broadly, the relationships between environment, settlement and surplus drive most models for the development of urbanism and hierarchical political systems.

Studies seeking to correlate social and climatic changes in the past tend either to focus on highly localised analyses of specific sites and surveys or to take a more synthetic overview at much larger, even continental, scales. The CLaSS project will take a ground breaking hybrid approach using archaeological data science (or 'big data') to construct detailed, empirical datasets at unprecedented scales. Archaeological settlement data and archaeobotanical data (plant and tree remains) will be collated for the entire Fertile Crescent and combined with climate simulations derived from General Circulation Models using cutting edge techniques. The resulting datasets will represent the largest of their kind ever compiled, covering the period between 8000BP and 2000BP and an area of 600,000km2.

Collecting data at this scale will enable us to compare population densities and distribution, subsistence practices and landscape management strategies to investigate the question: What factors have allowed for the differential persistence of societies in the face of changing climatic and environmental conditions? This ambitious project will provide insights into the sustainability and resilience of societies through both abrupt and longer term climate changes, leveraging the deep time perspective only available to archaeology.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802752	**DEADSEA_ECO**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. NIMROD MAROM**
Host Institution: University Of Haifa, IL

Modelling Anthropocene Trophic Cascades of the Judean Desert Ecosystem: A Hidden Dimension in the History of Human-Environment Interactions

This project aims to explore the effects of human settlement intensity on desert ecological community structure, focusing on the hitherto unstudied phenomenon of trophic cascades in antiquity. Its key research question is whether human-induced changes in arid land biodiversity can feedback to affect natural resources important for human subsistence, such as pasture and wood. The role of such feedback effects in ecological systems is increasingly acknowledged in recent years in the biological literature but has not been addressed in the study of human past. The research question will be approached using bioarchaeological methods applied to the uniquely-preserved material record from the middle and late Holocene settlement sequence (approximately 4,500 BCE to 700 CE) of the Dead Sea Ein Gedi Oasis, and to the contemporary palaeontological assemblages from caves located in the surrounding Judean Desert. The proposed research is expected to bridge between aspects of current thinking on ecosystem dynamics and the study of human past by exploring the role of trophic cascades as an invisible dimension of Anthropocene life in marginal environments. The study of the history of human impact on such environments is important to resource management planning across a rapidly expanding ecological frontier on Earth, as climate deterioration brings more people in contact with life-sustaining and sensitive arid land ecosystems.

Project End Date: **31-DEC-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802918	**DUNES**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. JOANA FREITAS**
Host Institution: Faculdade De Letras Da Universidade De Lisboa, PT

Sea, Sand and People. An Environmental History of Coastal Dunes

Dunes are now protected environments, being top priority for coastal managers, because of their important role as coastal defences. But, it was not like that in the past.

For centuries dunes were considered unproductive and dangerous. The sand blown by the wind was taken inland, invading fields, silting rivers and destroying villages. In the eighteenth century, a strategy was developed to fight against the dunes: trapping them with trees, with the double purpose of preventing the destruction of arable land and increasing their economic value converting them into forest areas. Different governments, in different countries supported the immobilization of the shifting sands. The strategy, developed in Europe, was taken to other places in the world. These works caused profound changes in vast coastal areas transforming arid landscapes of sandy dunes into green tree forests.

This project aims to explore human-environment relations in coastal areas worldwide, since the eighteenth century until today, through the study of dunes as hybrid landscapes. Based on selected case-studies and comparative approaches, the project will focus on the origins, reasons and means of dunes afforestation; the impacts of the creation of new landscapes to local communities and ecosystems; and the present situation of dunes as coastal defences and rehabilitated environments. The final purpose is to produce an innovative global history of coastal dunes, combining knowledges from both Humanities and Social Sciences and Physical and Life Sciences, which has never been done. Supported by an interdisciplinary team, this research will result in new developments in the field of the Environmental History studies; provide relevant knowledge considering the need of efficient management solutions to adapt to the expected mean sea level rise; and stimulate environmental citizenship by disseminating the idea that the future of the world coasts depends on today's actions.

Project End Date: **31-OCT-23**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
805098	**J-INNOVATECH**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. ALEKSANDRA KOBILJSKI**
Host Institution: Centre National De La Recherche Scientifique, FR

Beyond Eureka: The Foundations of Japan's Industrialization, 1800-1885

Beyond Eureka seeks to challenge current understanding of how Japan became a global industrial power along with the model of how innovation takes place. Japan was the first Asian nation to industrialize and in a space of several decades went from a relatively isolated agrarian economy to an industrialized nation. The key assumption of this project is that a grasp of the salient features of the technological landscape during the pivotal period between 1800 and 1885 is an important tool for understanding Japan's industrialization. To date, this transitional period has been widely acknowledged as crucial for later development but remains empirically poorly understood. Recognizing the complexity of causation, this project seeks to use technology as a site for forging a more nuanced understanding of the emergence of Asia's first industrial power.

By bringing technological change into historical focus, the project challenges the notion of innovation as necessarily a matter of disruption. In Japanese, for example, there is no conceptual or cultural equivalent to Eureka, to stand for a unique, distinct moment of individual ingenuity. If we choose the Eureka moment to epitomize the conception of innovation, early examples in Japanese industry are few and far between. Instead, a small but growing body of research shows that a sophisticated and patient examination of archives can reveal innovative processes in place of what historiography has described as borrowing, imitation or adaptation. This project seeks to foreground innovation as a long-term process of accumulation in which the new only could only work by taking root and embedding itself within the old, not by replacing it and starting from scratch.

The team, comprising the PI and five postdoctoral fellows, will combine expertise and previously unexamined archives to bring depth and nuance to not only to the specific case of Japanese industrialization, but also more
broadly of innovative processes in human past.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
817564	**CLIOARCH**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. FELIX RIEDE**
Host Institution: Aarhus Universitet, DK

Cliodynamic archaeology: Computational approaches to Final Palaeolithic/earliest Mesolithic archaeology and climate change

Late Pleistocene/early Holocene Europe is said to be the ideal laboratory for the investigation of human responses to rapidly changing climates and environments, migration and adaptation. Yet, pinpointing precisely how and why contemporaneous Final Palaeolithic/earliest Mesolithic (15,000-11,000 years BP) foragers migrated, and which environmental or other factors they adapted to – or failed to – has remained remarkably elusive. At the core of ClioArch is the radical but, in light of research-historical insights, necessary hypothesis that the current archaeological cultural taxonomy for this iconic period of European prehistory is epistemologically flawed and that operationalisations and interpretations based on this traditional taxonomy – especially those that seek to relate observed changes in material culture and land-use to contemporaneous climatic and environmental changes – are therefore problematic. Hence, novel approaches to crafting the taxonomic building blocks are required, as are novel analyses of human|environment relations in this period. ClioArch's premier ambition is to provide operational cultural taxonomies for the Final Palaeolithic/earliest Mesolithic of Europe and to couple these with interdisciplinary cultural evolutionary, quantitative ecological methods and field archaeological investigations beyond the state-of-the-art, so as to better capture such adaptations – almost certainly with major implications for the standard culture-historical narrative relating to this period. In so doing, the project will pioneer a fully transparent and replicable – and eminently transferable – methodology for the study of the impacts of climate change and extreme environmental events in deep history. In turn, such a quantitative understanding of past adaptive dynamics will position archaeology more centrally in contemporary debates about climate change, environmental catastrophe and their cultural dimensions.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819461	**UnRef**	**SH6** The Study of the Human Past

Principal Investigator:	**Dr. MICHAL FRANKL**
Host Institution:	Masarykuv Ustav A Archiv Av Cr Vvi, CZ

Unlikely refuge? Refugees and citizens in East-Central Europe in the 20th century

The project aims to write refugees back into the history of East-Central Europe in the 20th century. In this "age of refugees", the region became a destination of large refugee migrations, forcing civil societies and governments to negotiate difficult decisions about protection for those fleeing the war and persecution. Yet, at the same time, East-Central Europe does not enjoy the reputation as a welcoming place for people persecuted for political persuasion, for their "racial", ethnic identity or any other reason. It would appear that the histories of ethnic conflict and violence, political oppression and economic underdevelopment make it a place to leave behind rather than to search for as a safe harbour.

Studies about specific groups and instances notwithstanding, historical research remains highly unsatisfactory, failing to address refugee protection in a systematic comparative way and transcending national master narratives. Worse than this, historical writing about refugees in the "East" often re-inscribes the very (ethnic, political) categories which lead to the production of refugees in the first place.

Comparative research spanning across a longer period and a wider territory promises therefore not only major insights about the "East" as a refuge, but also a significant contribution to the emerging field of global refugee history. In this project, an international research team led by the PI will, using comparative historical research combined with multi-disciplinary approaches, probe the multifaceted entanglements with refugees in countries created in 1918 on the ruins of the Habsburg Monarchy (Poland, Czechoslovakia, Austria, Hungary, Yugoslavia) over the 20th century. By doing so, it wishes to return the discussion of protection of refugees into the region's history and to contribute – from a scholarly perspective – to the cultivation of current and future public debate about this divisive subject.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819734	**VINCULUM**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. MARIA DE LURDES ROSA**
Host Institution: Universidade Nova De Lisboa, PT

Entailing Perpetuity: Family, Power, Identity. The Social Agency of a Corporate Body (Southern Europe, 14th-17th Centuries)

Few legal phenomena have been so relevant to premodern southern Europe societies as entails, a specific strategy that evolved to protect family inheritances, thus enabling the reproduction of elite social status. The VINCULUM project aims to explain how entailment became possible, how it functioned, and why it lasted for so many centuries. The project rests on the innovative theoretical claim that entails, as corporate bodies, functioned as a key social agent, created and acting within societies for which non-personal legal subjects were normal. Building on the Portuguese-Iberian case, and on the extensive research already carried out by me and my team, I propose to study 'entailment' as a diverse but pivotal practice, one embedded in law, aristocratic discourse, and kinship-based organization, and to carry out comprehensive analysis that explores this global nature. The research approach systematically breaks with traditional research frontiers: cases will extend from the 14th to 17th century in both continental and Atlantic spaces, and include both comparative perspectives and the study of later social reconfigurations.

VINCULUM will be anchored in extended research in public archives and on unprecedented access to extensive private family archives, which have been opened to research by the ARQFAM program I have led since 2008. Data collection will allow for the construction of a large database, gathering all documents relating to each entail, under a theoretical model that seeks to reconstruct past information systems, thus testing a novel methodology developed in my previous research. The database that will gather c.7000 thousand entails, enabling systematic inquiries organized around the new conceptual definitions proposed by the project. The research will be strongly interdisciplinary, engaging with historical anthropology and archival science in order to construct a proper theoretical model for understanding this crucial legal and social phenomenon.

Project End Date: **31-MAY-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
819960	**NewHuman**	**SH6** The Study of the Human Past

Principal Investigator:	**Dr. MATTHEW SKINNER**
Host Institution:	University Of Kent, UK

Pathways to humanity: Adaptive niche diversity at the origins of the human lineage

For almost 100 years, the evolution of humans has been summarized as a transition from small-brained bipeds with an ape-like body plan (referred to as australopiths), to large-brained striding bipeds with a human-like body plan (members of the genus Homo). This characterisation dominates popular perception of human evolution in the public sphere. However, three newly discovered fossil human (hominin) species (H. naledi, H. floresiensis and Australopithecus sediba) do not fit this simple transitional model in either morphology or time (the former two surviving contemporaneously with modern humans), and have re-ignited debate about the origin of the Homo lineage, including perceptions of the earliest putative Homo species, H. habilis. These new fossils raise fundamental questions about the ecological niches occupied by hominins and the inferred transitions between niches throughout human evolution. With NewHuman, I will pioneer a novel, interdisciplinary and holistic approach using cutting-edge analyses of internal structures of fossil hominin teeth and bones to reconstruct the adaptive niche of these enigmatic species and test whether there is an unrecognized adaptive branch on the human family tree. Specifically, NewHuman will employ ground-breaking imaging techniques and analytical tools to reveal never-before-examined tooth and bone structures in these hominins. In doing so, it will 1) characterize the behaviour of these enigmatic species and place them more firmly into their ecological environment; and 2) elucidate the adaptive strategy that was likely the transition from australopith-like hominin species to later Homo, but which also represents a highly successful lifeway that persisted for over 2 million years alongside the evolving human lineage. By achieving these ambitious aims, NewHuman will have a significant impact on hypotheses about human evolution, and could result in a paradigm shift that overturns current views on human evolutionary history.

Project End Date: **30-JUN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833438	**RUTTER**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. HENRIQUE LEITÃO**
Host Institution: Faculdade De Ciencias Da Universidade De Lisboa, PT

Making the Earth Global: Early Modern Nautical Rutters and the Construction of a Global Concept of the Earth

Early modern nautical rutters (sailing directions) are the earliest Western documents that testify to the stable and regular lived experience of traversing the earth's oceans on a global, planetary scale. Nautical rutters (and ship's loogbooks) are technical documents that collect and analyse critical information for the successful accomplishment of oceanic navigation. This includes elements of strict nautical nature (courses, distances, and latitudes), as well as information on oceanography (currents and tides), meteorology (winds and storms), geography, geophysics (magnetic declination) and the natural world. Their unique value lies not only in the fact that they are exceptional historical repositories of information about the world on a planetary scale but, more importantly, that they document the emergence of global concepts about the earth. In fact, no earlier documents contain information about the earth on a comparable worldwide scale. Thus, their historical value is peerless. Using these exceptional, yet poorly known sources, the main objective of this project is to write a narrative of the scaling up of a scientific description of the earth in the sixteenth and seventeenth centuries, from the lived experience of travelling and observing the earth in long-distance sea voyages. As a preliminary task, a systematic search, identification and classification of the information contained in early modern Iberian rutters and ship's logbooks will be performed. This will be followed by an extensive multidisciplinary study of their content aiming at radically improving our present knowledge of the historical process that led to the formation of global concepts about the earth.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
833691	**ZARAH**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. SUSAN CARIN ZIMMERMANN**
Host Institution: Kozep-Europai Egyetem, HU

Women's labour activism in Eastern Europe and transnationally, from the age of empires to the late 20th century

ZARAH explores the history of women's labour activism and organizing to improve labour conditions and life circumstances of lower and working class women and their communities—moving these women from the margins of labour, gender, and European history to the centre of historical study.

ZARAH's research rationale is rooted in the interest in the interaction of gender, class, and other dimensions of difference (e.g. ethnicity and religion) as forces that shaped women's activism. It addresses the gender bias in labour history, the class bias in gender history, and the regional bias in European history. ZARAH conceives of women's labour activism as emerging from the confluence of local, nation-wide, border-crossing and international initiatives, interactions and networking. It studies this activism in the Austro-Hungarian and Ottoman Empires, the post-imperial nation states, and during the Cold War and the years thereafter. Employing a long-term and trans-regional perspective, ZARAH highlights how a history of numerous social upheavals, and changing borders and political systems shaped the agency of the women studied, and examines their contribution to the struggle for socio-economic inclusion and the making of gender-, labour-, and social policies.

ZARAH comprises, in addition to the PI, an international group of nine post-doctoral and doctoral researchers at CEU, distinguished by their excellent command of the history and languages of the region. Research rationale, research questions, and methodological framework were developed through an intensive exploratory research phase (2016–2017). ZARAH is a pioneering project that consists of a web of component and collaborative studies, which include all relevant groups of activists and activisms, span the whole region, and cover the period between the 1880s and the 1990s. It will generate key research resources that are available to all students and scholars, and will set the stage for research for a long time to come.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834087	**COMMIOS**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. IAN ARMIT**
Host Institution: University Of York, UK

Communities and Connectivities: Iron Age Britons and their Continental Neighbours

Recent breakthroughs in ancient DNA and isotope analysis are transforming our understanding of diversity, mobility and social dynamics in the human past. COMMIOS integrates these cutting-edge methods on a scale not previously attempted, within a ground-breaking interdisciplinary framework, to provide a radically new vision of Iron Age communities in Britain (800 BC – AD 100) within their wider European context.

At the broad scale, we will conduct the first concerted programme of genome-wide ancient DNA analysis on Iron Age populations anywhere in the world (c. 1000 individuals in the UK, 250 in Europe), mapping genetic clusters to shed light on ancient populations themselves and on their relationships to modern genetic patterning. Together with isotope analysis, and underpinned by both osteoarchaeological and cultural archaeological approaches, this will also enable us to directly address critical issues of population movement and inter-regional connectivity in Iron Age Europe. We will utilise the power of these new scientific methods to examine the structure and social dynamics of Iron Age societies in Britain, including household and kin-group composition, the identification of familial relationships, gender-specific mobility, and the development of social inequalities. Previously the preserve of cultural anthropologists studying recent societies, we will draw these questions into the archaeological domain, opening up new areas of enquiry for prehistoric societies.

The scope and scale of the project represents a new departure for European archaeology, made possible by the coming-of-age of new analytical methods. Many of these have been pioneered by the project team, which comprises world-leaders in the fields of ancient DNA, isotope analysis, osteoarchaeology, chronological modelling and cultural archaeology. Although focussed on Iron Age Britain, the project will establish a new benchmark for future analyses of other regions and periods in Europe and beyond.

Project End Date: **30-SEP-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834385	**FORMSofLABOUR**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. JANE WHITTLE**
Host Institution: The University Of Exeter, UK

Forms of Labour: Gender, Freedom and Experience of Work in the Preindustrial Economy

The history of labour and its role in Europe's preindustrial development has very largely been the history of adult men. FORMSofLABOUR seeks to put other workers in the picture, particularly women and servants, not simply by 'adding them on' but by showing how a full understanding of women's work and of service offers a radical critique of existing approaches to work and to the idea of free labour. It focuses on England in the period 1300-1700 viewed in a comparative Western European perspective, and addressed these issues through three themes. (1) A revolutionary research technique which collects evidence of work tasks from court records to simulate a time-use study is used to explore the experience of work. This technique allows the work activities of women and men, young and old, employees and family members to be illuminated, with evidence of tasks, location and timing of work, creating an entirely new perspective on England's early modern economy. (2) The theoretical underpinnings of the history of women's work in the preindustrial economy are explored, reassessing key debates using interdisciplinary perspectives from economics and political science, as well as new archival evidence from themes 1 and 3. Gendered work patterns are viewed through the lens of freedom, rather than patriarchy, to create a step-change in our understanding of gender and work. (3) The issue of the extent to which labour was 'free' after the end of serfdom is interrogated through a careful examination of the range of forms of labour and the nature of labour laws, using a variety of archival evidence combined with a comparisons with serfdom and slavery, and the adoption of insights from development economics and anthropology. Together these interlocking themes create a new history of work in the economy which formed the background to grand narratives of Smith and Marx, arguing that with women and servants had been in picture, the story of economic development is transformed.

Project End Date: **31-AUG-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
834616	**ARCHCAUCASUS**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. SVEND HANSEN**
Host Institution: Deutsches Archaologisches Institut, DE

Technical and Social Innovations in the Caucasus: between the Eurasian Steppe and the Earliest Cities in the 4th and 3rd millennia BC

This project leads to one of the most dynamic regions in prehistory: the Caucasus of the 4th and early 3rd mill. BC. During this vibrant time, basic innovations emerged, which were crucial until the 19th century: wheel and wagon, copper alloys, the potter's wheel, new breeds of woolly sheep, domestication of the horse, and others. At the same time, massive migrations from the East European steppe during the early 3rd mill. BC changed the European gene pool.

The project challenges the still predominant narrative that all technical achievements stemmed from urban centres in Mesopotamia. New studies have created space for alternative hypotheses: possibly it was not the development of new techniques, but instead their adaptation from different 'peripheries' and their re-combination and re-configuration that formed the basis for the success of these 'civilisations'.

The Caucasus, linking Mesopotamia to the Eurasia and Europe, is for the first time in the focus of a study on innovation transfer. The study will make a major contribution by investigation of four axial innovations: wheel and wagon, metal alloys, silver metallurgy and woolly sheep. 40 wheels will be analysed by computer tomography and strontium isotopes. Some 300 copper alloys artefacts and 200 silver objects will be examined using mass spectrometry with laser ablation. 400 aDNA genom-wide analyses of humans from burials in the North Caucasus will offer the unique chance of elucidating the role of migrations for the spread of innovations. The pottery in the region, often linked to Mesopotamia, will be studied under technical aspects and is a complementary path to shed light on migration and the transfer of knowledge. Excavations in settlements will allow building up a chronology using 400 AMS 14C analyses. The project is multidisciplinary, making use of the most up-to-date analytical methods. Our long experience and reputation on both sides of the Caucasus is the ideal background for cutting-edge research.

Project End Date: **30-JUN-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
849911	**JANET**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. IOANNIS SPYROPOULOS**
Host Institution: Idryma Technologias Kai Erevnas, GR

Janissaries in Ottoman Port-Cities: Muslim Financial and Political Networks in the Early Modern Mediterranean

JaNet investigates the economic and sociopolitical role of the Janissaries in the 18th and early 19th centuries through their examination as a complex of interconnected networks in the 'extended Mediterranean' (including major Black Sea and Danubian ports). By studying the Janissary corps, the project brings forward a radically new historical analysis concerning, on the one hand, the role of Muslims in the Ottoman and wider Mediterranean commercial economy – a role largely ignored by the bibliography – and, on the other, the processes that led to the creation of diasporas and the dissemination of people and ideas among various Muslim communities in the area.

According to our thesis, in the period under examination, the Janissary corps became one of the main channels for the participation of various Muslim social strata of the Ottoman periphery in the Empire's developing credit market and commercial life, as well as a gateway for their involvement in local and imperial politics. Moreover, it became a platform for the exchange of people, goods, and ideas between different localities covering a vast geographical area. When examined from a Mediterranean perspective, this view allows us to look beyond the information provided by Europe-centered sources and to drastically redefine the sociopolitical and financial role of Muslims in the area, an approach which historical analysis sorely lacks.

The project uses a comparative approach to examine a large number of port-cities in North Africa, Egypt, the Aegean, the Adriatic, the Danube, and the Black Sea. The research team – composed of the PI, three senior researchers, five post-doctoral fellows, and two PhD candidates – will study a variety of unpublished sources in Ottoman Turkish, Arabic, Greek, Russian, French, and English. The team will produce a main monograph, a collective volume, several articles, two PhD dissertations, four workshops, one international conference, and a website.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851053	**Back2theFuture**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. JEROEN PUTTEVILS**
Host Institution: Universiteit Antwerpen, BE

Back to the Future: Future expectations and actions in late medieval and early modern Europe, c.1400-c.1830

From the eighteenth century onwards, the future was considered as open, uncertain and constructible – the way we tend to perceive the future today. In contrast, early modern Europeans believed that the future was beyond the control of man. The aim of this project is to challenge such grand narratives on past futures, which are generally highly linear and focused on modernity, have a fuzzy chronology and thin empirical base, biased by learned text. Moreover, these hypotheses fail to do justice to the presence and interplay of various (multi)temporalities and do not link future expectations to the concrete actions of men and women in the past. Most historians simply ignore the topic, since past futures are extremely hard to find in the written record. Hence, they focus on the actions of men and women in the past rather than their motivations.

To gain more insight in how people in the past thought about the future and how this affected their actions, this project draws on a highly innovative combination of close and distant reading methods of more than 15,000 letters written in (varieties of) Italian, German, French, Dutch and English by and to European merchants in the period 1400-1830. These practical documents enable us to reconstruct different types of future thinking of these merchants and to assess how these thoughts powered their actual behaviour. Better still, they also shed light on the future expectations of their non-merchant correspondents: their wives, children and other family members, clerks, clergy, nobles, craftsmen, etc. A comparative analysis of the letters from these different social groups, written in several languages, in a variety of European regions and during distinct moments, allows us to identify the impact/speed of potential agents of change that loom large in the literature (capitalism, the Reformation, probability calculus, and the Enlightenment) more carefully. With this methodology, we will be able to provide fine-grained explanations.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851352	**MAMEMS**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. ZACHARY CHITWOOD**
Host Institution: Johannes Gutenberg Universitaet Mainz, DE

Mount Athos in Medieval Eastern Mediterranean Society: Contextualizing the History of a Monastic Republic (ca. 850-1550)

MAMEMS will constitute the first comprehensive examination of the monastic communities of Mount Athos as independent actors in medieval Eastern Mediterranean Society. This "monastic republic" was intimately connected with the Byzantine Empire, the various Orthodox principalities of the Balkans and Caucasus, South Italy, as well with the Ottoman Empire. By taking advantage of considerable advances in subfields like prosopography, analyzing and making available a set of sources (lists of commemoration) that are either poorly studied or unedited, and by bringing together an interdisciplinary team (a Byzantinist, Slavicist annd Kartvelologist) under the direction of the PI, MAMEMS will transform the way the Holy Mountain is viewed within scholarship and the general public via a triad of leitmotifs: wealth, ethnicity and gender (WEG). The exploration of these topics will be undergirded by the creation of a prosopographical database, Prosopographika Athonika, containing entries for every monk to have resided on the Holy Mountain, every Athonite benefactor and every person to have visited there from ca. 850 to 1550, that is from the time of the first surviving documents in the Athonite archives until the founding of the last of the major Athonite houses, Stavronikita. This database will finally allow a concrete analysis of how medieval Mount Athos was embedded within wider networks of economic interests, church leadership, intellectual exchange and patronage.

Project End Date: **28-FEB-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851511	**MICROSCOPE**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. STEPHAN SCHIFFELS**
Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Zooming into the Population History of Iron Age Europe with Rare Genetic Variants.

In recent years, archaeogenetic studies have yielded striking insights into European prehistory from ancient DNA. However, these studies focus on times prior and up to the Bronze Age, whereas more recent periods are still poorly covered. A key challenge with studying more recent time periods is the homogenisation of European populations since the late Neolithic, which exposes the limits of many existing analytical methods that try to detect population movements. To overcome these limits, in this proposal I will develop a genetic 'microscope', a new set of fine-scaled analytical methods based on rare genetic variation, which will allow us to analyse ancient genomic data to infer population structure with unprecedented detail. With this new toolbox, I will undertake the largest archaeogenetic investigation of the pre-Roman European Iron Age to date. A specific focus will be the ‘Celtic’ world, encompassing a core region spanning from parts of France into Slovakia, and which reached its maximum extent in the third century BC, spanning from the Iberian Peninsula to Anatolia. I will collaborate with a large number of partners from archaeology and anthropology, as well as genetic laboratories, to sample and analyse 600 skeletal remains from this region and time period. Using the new methods, I aim to investigate i) population structure during the early Iron Age in the 'Celtic' core region of Western and Central Europe; ii) the genetic evidence for the so-called 'Celtic migrations' from the third century BC, specifically by analysing samples from the Iberian Peninsula, Northern Italy, Hungary/Romania and the British isles; iii) how migration and population admixture are reflected at the community- and family level by ‘zooming in’ into selected archaeological sites to reconstruct family pedigrees. With new methodology, new reference data, and hundreds of ancient genomes from the pre-Roman Iron Age, this project will set new standards for archaeogenetic studies in Europe.

Project End Date: **31-OCT-24**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851793	**QuinaWorld**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. GUILLAUME GUERIN**
Host Institution: Centre National De La Recherche Scientifique, FR

Tracking Neanderthals in Time and Space: was the "Quina World" the first regional cultural entity in the history of Europe?

Neanderthals disappeared ~40 000 years ago; although they have received significant public and academic attention, their evolution and behavioural diversity remain little known. Quina Mousterian designates a singular Neanderthal lithic industry; it is often associated with specific, large game seasonal hunting (herds of reindeer). Particular mobility patterns and elaborate carcass processing suggest an image of a complex, intriguing cultural entity. Outside its core area (SW France), Quina Mousterian is also mentioned in different parts of Europe. My project will first aim at testing the hypothesis that a Quina cultural entity existed, i.e. that the occurrences of Quina Mousterian correspond to a short period of time and can thus be attributed to affiliated or connected groups of Neanderthals. A widely interdisciplinary consortium will then aim at defining the characteristics of the assumed Quina entity, how it evolved in time and potentially diffused in space across Europe. High-resolution OSL dating, based on new Bayesian models allowing cutting-edge uncertainties (~2-3%) for periods beyond the radiocarbon dating range, will be implemented to obtain a tight chronological framework and tie the archaeological record with palaeo-environments. Tool production and use, as a function of raw material availability and procurement, will be studied based on a technological and techno-functional approach. The influence of varying climates and environments on the Quina subsistence strategies – approached in terms of both food acquisition and storage – will be deciphered. Palaeo-anthropological and genetic studies will aim at defining the biological identity of the makers of Quina Mousterian, and possible human migrations associated with its diffusion. Eventually, the Quina World project will allow discussing the potentially oldest regionalisation and cultural diffusion patterns of Europe, and shed new light on the array and complexity of Neanderthal behaviours.

Project End Date: **31-DEC-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
851871	**DECOLMAD**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. ANA ANTIC**
Host Institution: Kobenhavns Universitet, DK

Decolonising madness? Transcultural psychiatry, international order and the birth of a global psyche in the aftermath of the Second World War

This project will provide crucial insights into the debate on the universality and cross-cultural applications of the notions of mental health and illness by offering the first and inter-disciplinary account of the historical origins and development of the concept of 'global psyche' and transcultural psychiatry. It will offer the first historical analysis of the colonial and post-colonial roots of the current global mental health movement, and the first systematic account of the decolonisation of psychiatry and mental health sciences. It will argue that the concept of universal, global psyche emerged in the aftermath of WWII and during decolonisation, when Western psychiatry strove to leave behind its colonial legacies, and lay the foundation for a more inclusive conversation between Western and non-Western mental health communities. In this period, leading psychiatrists across the globe set about identifying and defining the universal psychological mechanisms supposedly shared among all cultures (and 'civilisations'). I will explore this far-reaching psychiatric, social and cultural search for a new definition of 'common humanity', which developed in an increasingly inter-connected and culturally diverse global context, and examine the historical forces that drove it. I will also examine how the profession negotiated the tensions between researching cultural particularities and developing new, cross-cultural models of the mind.

The project will answer some of the core questions related to this transformative period: How did psychiatrists and anthropologists from all over the world re-define the relationship between culture, race and individual psyche following the end of the Second World War and colonialism, what was the role of experts from the Global South and Eastern Europe in this transformative process, and did this new global and transcultural psychiatry succeed in departing from the erstwhile colonial frameworks?

Project End Date: **31-JUL-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852176	**INVISIHIST**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. ALANNA O'MALLEY**
Host Institution: Universiteit Leiden, NL

Challenging the Liberal World Order from Within: The Invisible History of the United Nations and the Global South

Of the 193 member states of the United Nations (UN), over half belong to the grouping known as the Global South (also called the Developing World or Third World). Since its creation in 1945, Global South actors have sought to redefine political dynamics and change normative practices through the UN. Yet, histories of the organization are predominantly from the Western perspective. Challenging this view, this research will make a ground-breaking contribution to the field, providing a new genealogy of the UN within the contextual frame of global history in order to investigate how Global South actors shaped global order. It will bring together different perspectives of the UN from archives across the Global South, revealing currently invisible histories of the organization by examining how it was developed by Global South actors between 1945-1981. The project has 3 closely related objectives: 1. To examine how actors from the Global South changed the UN by developing its functions in the areas of decolonization, economic development and human rights; 2. To trace the ways in which Global South actors challenged the liberal world order as they pursued these rights; 3. To analyze why Global South agency at the UN led to the promotion of some issues and actors and excluded others and ask what the consequences were for order within the Global South. The project's innovative contribution is in explaining the ways in which the UN has changed over time by placing an emphasis on the dynamic role of Global South actors. The research will elucidate histories of the ordering role of institutions at a moment when global governance is in crisis and the liberal world order appears to be fragmenting. Its primary impact will be in decolonizing the historiography by highlighting the historical agency of Global South actors, and transposing the importance of the organization in the longer history of the latter half of the twentieth century to provide a truly global history of the UN.

Project End Date: **31-JAN-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
852448	**MaDAf**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. ROMAIN TIQUET**
Host Institution: Centre National De La Recherche Scientifique, FR

A History of Madness in West Africa: Governing Mental Disorder during Decolonisation (Senegal, Burkina Faso and Ghana - 1940s – 1970s)

Combining multi-site archival work, the MaDAf project will outline a history of madness in West Africa, during the decolonisation period and after independence. The project will focus on three main areas connected to the history of Africa, decolonisation, and the history of madness: by looking at a the decolonisation and post-independence periods, the project aims firstly to underline the ruptures but also the continuities in the everyday government of madness; it will offer a theoretical framework for using hitherto unexplored archives in order to construct a comparative history of madness from below; it intends to give a comparative social history of madness that goes beyond the history of psychiatry, and to outline broader analytical pathways to integrating the results into global trends;

Although sociology and anthropology have explored mental disorder in Africa, this theme of research remains under-analysed by historians. This project follows three transversal lines of research: firstly, it will look at the processes of definition and categorisation of madness by a diversity of actors in order to analyse the processes of population control during the (post)colonial era; secondly, it will shed light on a multi-site analysis of madness in West Africa by looking beyond strictly psychiatric spaces in order to scrutinise all the institutions that handle madness in a punitive manner; thirdly, the project will investigate psychiatric institutions in West Africa, understood as a non-penal form of confinement.

MADAF will be the first detailed and comparative historical investigation of madness and psychiatry on the African continent. The project aims to offer ground-breaking results with regard to the ordinary practices and experiences of madness on the ground in West Africa. Combining the methodology offers by micro-history and social history and an interdisciplinary approach, the project will more generally open up new pathways in both African and global history.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
853356	**ANTHEA**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. METTE LØVSCHAL**
Host Institution: Aarhus Universitet, DK

Anthropogenic Heathlands: The Social Organization of Past Grazing Landscapes

In a time of accelerating human-caused ecological catastrophe, questions of institutional resilience have become extremely timely. In bringing the archaeological perspective of a 4200-year timespan, ANTHEA seeks to fundamentally rethink the concept of resilience in past forms of social organization. By shifting attention away from seeing institutional robustness as equilibrium, stability and continuity and placing the questions of instability, uncertainty, and areal flexibility at the centre, ANTHEA introduces a new archaeology of the long-term temporal dynamics that promote super-resilient past land-use regimes. ANTHEA will show how collaborative institutions of common land use were organized in the North European heathland regimes (3200 BC-AD 1000), with a particular emphasis on their earliest emergence, their adaption to internal and external factors as well as their ecological, spatial, and social fabric. ANTHEA is truly multidisciplinary and links landscape and settlement archaeology with paleo-ecological evidence and a new pollen-sampling method, landscape distribution modelling, and spatial analysis. Moreover, ANTHEA is based on 7 case study areas, each targeted by four workpackages focusing on 1) the chronological trajectories, 2) paleoecology, 3) spatiality, and 4) social forms of heathland management in the past. The key contributions of this project will be the introduction of a pioneering theoretical advancement of past super-resilient common land-use forms, and methodological innovation in the temporality of resilience, to be made usable in contemporary land-use policies. The long-term perspective will allow detailed historical trajectories to be established of how common land-use institutions emerged and reorganized according to changing circumstances, challenging the "tragedy of the commons" narrative. Moreover, ANTHEA will provide a new cultural history of heathlands that breaks with rooted ideas of these areas being marginal and underdeveloped.

Project End Date: **31-JUL-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
853390	**StateHorn**	**SH6** The Study of the Human Past

Principal Investigator:	**Dr. JORGE DE TORRES**
Host Institution:	Agencia Estatal Consejo Superior De Investigaciones Cientificas, ES

Pathways to Statehood: Authority, legitimacy and Social Diversity in the Horn of Africa (11th-16th centuries)

The StateHorn Project presents a radically new, archaeology-based approach to one of the key issues in the contemporary world: the nature and characteristics of weak and failed states. Based in the Horn of Africa, an area widely known by recurrent problems of fragmented systems of governance and legitimate authority, the StateHorn project aims to build an alternative vision on the ways statehood has been conceptualized, studied and analyzed in the region. It will do it from a archaeological, deeper past perspective which will take as its focus the medieval period (1100—1600) in northern Somalia and south-eastern Ethiopia, a period which saw the emergence of the defining political, demographic and economic characteristics which have shaped the modern region until the present day. The project aims to understand the nature and conceptualization of the medieval states in this region, which were the roots of their legitimacy and power and how they related with their populations and other neighbouring states.

Organized around five Research Lines (Territory, Material Culture, Written and Oral Sources, Urbanization and Trade), the State Horn project will complement archaeological information with written historical sources, oral traditions, linguistics, literature and ethnography to present the most comprehensive study of statehood in the Horn of Africa during the medieval period. It will also move beyond an enclosed, isolated study of a specific historical period to develop a theory of statehood in the Horn of Africa which is at the same time coherent with the archaeological and historical sources and useful to analyze the current political situation in the region and any other places where weak or failed states are present.

Project End Date: **31-MAY-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
853539	**ANTIGONE**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. ANNA MARIA STAGNO**
Host Institution: Universita Degli Studi Di Genova, IT

Archaeology of shariNg pracTIces: the material evidence of mountain marGinalisatiON in Europe (18th- 21st c. AD)

The main aim of the ANTIGONE project is to investigate how the disappearance of practices for managing shared environmental resources played a role in the abandonment and political marginalisation of European mountain areas from the 18th c onwards. The legacy of these processes can be seen in population levels in these areas, and in the worsening of their natural and cultural heritage. Current policies – aiming to promote their 'heritagisation' – do not seem likely to be more effective, in the long-term, as development interventions than the drive for rationalisation in the 19th c. and modernisation in the 20th c. A new historical perspective is needed which addresses the process of abandonment and marginalisation in its entire complexity. ANTIGONE will analyse the critical period from the 18th to the 21st c. and provide new insights into the links between individuals, communities, central States and landscape, grounded in a new understanding of the relationship between practices, resources and objects.

By means of archaeological, historical, environmental, ethnological analyses, and through the comparison of case studies from European mountain areas, ANTIGONE aims to verify if alleged 'improvement' practices involved not just changes in management technique, but also contributed to decline in the sharing of work, time and space, with knock-on effects on the social dimension of the whole historic system.

Through its multidisciplinary approach ANTIGONE aims at provide: new knowledge on the historical mechanisms underlying the abandonment of mountain and, more broadly, rural areas, as a key to understanding marginalisation; new knowledge on landscapes, practices and their features; a new methodological toolbox for interdisciplinary investigations driven by archaeology; a new role for archaeology, beyond the acknowledged one as a heritage science; new contributions to community based policies for local sustainable development and landscape management.

Project End Date: **31-OCT-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
863650	**GloQur**	**SH6** The Study of the Human Past

Principal Investigator:	**Dr. JOHANNA PINK**
Host Institution:	Albert-Ludwigs-Universitaet Freiburg, DE

The Global Qur'an. Shared Traditions, Imperial Languages and Transnational Actors

This project looks at Qur'an translations as a central medium through which Muslims across the globe today approach their faith. Since the early 20th century, Qur'an translations have been produced in nearly all languages read by Muslims by a variety of individual and institutional actors across nation-state borders. GloQur aims to elucidate three major transnational dimensions of the burgeoning field of Qur'an translation and their interdependence. First, it will examine transnational governmental and non-governmental actors in the field as well as the translations produced by them. Second, it strives to transcend the simple dichotomy between Arabic and 'vernacular' languages by analysing, from a historical perspective, the complex centre-periphery structures created by the spread of European languages such as English, French and Russian. Third, we will study the negotiation and reconstruction of a shared exegetical heritage in various linguistic, social and ideological settings. We will examine the conditions in which translations were and still are commissioned and produced, the literary history and ideological backdrop of translations, the translators' decisions as they become manifest in the texts and their use by local audiences. By studying the role of Qur'an translations in specific Muslim communities, as well as their use in social media, we seek to shed light on the linguistic, cultural and religious significance that is attributed to them and on the processes through which specific translations are elevated to a position of authority. GloQur will thus bridge the gap between philological, historical and anthropological approaches to modern and contemporary Muslim engagement with the Qur'an. By developing an analytical framework for understanding the translation of a sacred text as a transnational religious, social and political practice, the project will break new ground in understanding the global dynamics of contemporary Islam.

Project End Date: **30-APR-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
863671	**IN THE SAME SEA**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. GUNVOR SIMONSEN**
Host Institution: Kobenhavns Universitet, DK

IN THE SAME SEA: THE LESSER ANTILLES AS A COMMON WORLD OF SLAVERY AND FREEDOM

IN THE SAME SEA is the first systematic investigation of the combined history of the Lesser Antilles from the 1650s to the 1850s.

The project advances the hypothesis that the Lesser Antilles were decisively shaped by inter-island connections that transformed separate islands into a common world of slavery and freedom. Living in fragile societies of limited resources and marked by racial slavery, plantation production, and long-distance commerce, enslaved Africans, free people of color, and Europeans depended on and gained vital resources from crossing the short sea routes to their neighbors in English, French, Dutch, Spanish, Danish, and Swedish colonies.

The project consists of a team specializing in the historiographies, archives, and languages of the six colonial powers present in the Lesser Antilles. A collaborative research methodology and digital solutions to data collection and mapping, enable the project to generate crucial new knowledge of how inter-island connections shaped the Lesser Antilles. This is done in five work packages covering the inter-island trade, enslaved movement, maintaining slavery, island belonging, and cultural responses to living in fragile societies.

The project features a number of key elements designed to ensure its impact on the historical field and beyond. First, the project challenges the long-standing focus on European empires as the fundamental lodestone of the history of the Lesser Antilles. Second, it lays the foundation for an online database and digital mapping resource, which will become a crucial research tool in the fields of Caribbean and Atlantic history. Third, it brings a new analytical model to the efforts of studying spatial processes within several fields, amongst others, Atlantic history, new imperial history, and global history. Finally, the project provides vital input to the ongoing dialogues between states and institutions in the Lesser Antilles and Europe regarding the legacies of European colonialism.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864358	**AMI**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. KRISTIINA MANNERMAA**
Host Institution: Helsingin Yliopisto, FI

Animals Make identities. The Social Bioarchaeology of Late Mesolithic and Early Neolithic Cemeteries in North-East Europe

AMI aims to provide a novel interpretation of social links between humans and animals in hunter-gatherer cemeteries in North-East Europe, c. 9000–7500 years ago. AMI brings together cutting-edge developments in bioarchaeological science and the latest understanding of how people's identities form in order to study the relationships between humans and animals. Grave materials and human remains will be studied from the viewpoint of process rather than as isolated objects, and will be interpreted through their histories.

The main objectives are

1) Synthesize the animal related bioarchaeological materials in mortuary contexts in North-East Europe,

2) Conduct a systematic multimethodological analysis of the animal-derived artefacts and to study them as actors in human social identity construction,

3) Reconstruct the individual life histories of humans, animals, and animal-derived artefacts in the cemeteries, and

4) Produce models for the reconstruction of social identities based on the data from the bioanalyses, literature, and GIS.

Various contextual, qualitative and quantitative biodata from animals and humans will be analysed and compared. Correlations and differences will be explored. Intra-site spatial analyses and data already published on cemeteries will contribute significantly to the research. Ethnographic information about recent hunter-gatherers from circumpolar regions gathered from literature will support the interpretation of the results from these analyses.

The research material derives from almost 300 burials from eight sites in North-East Europe and includes, for example, unique materials from Russia that have not previously been available for modern multidisciplinary research. The project will make a significant contribution to our understanding of how humans living in the forests of North-East Europe adapted the animals they shared their environment with into their social and ideological realities and practices.

Project End Date: **31-MAR-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
864542	**KnowStudents**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. VALENTINA LEPRI**
Host Institution: Instytut Filozofii I Socjologii Polskiej Akademii Nauk, PL

From East to West, and Back Again: Student Travel and Transcultural Knowledge Production in Renaissance Europe (c. 1470- c. 1620)

This project is the first comprehensive study of transcultural knowledge production in early modern Europe. Its underpinning idea is that the students who travelled from central-eastern Europe to attend renowned universities were active agents of this transcultural knowledge. During their stays abroad they created personal hand-written notebooks containing lecture notes and any other texts that attracted their interest. Conserved in the archives of the Czech Republic, Hungary, Lithuania, Poland and Ukraine, these notebooks provide us with unique and first-hand documentary evidence of the impact of multiple cultural stimuli on knowledge. Combining intellectual history, history of migration and physical analysis of documents, the project will consider the period from the rise of this practice among students, due to an unprecedented availability of paper (c. 1470), up to the Thirty Years' War, which restricted their travels. Its objectives are to analyse: the relationship between academic and non-academic knowledge gathered in the students' notebooks; the emergence of new forms of self-learning, examining the criteria of text selection; and the contact between humanist culture and the cultures of the countries the students came from. Early modern studies of knowledge production have traditionally focused on academic teaching. Although the cosmopolitan nature of universities is an established fact in these studies, the impact of different cultures (languages, artistic-literary interests, religious practices) on knowledge creation has been neglected, due to lack of evidence. Students' experience makes it possible to observe links between knowledge and a plurality of languages and traditions which best reflects the European scenario at the time. The project will explore knowledge creation from an unprecedented angle, fostering a rethinking of the notion of centre and peripheries in Renaissance studies and breaking important new ground for research on intellectual history.

Project End Date: **31-OCT-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865463	**DiverseNile**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. JULIA BUDKA**
Host Institution: Ludwig-Maximilians-Universitaet Muenchen, DE

Cultural diversity in the Middle Nile Valley. Reconstructing biographies in the periphery of urban centres in northern Sudan during the Bronze Age

One of the biggest scientific challenges for archaeology is to move away from established concepts of cultural categories such as static views of culture, which are not suitable to describe realities of ancient lives. Significant work on the complex encounters between Egyptian and Nubian groups in the Middle Nile was conducted by recent projects including my ERC-2012-StG AcrossBorders. They introduced the modern approach of 'cultural entanglement' to the main urban sites, but left the peripheries unaddressed.

Based on recent successful results, it is now timely to investigate the actual cultural diversity of Middle Nile groups focusing on the periphery of the main centres. The project will explore a crucial part of northern Sudan as a case study to reconstruct Bronze Age biographies (c 1650–1200 BCE) beyond the present categories 'Egyptian' and 'Nubian'.

The main hypothesis is that cultural diversity becomes archaeologically more visible in the peripheral zones of the central sites. We need to investigate the regional cultural relations within the peripheries in order to catch a more direct cultural footprint than in state built urban centres.

Based on the PI's excellent knowledge of Bronze Age settlements and material culture in the Nile Valley, she will test with new excavations in a cultural borderscape whether it is feasible to disentangle sites from previous classifications. By applying the new concept of 'Biography of the landscape' in conjunction with the 'contact space' model, she intends to investigate whether degrees of diversity relate to the peripheral location of sites, which may also be influenced by the geographical topography.

Beyond the impact for archaeology, the project's innovative theoretical approach together with a large set of interdisciplinary methods such as neutron activation and isotope analysis offers a long-overdue input to general questions of border studies, which are also essential to understand the role and function of main centers.

Project End Date: **31-MAR-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
865898	**BuildingTomorrow**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. ARTEMY KALINOVSKY**
Host Institution: Universiteit Van Amsterdam, NL

Building a Better Tomorrow: Development Knowledge and Practice in Central Asia and Beyond, 1970-2017

The landscape of post-Soviet Central Asia (Tajikistan, Uzbekistan, Kyrygzstan, Kazakhstan, Turkmenistan) is littered with the physical remnants of Soviet development, both positive –health clinics and schools – and negative - decaying factories, polluted soil, and dried out rivers. Less visible are Soviet development's political, intellectual, and institutional legacies. Yet just as post-socialist states and international development organizations have been forced to deal with the physical legacies of socialism, their approaches to economic development, welfare provision, and governance has been shaped by the socialist past. After the collapse of the USSR in 1991, the newly independent states of Central Asia invited international institutions and foreign donors to help them achieve prosperity and transition to a market economy. At the time, most development institutions and national governments subscribed to the so-called "Washington Consensus" which emphasized financial discipline, minimum state regulation, and open borders. This project proposes to study the influence of Central Asian economists, activists, specialists, and government officials who straddled the Soviet/post-Soviet divide by going to work in national and international development institutions after independence. By studying these individuals and the legacies of their work will allow us to investigate how ideas and practices of economic development and welfare provision were shaped and reshaped at the local and international level. The project will uncover how international development transformed post-Soviet Central Asia, and how the encounter with post-socialist states transformed paradigms and practices of international development. The research will thus make an innovative scholarly contribution to understanding the legacy of socialism, the history of economic development, and the the global history of development.

Project End Date: **30-APR-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866421	**TIMEHIST**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. NITIN SINHA**
Host Institution: Geisteswissenschaftliche Zentren Berlin Ev, DE

Timely Histories: A Social History of Time in South Asia

This project aims to write the history of time and temporal cultures in South Asia between the 1500s and the 1950s on a practice- and process-based history. Covering this broad timespan under five modular units, the objective is to investigate and write the graded pasts of shifts and transformations within them. In doing so, it departs from the usual approaches that focus either on the device (clock) or on the modern nation-state institutions such as army, school, factory, and office. Instead, while going beyond device-centrism, it puts 'othered' spaces of temporal practices such as field, farm, jungle, and river in the centre of the time's history.

The project's novelty is in the combined strength of transcending the widely applied frameworks across regions as well as in opening new fields of inquiry for South Asia. By generating rich empirical works, guided by interdisciplinary theoretical approaches, five clearly laid-out units will achieve this.

One, the history of work and time in which instead of factory and clock the focus is on ecology and legality across agrarian, informal, and industrial sites; two, the role of nocturnal time in shaping the practices of social transgressions but crucially in constituting the 'rule of law'; three, the history of 'hidden scripts' of waiting and delay that have been neglected under the weight of technologies of speed; four, the history of the future as imagined and shaped by people using diverse resources ranging from life insurance to visiting religious time-tellers; and five, an independent unit on the early modern period that would break the rigid periodisation in history writing by exploring continuous and changing time-practices. Temporal modernity, the project argues, emerged from the existing temporal cultures rather than supplant them. Through its bold yet feasible scope, TIMEHIST promises to establish temporality as an independent analytical category in studies on spatiality, colonialism, and social history.

Project End Date: **31-DEC-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
866454	**archaeoscape.ai**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. DAMIAN EVANS**
Host Institution: Ecole Francaise D'Extreme-Orient, FR

Exploring complexity in the archaeological landscapes of monsoon Asia using lidar and deep learning

Compelling evidence is now emerging that tropical environments were cradles of innovation and complexity from prehistory to the present. Tropical forests in particular have long been considered marginal and inhospitable, but recent work suggests that several critical milestones were achieved in these landscapes. Vast expanses were terraformed by increasingly complex societies, often in a quest to mitigate the sharp seasonality of the monsoon. Ostensibly wild and pristine rainforests are now characterised as managed 'gardens'. The giant low-density settlement complexes of 'rainforest civilisations' anticipate the sprawling megacities of our contemporary world, and offer a laboratory for understanding the profound challenges that they create.

To date, these emerging perspectives have largely been driven by advances in palaeobotany, archaeogenetics, isotopic analyses, and contemporary rainforest ecology. Remote sensing has so far played only a modest role in this broader agenda, in spite of the unique capability of lidar technology to 'strip away' vegetation and reveal archives of human activity inscribed in the Earth's surface.

This program will tackle the core problems that currently constrain the 'lidar revolution' in archaeology: We will use a new generation of lidar technologies to greatly expand coverage in Southeast Asia, home to many of the most important and understudied rainforest landscapes. We will develop open access frameworks and infrastructures for aggregating, sharing and collaborating on new and existing lidar datasets. We will build on recent advances in artificial intelligence to develop generic models for automation and analysis, in order to move beyond localised, culturally-specific lidar applications. The net result of this work will be to create consistent, comparable datasets of human impacts on the Earth's surface, with a view to understanding trajectories of innovation and complexity in the tropical world from the deep past to the present.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
882894	**The Wall**	**SH6** The Study of the Human Past

Principal Investigator:	**Dr. GIDEON SHELACH-LAVI**
Host Institution:	The Hebrew University Of Jerusalem., IL

The Wall: People and Ecology in Medieval Mongolia and China

Why did some (but not all) Chinese dynasties invest huge amount of resources in the construction of 'Great Walls'? The proposed project will focus on precisely that question, in an attempt to unravel what is perhaps the most enigmatic episode of 'Great Wall' construction. Roughly dated to the 10th-13th centuries CE and located far to the north of other 'Great Wall' lines, this Medieval Wall System (MWS) is one of the longest walls ever constructed in world history, stretching over more than 3,500 km and including large auxiliary structures (Fig. 1). The amount of resources invested in this MWS must have been enormous, but historical sources are mute about its construction, and modern scholarship is unable to date it precisely or understand why it was built and how it functioned. The motives behind the construction of the MWS, its political context and ecological implications, are highly relevant for the understanding of the complex history of China and Mongolia on the eve of Chinggis Khan's rise to power. However, because in the past scholars have assumed that 'Great Walls' were fortified border lines designed to stop military incursions, such issues' impetus and consequences were never addressed. Hence, the proposed project will put forward novel hypotheses, analyse them by using advanced recovery and analytical methods, and examine them against a broad archaeological, historical, environmental, and geographical background. The research hypothesis of the proposed project is that the MWS was not built as a defence against invading armies, but rather as a means to monitor and sometimes stop the movement of nomadic people and their herds. The large-scale movements of nomadic people towards more central areas of the empire happened, I would suggest, in times of ecological stress in the Steppe.

Project End Date: **30-SEP-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
810104	**PoInt**	**SyG** Synergy

Principal Investigator:	**Dr. REINHARD FÄSSLER**
Host Institution:	Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Principles of Integrin Mechanics and Adhesion

Integrin-mediated adhesion to the extracellular matrix is a prerequisite for the development and homeostasis of multicellular organisms. A hallmark of integrins is that ligand binding requires an “integrin activation” step affecting the shape of the entire molecule is induced by the integrin tail- and actomyosin-binding adaptor proteins talin and kindlin. In a second step, integrins cluster and assemble a gigantic signaling hub, where they integrate biochemical and biophysical signals to achieve their functional output. Due to the lack of combined expertise and suitable technologies, the key steps of integrin activation are still largely unknown and the underlying physical principles still need to be identified. We propose a multifaceted approach combining quantitative single molecule measurements, reconstitution of minimal and cellular adhesion complexes as well as development of multicellular structures and organoids. We propose four aims. In our first aim we will unravel how forces are propagated through the talin-integrin tail bonds and how force-induced integrin shape changes affect signaling. In the second aim we will use novel force spectrometers to determine energy landscapes and the high-resolution structure of fibronectin-integrin complexes. In our third aim we will use in vitro model membranes to test how integrin tail-binding adaptors, cortical F-actin and specific domains of integrins induce integrin clustering. With our fourth aim we will unravel how integrins integrate chemical and biophysical signals during organ development. Using the proposed synergistic approach, we will decipher fundamental principles of cell adhesion biology. Furthermore, our research will result in a better understanding of the fundamental mechanisms regulating adhesion signaling that will allow us to develop strategies to curb adhesion functions without completely blocking integrins, thus limiting the enormous side effects of current interventions.

Project End Date: **31-MAR-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
810115	**DYNASNET**	**SyG** Synergy

Principal Investigator:	**Dr. LASZLO LOVASZ**
Host Institution:	Magyar Tudomanyos Akademia Renyi Alfred Matematikai Kutatointezet, HU

Dynamics and Structure of Networks

Networks define our life, being essential to cell biology, communications, social and economic systems, and impacting virtually all areas of science and technology. The aim of this proposal is to engage leading experts in network science and graph theory to build a mathematically sound theory of dynamical networks, which will be transformative to our understanding of complex systems, with applications in multiple disciplines.

Both fields have made major conceptual advances in the past decade: network science has offered a data-based basic topological description of complex networks, and has started to address the inherently dynamical nature of real networks, their reconstruction and control; in mathematics we have seen major advances in graph limit theory, the local-global dichotomy in observation, and promising steps in the theory of graphs with intermediate degrees, that capture real networks. While these concepts offer different formalisms to capture the same underlying reality, there has been no conversation between the two communities, limiting our understanding of real networks.

The proposed research aims to build on these advances to construct a coherent theory of dynamical networks, and to exploit its applications and predictive power to various real systems. We plan to offer a sound mathematical foundation of network science, helping us better analyze, predict and control the behavior of real networks. It will benefit mathematics in leading to an enriched, robust graph limit theory, with exciting applications in multiple areas of mathematics. To enhance the wider impact of the proposed mathematical advances, we plan to conduct a permanent conversation with experts from different domains that encounter and explore real networks, from cell biology to brain science and transportation and communication networks, inspiring with novel questions and helping the application of our advances in these domains.

Project End Date: **31-AUG-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
810131	**PLAMORF**	**SyG** Synergy

Principal Investigator: **Dr. FRIEDRICH KRAGLER**
Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Plant Mobile RNAs: Function, Transport and Features

An essential consequence of multi-cellularity is the need for intercellular and tissue wide communication. As seen with animals, higher plants coordinate metabolic and developmental processes via signals transferred to different body parts. Plants use a dual vascular system consisting of phloem and xylem for long-distance transfer of metabolites and signalling molecules. In contrast to circular systems in animals, transport in flowering plants occurs in the phloem via the cytoplasm of connected cells devoid of nuclei. In addition to small molecules, a remarkably large number of so-called mobile micro RNAs (miRNAs), messenger RNAs (mRNAs), and phloem RNA-binding proteins (RBPs) were identified in the phloem and in chimeric plants. Mobile RNAs and RBPs move through plasmodesmata into and through the phloem to distinct tissues. Thus, mobile RNAs represent an additional class of signalling molecules, raising important questions in the field of intercellular signalling. This project combines the expertise of three research groups in the fields of cell biology/macromolecular transport, mathematical modelling/bioinformatics and phloem function/protein biochemistry. It addresses the questions: How are mobile miRNAs and mRNAs selected for transport? Is this process specific and regulated by RBPs and motifs? What determines their destination? And importantly, how are these signals processed in the destination cells? To address these questions, we will develop predictive models, using novel single cell transcriptomics pipelines to establish cell-type specific RNA transport and motifs (WP1), and studying the structure, affinity, and functions of phloem RBPs to gain insights in the RNA delivery mechanism (WP2). We will combine the advantages of the agronomically important plant oilseed rape to identify phloem RNAs and RBPs with the well-established A. thaliana model that allows us to identify and test cell-specific transported RNA signals and RBPs in a time-efficient manner.

Project End Date: **31-MAR-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
810141	**EuQu**	**SyG** Synergy

Principal Investigator:	**Dr. MERCEDES GARCIA-ARENAL**
Host Institution:	Agencia Estatal Consejo Superior De Investigaciones Cientificas, ES

The European Qur'an. Islamic Scripture in European Culture and Religion 1150-1850

"The European Qur'an" (EuQu) will study the place of the Muslim holy book in European cultural and religious history (c.1150-1850), situating European perceptions of the Qur'an and of Islam in the fractured religious, political, and intellectual landscape of this long period. The Qur'an plays a key role not only in polemical interactions with Islam, but also in debates between Christians of different persuasions and is central to the epistemological reconfigurations that are at the basis of modernity in Europe, from Iberia to Hungary. The Qur'an is deeply imbedded in the political and religious thought of Europe and part of the intellectual repertoire of Medieval and Early Modern Europeans of different Christian denominations, of European Jews, freethinkers, atheists and of course of European Muslims. We will study how the European Qur'an is interpreted, adapted, used, and formed in Christian European contexts – often in close interaction with the Islamic world.
EuQu will produce, over a six-year period:

1. A GIS-mapped database of the European Qur'an, containing extensive information about Qur'an manuscripts and printed editions (in Arabic, Greek, Latin, and European vernaculars) produced between 1143 and 1800 as well as prosopographical data about the principal actors involved in these endeavours (copyists, translators, publishers).

2. A series of publications: PhDs, monographs written by postdocs and PIs, special issues of academic journals, and animated digital publications for a wider audience and educational uses. They will make key breakthroughs in their fields, dealing with aspects of the transmission, translation and study of the Qur'an in Europe, on the role the Qur'an played in debates about European cultural and religious identities, and more broadly about the place of the Qur'an in European culture.

3. A major exhibition during the final year of the project, "The European Qur'an" to be held at museums in Nantes, London, Budapest and Madrid.

Project End Date: **31-MAR-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
810172	**IndiGene**	**SyG** Synergy

Principal Investigator:	**Dr. EWAN BIRNEY**
Host Institution:	European Molecular Biology Laboratory, DE

Genetics of Individuality

We propose to thoroughly investigate and characterise the sources of variation that results in varying phenotypes in a complex vertebrate. As well as characterising the genetic and environmental sources of variation, we will also investigate individual stochastic variation present even in fixed settings (both genetically and environmentally). To achieve this we will exploit the unique properties of Medaka fish, which can be fully inbred from the wild. We have already inbred and performed whole genome sequencing of a panel of 111 diverse Medaka fish from a single location; we propose to phenotype these fish in depth with high replication structure, ranging from organismal to molecular phenotypes. We will also phenotype entirely wild fish from the same source population as the panel with a subset of the phenotypes. We will analyse the data using state of the art methods to partition variation between genetic, environmental and stochastic components, and their interactions. We will integrate across both the different levels of phenotypic information across the cardiovascular system, and also across vertebrate phenotypes, in particular the extensive human phenotypes. By using genetic crosses and CRISPR-Cas9 techniques we will definitively prove specific interactions. We will host a “Research Hotel” for other phenotyping schemes to be applied to this panel, in particular from the Zebrafish community. This comprehensive and carefully replicated study will allow us to understand the opportunities and limitations of genetic stratification and personalised medicine in humans.

Project End Date: **31-JAN-24**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
810182	**SCOPE**	**SyG** Synergy

Principal Investigator: **Dr. Annemie Bogaerts**
Host Institution: University of Antwerpen, BE

Surface-COnfined fast-modulated Plasma for process and Energy intensification in small molecules conversion

The SCOPE project will introduce a ground-breaking approach to use renewable energy in three major industrial reactions: 1) N2 fixation, 2) CH4 valorization and 3) CO2 conversion to liquid solar fuels. We will use non-thermal plasma, which has large potential to convert these small (low reactive) molecules under near ambient temperature and pressure, particularly for distributed processes based on renewable energy. The new processes have drastically lower carbon footprint (up to over 90% with respect to current ones). Furthermore, CO2 conversion is crucial for a world-based distribution of renewable energy. However, the selectivity and energy efficiency of plasma technologies for these reactions are too low, making radically new approaches necessary.

The Project idea is to realize a highly innovative approach for non-thermal plasma symbiosis with catalysis. By inducing excited states in solid catalysts to work in synergy with the excited short-lived plasma species, we introduce a brand new idea for catalyst-plasma symbiosis. In addition, we introduce a fully new concept of nano-/micro-plasma array through a novel electrode design, to generate the plasma at the catalyst surface, thereby overcoming long distance transport. By embedding ferro-magnetic nano-domains in the catalyst support and inducing radiofrequency heating, we create fast temperature modulations directly at the catalyst active sites. Combining these elements, the project will overcome the actual limits and enhance the selectivity and energy efficiency to levels suitable for exploitation. This requires a synergy over different scale elements: nano at catalyst, micro at the level of modelling plasma generated species, milli at the reactor scale and mega at the plant level for sustainability-driven opportunity guidance and impact assessment by Life-Cycle-Assessment. The synergy value derives from the integration of the PI competencies over this entire dimensional-scale level.

Project End Date: **31-MAR-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
810182	**SCOPE**	**SyG** Synergy

Principal Investigator:	**Dr. Gabriele CENTI**
Host Institution:	Universita Degli Studi Di Messina, IT

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Project End Date: **31-MAR-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
810296	**DECODE**	**SyG** Synergy

Principal Investigator:	**Dr. MICHAEL BOUTROS**
Host Institution:	Deutsches Krebsforschungszentrum, DE

Decoding Context-Dependent Genetic Networks in vivo

The evolutionary success of multicellular organisms is based on the division of labor between cells. While some of the molecular determinants for cell fate specification have been identified, a fundamental understanding of which genetic activities are required in each cell of a developing tissue is still outstanding. The DECODE project will develop and apply leading-edge system genetics methods to Arabidopsis and Drosophila, two major model systems from the plant and animal kingdoms to decode context-dependent genetic networks in vivo. To achieve this, DECODE will bring together experimental and theoretical groups with complementary expertise in model organism genetics and cellular phenotyping, single-cell genomics, statistics and computational biology. Building on our combined expertise, we will create functional genetic maps using conditional CRISPR/Cas9-based single- and higher order knockout perturbations in vivo combined with single-cell expression profiling and imaging. Coupled with powerful computational analysis, this project will not only define, predict and rigorously test the unique genetic repertoire of each cell, but also unravel how genetic networks adapt their topology and function across cell types and external stimuli. With more than 3000 conditional knockouts, characterized by at least six million single-cell transcriptome profiles and high-resolution imaging this project will create the largest single-cell perturbation map in any model organism and will provide fundamental insights into the genetic architecture of complex tissues. Analyzing two tissues with divergent organization and regulatory repertoire will enable us to uncover general principles in the genetic circuits controlling context dependent cell behavior. Consequently, we expect that the DECODE project in model organisms will lay the conceptual and methodological foundation for perturbation-based functional atlases in other tissues or species.

Project End Date: **30-JUN-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
810316	**4-D nanoSCOPE**	**SyG** Synergy

Principal Investigator: **Dr. GEORG SCHETT**
Host Institution: Universitatsklinikum Erlangen, DE

Advancing osteoporosis medicine by observing bone microstructure and remodelling using a four-dimensional nanoscope

Due to Europe's ageing society, there has been a dramatic increase in the occurrence of osteoporosis (OP) and related diseases. Sufferers have an impaired quality of life, and there is a considerable cost to society associated with the consequent loss of productivity and injuries. The current understanding of this disease needs to be revolutionized, but study has been hampered by a lack of means to properly characterize bone structure, remodeling dynamics and vascular activity. This project, 4D nanoSCOPE, will develop tools and techniques to permit time-resolved imaging and characterization of bone in three spatial dimensions (both in vitro and in vivo), thereby permitting monitoring of bone remodeling and revolutionizing the understanding of bone morphology and its function.

To advance the field, in vivo high-resolution studies of living bone are essential, but existing techniques are not capable of this. By combining state-of-the art image processing software with innovative 'precision learning' software methods to compensate for artefacts (due e.g. to the subject breathing or twitching), and innovative X-ray microscope hardware which together will greatly speed up image acquisition (aim is a factor of 100), the project will enable in vivo X-ray microscopy studies of small animals (mice) for the first time. The time series of three-dimensional X-ray images will be complemented by correlative microscopy and spectroscopy techniques (with new software) to thoroughly characterize (serial) bone sections ex vivo.

The resulting three-dimensional datasets combining structure, chemical composition, transport velocities and local strength will be used by the PIs and international collaborators to study the dynamics of bone microstructure. This will be the first time that this has been possible in living creatures, enabling an assessment of the effects on bone of age, hormones, inflammation and treatment.

Project End Date: **31-MAR-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
810370	**CloudCT**	**SyG** Synergy

Principal Investigator: **Dr. YOAV SCHECHNER**
Host Institution: Technion - Israel Institute Of Technology, IL

Climate CT- Cloud Tomography by Satellites for Better Climate Prediction

Clouds play a lead climatic role, controlling energy fluxes and regulating fresh water distribution. There is an acute need for cloud-resolving and global-climate models that accurately describe and parametrize the physics of warm convective and stratiform clouds, and the clouds' sensitivity to environmental changes. Currently this requirement is not being met due to a gap in observational capabilities. Namely, there is a lack of sufficient sensing tailored to capture the 3D macro and microphysical properties of warm clouds, which are often spatially unresolved. Moreover, current retrievals use a plane-parallel radiative model, which is incompatible with the 3D heterogeneous nature of clouds. These gaps lead to uncertainties in climate models and prediction.

We propose an innovative sensing approach: cloud scattering-tomography, relying on an unprecedented large formation of ten cooperating, small high performance satellites. They will simultaneously image cloud fields from multiple directions, at 50m resolution. Based on this data, the novel tomography approach will seek the 3D volumetric structure of cloud fields, base-to-top profiles of droplets' size and their variance, volumetric distribution of optical extinction and rain indicators. To meet the required pointing accuracy, data size, and coordinated control of such a formation, advanced and innovative space engineering methods are mandatory. We will optimize and validate this approach, based on advanced in-orbit autonomy, distributed computing, networked control and communication in the formation.

This multidisciplinary, synergic approach will establish and test critical and currently unconventional aspects of remote sensing and mathematical retrieval. It will yield a database of 3D macro and micro structure of warm cloud fields, while setting the stage for next-generation distributed spaceborne global observations.

Project End Date: **31-JUL-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
854843	**FASTCORR**	**SyG** Synergy

Principal Investigator:	**Dr. OLLE ERIKSSON**
Host Institution:	Uppsala Universitet, SE

Ultrafast dynamics of correlated electrons in solids

Experimental activities at advanced photon sources, such as pulsed lasers, high harmonic generation facilities, and X-ray free electron lasers, generate results that challenge our understanding of light-matter interaction and ultrafast dynamics at the femtosecond and sub-femtosecond timescales. These results are particularly difficult to interpret for materials with correlated electrons, where a driving pulse can produce strong non-linear effects.

In FASTCORR, we answer this challenge with the development of a theory for driven quantum many-body systems that goes well beyond existing methods. This will be accomplished by developing dynamical mean-field theory and its generalizations, e.g., the dual fermion and dual boson theory, to cover out-of-equilibrium phenomena.

We aim to create a solid theoretical foundation on which we will build practical tools that allow to interpret and predict ultrafast time-resolved phenomena of correlated electron systems. This involves (i) the development of fundamental mathematical and physical concepts, (ii) software implementation, and (iii) numerical simulations that will be compared to experiments. Synergies between the three applicants are crucial to achieving the goals of this project.

FASTCORR will result in novel high-performance software that we will distribute freely. These computational tools will enable designed and targeted calculations for driven materials where the electronic structure is determined by strong correlation effects. The developed theory will be used hand in hand with world-leading experimental works in the field of pump-probe measurements and spectroscopy, e.g., as investigated at X-ray free-electron laser laboratories.

Project End Date: **31-MAY-26**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
855005	**urbisphere**	**SyG** Synergy

Principal Investigator: **Dr. Nektarios CHRYSOULAKIS**
Host Institution: Idryma Technologias Kai Erevnas, GR

urbisphere - coupling dynamic cities and climate

urbisphere will change how the scientific community conceptualises, characterizes and forecasts cities in the climate system and in urban planning, by developing a radically new approach to integrate multiple dimensions of urban change, their interaction and feedbacks. It aims to forecast and project urban futures and climates in a dynamic framework considering weather, air quality, differential exposure and vulnerability of people at neighbourhood to city scale. It will provide new insights into existing and emerging risks, based on a synergistic effort across disciplines which currently work mostly in parallel. Urban-Surface Models (USM) and Human Exposure and Vulnerability models (HEV) will be developed and coupled to improve the forecasting of exposure, emissions, and intervention potentials in cities. This will transform emergency/risk management, atmospheric forecasting and long-term urban development/adaptation strategies in the urban sphere. The system will use a real-time 4D Smart Urban Observation System (SmUrObS) to provide targeted urban form/function/emissions/exposure data using novel ground and remote sensing technology. The USM-HEV-SmUrObS system will equip us with: 1) a deep understanding of socio-economic dynamics and human behaviour and responses to weather and climate, economic (and other) drivers that transform cities' exposure and vulnerability to climate change-related hazards (like heat); 2) a consistent method that can be scaled from detailed high-resolution modelling of intra-neighbourhood scale characteristics, to climate and socio-economic modelling and assessment at city, regional and global scales; 3) an approach that can inform global climate and global vulnerability and risk modelling; will allow consistent downscaling to the city for decision making for local urban risk and resilience management; and provide information on the dynamic nexus of exposure and vulnerability of people in cities.

Project End Date: **31-MAR-26**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
855005	**urbisphere**	**SyG** Synergy

Principal Investigator: **Dr. Sue Grimmond**
Host Institution: University of Reading, UK

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Project End Date: **31-MAR-26**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
855005	**urbisphere**	**SyG** Synergy

Principal Investigator: **Dr. Andreas Christen**
Host Institution: University of Freiburg, DE

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Project End Date: **31-MAR-26**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
855005	**urbisphere**	**SyG** Synergy

Principal Investigator: **Dr. Joern Birkmann**
Host Institution: University of Stuttgart, DE

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Project End Date: **31-MAR-26**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
855109	**GALVANI**	**SyG** Synergy

Principal Investigator:	**Dr. FABRICE WENDLING**
Host Institution:	Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

Controlling epileptic brain networks with computationally optimized weak electric fields

Epilepsy is a neurological disorder affecting 65 million people worldwide. Pharmacological treatments or surgery are ineffective in one third of the cases – 19 million people. Recent findings indicate that non-invasive brain transcranial current stimulation (tCS) is safe and of therapeutic promise in epilepsy. However, it is not yet indicated as a standard treatment due to major scientific limitations: unknown mechanisms of action, insufficient account for patient-specific factors, poor understanding of short- and long-term effects.

Our ambition is to transform the care of a large fraction of patients living with drug-resistant epilepsies by solving a fundamental problem: to efficiently target and control large-scale epileptic brain networks with tCS-induced neuromodulatory weak electric fields.

To proceed, GALVANI's synergetic research strategy addresses four interdisciplinary challenges: (1) Unravel the intricate relationship between weak electric fields and their neurophysiological effects at the level of neurons, neuronal assemblies and networks; (2) Maximize their therapeutic effects by altering the neurodynamics of patient-specific epileptogenic networks; (3) Develop optimal personalized neuromodulation protocols for novel multichannel tCS technologies; (4) Test optimized protocols in a cohort of patients and objectively define potential responders.

The required competences and resources are met in GALVANI, uniting the passion and background of three experts and their teams in biomathematics (computational neuroscience), biophysics (bioelectromagnetism) and medicine (epileptology).

The project vision is that critical features of pathological networks can be effectively captured in a new generation of hybrid computational models developed for tailored therapy. The inflection point is to prevent epileptic seizures from a bottom-up mechanistic understanding and control of tCS effects. This will entail a paradigm shift in epileptic disorders and beyond.

Project End Date: **31-MAY-26**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
855158	**ANEUPLOIDY**	**SyG** Synergy

Principal Investigator: **Dr. IVA TOLIC**
Host Institution: Ruder Boskovic Institute, HU

Molecular origins of aneuploidies in healthy and diseased human tissues

Chromosome segregation errors cause aneuploidy, a state of karyotype imbalance that accelerates tumor formation and impairs embryonic development. Even though mitotic errors have been studied extensively in cell cultures, the mechanisms generating various errors, their propagation and effects on genome integrity are not well understood. Moreover, very little is known about mitotic errors in complex tissues. The main goal of this project is to uncover the molecular origins of mitotic errors and their contribution to karyotype aberrations in healthy and diseased tissues. To achieve our goal, we have assembled an interdisciplinary team of experts in molecular and cell biology, cell biophysics, chromosomal instability in cancer, and theoretical physics. Our team will introduce novel approaches to study aneuploidy (superresolution microscopy, optogenetics, laser ablation, single cell karyotype sequencing) and apply them to state-of-the-art tissue cultures (mammalian organoids and tumoroids). In close collaboration, Tolić will establish assays to detect and quantify error types in cells, and Kops and Amon will use the assays on various healthy and cancer tissues. Tolić and Kops will uncover the molecular origins of errors, their propagation and impact on genome integrity, while Amon will lead the investigation of the mechanisms that ensure high chromosome segregation fidelity in healthy tissues. Interwoven in these collaborations are the efforts of Pavin, who will develop a theoretical model to describe the origin of errors and to quantitatively link chromosome segregation fidelity in single cells and tissues. Model and experiment will continuously inspire each other, to achieve deep understanding of how mitotic errors arise, how they propagate and how they impact on cell populations. Thus, the extensive sets of expertise present in our team will be combined and expanded with novel technologies to tackle the big challenge of the origins of aneuploidy in humans.

Project End Date: **31-MAR-26**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
855741	**DDREAMM**	**SyG** Synergy

Principal Investigator: **Dr. JACOB CORN**
Host Institution: Eidgenoessische Technische Hochschule Zurich, CH

Dna Damage REsponse: Actionabilities, Maps and Mechanisms

To monitor and protect their genomes, eukaryotic cells have evolved sophisticated DNA-damage response (DDR) systems that comprise DNA repair and DNA-damage signaling processes. DDR deficiencies are associated with diverse human disorders, ranging from aggressive hereditary and sporadic cancers to inherited genetic diseases. The impact of DNA repair has also recently been harnessed to treat diseases through “synthetic lethal” cancer treatments and CRISPR-Cas genome editing. However, the fundamental interactions between DDR pathways that underpin such therapeutic opportunities are still not well understood. Furthermore, we are only just beginning to understand how suppressive functional interactions (so-called “synthetic viability”) can lead to resistance to DDR-targeting therapeutics. Our proposed research will address these important issues by using cutting-edge technologies in gene editing and chemical biology, and by taking a multidisciplinary approach to create deeply integrated genetic and physical maps of DDR pathways and interactions in many human cell types. Next-generation CRISPR-Cas transcriptional genome-wide approaches will be used to uncover hypo- and hyper-morph alleles that affect cellular sensitivity to DNA-damaging agents and DDR-enzyme inhibitors, thus providing insights into DDR events and explaining human DDR-deficiency phenotypes. Mass spectrometry and in-depth mechanistic studies will establish physical interaction networks within the genetic framework and reveal the signaling logic that underpins DDR outcomes and vulnerabilities. With chemical-genetic approaches, we will develop small molecule tools to precisely interrogate DDR pathways and that could lead to new therapeutic agents. In sum, our work should provide major insights into human genome surveillance in multiple cell types, yield powerful tools to precisely control DNA repair outcomes, and speed the development of new therapies for cancer and other diseases.

Project End Date: **28-FEB-26**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
856404	**SPHERES**	**SyG** Synergy

Principal Investigator: **Dr. DOMINIQUE LANGIN**
Host Institution: Universite Paul Sabatier Toulouse Iii, FR

Lipid droplet hypertrophy : the link between adipocyte dysfunction and cardiometabolic diseases

The goal of SPHERES is to understand the dynamics and consequences of adipocyte hypertrophy (enlargement) through investigation of its large lipid droplet (LD). The adipocyte LD is a unique organelle specialized in storing energy in triglycerides (TGs). Its surface is composed of a phospholipid monolayer and specific LD-associated proteins (such as perilipins, CIDEs and lipases), which jointly regulate LD stability and TG turnover. Adipocyte hypertrophy due to an increase in LD size may, irrespective of body fat mass, cause a wide range of pathological conditions, notably cardiometabolic diseases. SPHERES PIs (Langin, Rydén, Antonny) postulate that disturbances in the interactions between LD proteins and LD lipid composition lead to adipocyte hypertrophy and its deleterious consequences. We have identified three fundamental unanswered questions: what determines the unique structure and dynamics of large LD; why does increased LD size alter the functional phenotype of the adipocyte; which factors cause inter-individual variations in LD size. To address these questions, SPHERES gathers expertise in clinical and cellular studies on human adipocytes, in/ex vivo investigations in mouse models, and biophysical analyses of LDs. At the core of this application is the development of beyond-state-of-the-art models and methods (spheroid cultures, native large LD preparation and reconstitution, proximity labelling of LD proteins, gene editing in cell and mouse models, and advanced LD imaging), only achievable through joint integrated effort of the PIs and co-workers. Spanning from molecular, cellular to the whole-body level, SPHERES will link new knowledge on the formation and maintenance of large adipocyte LDs to the deleterious impact of adipocyte hypertrophy. Altogether, SPHERES has a strong potential to discover novel pathogenic mechanisms, leading to a better understanding of highly prevalent diseases and identification of therapeutic strategies targeting adipocytes.

Project End Date: **31-AUG-26**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
856405	**ADAM**	**SyG** Synergy

Principal Investigator: **Dr. GRAEME DAY**
Host Institution: University Of Southampton, UK

Autonomous Discovery of Advanced Materials

Materials impact most aspects of our lives, including healthcare, energy production, data storage and pollution control. However, the design of functional materials cannot be approached with the certainty and the engineering rules that would be used in planning and constructing a macroscopic object, such as a car or bridge. This is because of the limited scope for design that exists at the atomic scale: experimentally realizable materials must correspond to local minima on a complex, multidimensional energy surface, whose positions and depths are difficult to predict. This project will change the way that we discover new molecular materials by revolutionizing the exploration process, rather than focussing on rules for intuitive design. This will be achieved through a unique synergistic partnership between three principal investigators, bringing together an international leader in crystal structure modelling and prediction methods, an experimental chemist with a track record for inventing new classes of functional materials, and a pioneer in robotics for laboratory and process automation. The programme integrates state-of-the-art computation, experiment and robotics, building on joint breakthroughs from our team (Nature, 2011; Nature, 2017) that lay the groundwork for a transformation in our materials discovery capabilities. We will build a Computational Engine for evolutionary exploration of chemical space using crystal structure prediction and machine learning of structure-property relationships for the assessment of molecules. In parallel, we will develop an Experimental Engine for autonomous synthesis and properties testing using newly-developed, artificially-intelligent, mobile 'robot chemists'. The vision of ADAM is to couple these two engines together, creating an autonomous discovery platform that amplifies human creativity by searching the vast, unexplored chemical space for new materials with step change properties.

Project End Date: **31-AUG-26**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
856415	**ThoriumNuclearClock**	**SyG** Synergy

Principal Investigator: **Dr. THORSTEN SCHUMM**
Host Institution: Technische Universitaet Wien, AT

Thorium nuclear clocks for fundamental tests of physics

Th-229 has an exceptionally low-energy excited nuclear isomer state with an excitation energy of only a few electron volts, making it accessible to laser manipulation. With a predicted relative radiative linewidth of 1e-19, constructing a Thorium nuclear clock becomes possible that could rival todays most advanced optical atomic clocks.

The few-eV transition emerges from a fortunate near-degeneracy of the two lowest nuclear energy levels. However, the Coulomb and strong-force contributions to these level energies differ on the MeV level. This makes the Th-229 nuclear level structure uniquely sensitive to variations of fundamental constants and ultralight dark matter.

Very recently, the applicants have proven the long-sought existence of the low-energy isomer, determined the lifetime in different electronic environments, quantified the nuclear moments and charge radius based on the hyperfine splitting, and constrained the isomer energy. However, knowledge on the electronic and nuclear properties is still insufficient to exploit the Th-229 system for fundamental tests.

This project aims to close this gap and realize three prototype nuclear Thorium clocks using complementary approaches in trapped ions and solids. We will develop customized VUV laser systems and perform precision spectroscopy of the Th-229 nuclear transition. Comparing these clocks among each other and with state-of-the-art optical clocks will allow us to benchmark the new frequency standard before ultimately applying it to test fundamental physics.

This project requires a unique combination of experimental and theoretical expertise in atomic and nuclear physics, high precision metrology and fundamental symmetries. Furthermore, special infrastructure is required for (distributed) clock comparison, precision spectroscopy as well as processing of Th-229. The synergy team is composed to optimally respond to these challenges while being rooted in established and successful collaborations.

Project End Date: **31-JAN-26**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
856416	**DEEP PURPLE**	**SyG** Synergy

Principal Investigator: **Dr. MARTYN TRANTER**
Host Institution: University Of Bristol, UK

DEEP PURPLE: darkening of the Greenland Ice Sheet

The stability of the Greenland Ice Sheet (GrIS) is a threat to coastal communities worldwide. The PIs have changed our understanding of why it darkens during the melt season, becoming increasingly deep purple due to pigmented ice algal blooms in the ice surface, producing more melt and accelerating the GrIS towards its tipping point, and increasing sea level. The next step jump in our understanding of biological darkening will be provided by DEEP PURPLE, which will establish the factors that control ice algal blooms. These factors are essential for modelling of future melting, which require a process-based understanding of blooming. DEEP PURPLE will quantify the synergies between the biology, chemistry and physics of ice algae micro-niches in rotting, melting ice, and examine the combination of factors which stabilise them. State-of-the-science analytical and observational methods will be employed to characterise the complex mosaic of wet ice habitats, dependent on factors such as the hydrology, nutrient status, particulate content and light fields within these continually evolving ice-water-particulate-microbe systems. We will quantitatively assess why and how the fine light mineral dust particulates contained within the melting ice amplify the growth of ice algae. The particulate content and composition of different layers in the GrIS is dependent on age, and so the algae that the melting ice can support may fundamentally change over time. We look back to understand if the ice biome has changed through the Anthropocene via analyse of fjord sediments. The first draft genome of ice algae will show their key adaptations to glacier surface habitats. DEEP PURPLE looks forward by providing the critical field data sets and conceptual models of ice algal growth that will facilitate the next generation of predictive models of sea level rise due to biologically enhanced melting of the GrIS.

Project End Date: **31-DEC-25**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
856421	**LeibnizDream**	**SyG** Synergy

Principal Investigator:	**Dr. ULI SAUERLAND**
Host Institution:	Geisteswissenschaftliche Zentren Berlin Ev, DE

Realizing Leibniz's Dream: Child Languages as a Mirror of the Mind

Children around the globe acquire language and with it the human ability to communicate complex thoughts. This project develops a new linguistic theory to explain language and its acquisition. Our central hypothesis is that language radically compresses thought structures to sound or sign. While current theories assume a parallel between thought and language or meaning-preserving transformations, we assume that thought is mapped to language by only realizing some pieces of conceptual representations. Adult language is hyper-efficient at compressing information. For this reason, Leibniz and many others over the last 300 years have been unable to agree on the primitives of human thought. We predict that child languages are a better mirror of the human mind. Our initial evidence suggests that children are not able to compress conceptual representations as efficiently as adults. Sometimes children produce more material than adults, leading to so-called commission errors, which have never been systematically investigated. Furthermore, comprehension is easier for children when there is a one-to-one match between language and thought. To test our central hypothesis and specify how conceptual structure is compressed into language, we carry out a series of at least twelve targeted language acquisition studies on a global scale. We have recruited collaborators for more than 50 languages from 21 different language families, two sign languages and two creoles to carry out our studies. With this data, we can formulate a complete formal model of the semantic primitives, their combination into conceptual structures, the morphological compression mechanism, and the acquisition process within our model. To accomplish these goals, we rely on insights from formal semantics, generative syntax, distributed morphology, and several other linguistic frameworks. As part of our work, we also create the first open, global research collaboration to conduct language acquisition studies.

Project End Date: **31-DEC-26**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
856487	**AgingTimer**	**SyG** Synergy

Principal Investigator: **Dr. VALERY KRIZHANOVSKY**
Host Institution: Weizmann Institute Of Science, IL

Systems biology of the individual stochastic timer of aging

Aging is the biggest risk factor for frailty and death. However, we lack basic understanding of a fundamental question: Why do genetically identical organisms raised in the same conditions get sick and die at different times? If we understood the stochastic timer that drives aging in each individual, we could devise ways to turn back the timer and treat age-related diseases, extending the healthy lifespan. This requires addressing both molecular and social factors that vary between individuals, such as socioeconomic status in humans and social ranking in mice, which impact every aspect of aging. This synergy program aims to identify the stochastic timer of aging and develop methods to read the timer and turn it back. We use mice as a tractable organism relevant to human aging, and combine three disciplines: 1) systems biology to mathematically define the stochastic timer of aging and the basic concepts needed to understand its production, removal and noise processes; 2) neurobiology of behavioral individuality; and 3) biology of cellular senescence, which studies the most promising candidate for the timer: senescent cells that accumulate with age, causing chronic inflammation and whose removal delays age-related decline. To pinpoint the timer, we will follow the natural variability of large cohorts of genetically identical mice, tracked across the lifespan by video and RFID tags. We will measure a battery of behavioral, physiological and molecular parameters, as well as senescent cells in multiple organs throughout life. We will use new mouse models that allow us to visualize, pull down and ablate senescent cells, to provide full molecular profiles of senescent cells in different organs and to characterize their immune-surveillance mechanisms. This study will provide basic understanding of the timer of aging and provide ways to read the timer. Moreover, we will offer new ways to set back the timer in order to address age-related diseases and functional decline.

Project End Date: **31-JAN-26**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
856526	**NONLOCAL**	**SyG** Synergy

Principal Investigator: **Dr. KARSTEN FLENSBERG**
Host Institution: Kobenhavns Universitet, DK

Foundations of nonlocal and nonabelian condensed-matter systems

Emergent particles with nonabelian exchange statistics are a key element in the understanding of topological condensed matter system. However, the nonabelian nature has never been demonstrated experimentally, nor has the intimately connected nonlocality of quantum states been observed in any physical system. With this proposal, we outline a research program whose goal is to design and carry out experiments, with close theoretical coupling, that can – for the first time – verify or falsify the existence of these fascinating novel degrees of freedom and then, if observed, quantify the spatial and temporal limits for the nonabelian and nonlocal properties. The platform for the research is based on topological superconductivity in hybrid materials, a field in which the applicants have played a leading role. We put together a team of experimental and theoretical physicists in a strongly collaborative setup. The focus of the proposal is Majorana bound states, which exist at the boundaries of topological superconductors. Experiments have over the past five years shown observations consistent with their existence. All these experiments are based on local probes which cannot reveal the inner nature of their nonlocal and nonabelian properties. To address the fundamental aspects of nonlocality, we will design quantum devices that combine topological superconductors with known condensed matter quantum technologies, including quantum dots, two-dimensional electron gases, and fast measurement techniques. The nonabelian nature will be explored by design of multi-Majorana devices and of protocols that can reveal the nonabelian nature of braids in the space of topologically-protected groundstate manifolds. The gained knowledge will provide a breakthrough in the fundamentals of emergent degrees of freedom and quantum states encoded in topological macroscopic systems. Their possibly profound character might have future applications in quantum technologies.

Project End Date: **31-AUG-26**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
856543	**COSMOVIS**	**SyG** Synergy

Principal Investigator: **Dr. KATHERINE SWANCUTT**
Host Institution: King'S College London, UK

Cosmological Visionaries: Shamans, Scientists, and Climate Change at the Ethnic Borderlands of China and Russia

Cosmological Visionaries explores what global environmental initiatives of the future will look like, by asking: (1) How can scientists, shamans, priests, and other indigenous holders of animistic knowledge collaborate in regions of climatic vulnerability and (2) What are the geopolitics of climate change and the policies that surround it? Starting from the position that cosmology often evokes religious ways of knowing or being, the project brings together anthropologists, ethnologists, historians and philosophers of science and ethics, religious studies experts, space and satellite researchers, indigenous leaders and environmental scientists to examine how climate change is managed at the ethnic borderlands of China and Russia. The widespread deforestation undertaken in Siberia to meet Chinese market demands for wood is melting Russia's vast permafrost, accelerating the release of ancient greenhouse gases, which carbon capture and storage technologies of the future will not manage. Our project is an academic and a practical intervention driven by two research teams – the China Team and the Russia Team – with a fourfold methodology. Firstly, we will uncover the scientific and indigenous views on climate change in Southwest China and Siberia. Secondly, we will mobilise dialogues between scientists and animistic peoples to mutually inform their approaches to climate change. Thirdly, we will explore how collaboration can benefit both parties. Fourthly, we will map the policies and geopolitics of climate change in China and Russia. Scientists who collaborate with indigenous peoples can get more subtle data than when working alone. Indigenous persons who supply scientists with advice and logistical help can source scientific initiatives for managing local climate change. This feedback loop between scientists and indigenous peoples, advocating for each other, can enable religious leaders and scientists to translate shared findings into visions that everyone can commit to.

Project End Date: **31-AUG-26**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
856555	**MEET**	**SyG** Synergy

Principal Investigator: **Dr. ALEXANDER SOBOLEV**
Host Institution: Universite Grenoble Alpes, FR

Monitoring Earth Evolution Through Time

Efforts to reconstruct the early Earth evolution lack critical information on the contents of mobile and volatile elements and their isotope signatures in the mantle and crust. Fortunately, this information is preserved in inclusions of melt in relicts of olivine from komatiites and picrites, and zircons from mafic and felsic rocks. In Aim I, we will use compositions and temperatures of primary mantle-derived melts reconstructed from the study of melt inclusions in olivine from komatiites and picrites to constrain the evolution of mantle composition. We will further study crust-formation, crust-mantle recycling, and crust-hydrosphere exchange based on composition of melt inclusions and host zircons. We will analyse a wide range of volatile elements and their isotopes in homogenized melt inclusions and the elemental and isotopic compositions of host olivines and zircons. The samples come from 24 localities of komatiites and picrites originating at different cratons between 3.7 and 0.06 Ga, and detrital and magmatic zircons with ages from 4.4 Ga to present. We will apply published and new models to constrain the temperatures and compositions of mantle and crustal sources. In Aim II, geodynamic modelling will relate our observations to the evolution of mantle convection, crustal production and recycling, and plate tectonics (PT). We will couple geodynamic modelling with surface and climate models and use derived geochemical proxies to test our hypotheses on the importance of surface processes in evolution of PT. We will thus address several fundamental issues: the rate of crustal growth and recycling through time; the cause and timing of the onset of large-scale subduction and PT, and factors controlling its evolution; concentration and origin of H2O and halogens in the deep mantle, and the extent (if any) of core-mantle interaction. MEET will, therefore, offer an unprecedented look at the evolution of Earth from 4.4 Ga to today, and from the atmosphere to the core.

Project End Date: **31-OCT-26**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
856581	**CHUbVi**	**SyG** Synergy

Principal Investigator:	**Dr. PATRICK MATTHIAS**
Host Institution:	Friedrich Miescher Institute For Biomedical Research Fondation, CH

Ubiquitin Chains in Viral Infections

Viruses such as Influenza A (IAV) and others remain one of the greatest threats to human health and society. Despite their danger and widespread prevalence, the molecular mechanisms of how they infect mammalian hosts and evade the immune system remains poorly understood. Recent studies from our team implicate two common proteins – HDAC6 and unanchored ubiquitin chains – in host cells as key mediators of viral entry via the aggresome processing pathway. This discovery offers a new line of investigation for understanding and preventing viral infections.

By identifying the pathways and interactions involved in this infection process, we will provide new molecular targets for the development of broad-spectrum antiviral compounds. Multidisciplinary studies by a team consisting of a molecular biologist, a virologist, and a chemical biologist will use a diverse set of tools to validate these pathways and gain fundamental knowledge about their regulation. To achieve this, detailed studies on the exact nature of the ubiquitin chains needed to activate HDAC6 will allow the development of biochemical and cellular assays of Influenza A infection and enable the determination of the precise mechanism and the downstream cellular pathways necessary for viral infection. The chemical synthesis of labeled ubiquitin chains will support detailed structural studies and a clear understanding of how they are formed and packaged into infectious viral particles. The strong possibility that numerous other virus types also utilize this pathway will be tested with life-threatening agents of current concern including Zika, Dengue, Ebola, and MERS viruses.

By demonstrating – with both biological approaches and small molecule compounds – that blocking these cellular processes in cells and animal models reduces viral infection, this project will provide a wealth a novel insights and the basis for the development of a new generation of anti-viral therapies.

Project End Date: **28-FEB-26**