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2019

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Project ID:	Project Acronym:	Evaluation Panel:
681178	**G-EDIT**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. MARIUSZ NOWACKI**
Host Institution: Universitaet Bern, CH

Mechanisms of RNA-guided genome editing in eukaryotes

The goal of this project is to contribute to our understanding of RNA-mediated epigenetic mechanisms of genome regulation in eukaryotes. Ciliated protozoa offer a fantastic opportunity to investigate the complex process of trans-generational programming of chromosomal rearrangements, which is thought to serve as a form of immune defense against invasive DNA. Developmental processes in ciliates include extensive rearrangements of the germline DNA, including elimination of transposons and the precise excision of numerous single-copy elements derived from transposons. This process is considered to be maternally controlled because the maternal genome provides essential information in the form of RNA that determines the offspring's genome content and organization. This programmed DNA subtraction, the so-called 'RNA scanning' process, is mediated by trans-generational comparison between the germline and the maternal somatic genome. One of the most intriguing questions is how a complex population of small RNAs representing the entire germline genome can be compared to the entire rearranged maternal genome, resulting in the efficient selection of germline-specific RNAs, which are able to target DNA deletions in the developing genome. All this occurs in a very short time and involves a massively coordinated transport of all the components between three types of nuclei. This project focuses on characterizing the molecular machinery that can orchestrate the massive genome rearrangements in ciliates through nucleic acids and protein interactions. It also addresses the question how RNA targets DNA cleavage at the right place. In addition, this project aims to investigate the role of RNA in guiding chromosomal rearrangements in other eukaryotic systems, particularly in human cancer cells where genome editing often occurs on a large scale. This work may be the first step in providing novel insights into the process of programmed DNA rearrangements in higher eukaryotes.

Project End Date: **30-APR-21**

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Project ID:	Project Acronym:	Evaluation Panel:
693742	**MERA**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. PETER HEGEMANN**
Host Institution: Humboldt-Universitaet Zu Berlin, DE

Mechanism of Enzyme Rhodopsin Activation

Channelrhodopsin, which was discovered and described as a light-gated ion channel in my laboratory, has revolutionized the field of neuroscience over the past decade by enabling researchers to specifically activate selected neurons in a large ensemble of neuronal cells with short light flashes, a technology we now call "Optogenetics." However, though highly desirable, the inactivation of specific cells using moderate or low light intensities is not yet possible. The recently discovered rhodopsin-guanylyl-cyclase (RhGC) of the fungus Blastocladiella emersonii offers an elegant solution to this problem. Moreover, RhGC is a totally novel and uncharacterized sensory photoreceptor, and the first member of an enzyme rhodopsin family that urgently awaits in-depth characterization. Accordingly, the goal of the “mechanism of enzyme rhodopsin activation” (MERA) proposal is to obtain a comprehensive understanding of this novel photoreceptor, and to determine its functionality for broad application in optogenetics and other research fields. The MERA project is subdivided into four objectives. The first objective is the characterization and engineering of RhGC in cell lines and neurons as well as coexpression of RhGC with a cGMP-gated K+ channel to develop a "Light-Hypopolarizer" for cell inactivation. The second objective is to understand the dynamics of RhGC using a variety of biophysical technologies including time resolved UV-vis, FTIR, and Raman and EPR spectroscopy. A third objective is the generation of crystals for X-ray crystallography and the development of a three dimensional RhGC model. The fourth and final objective is the computer-aided conversion of RhGC into a rhodopsin-phosphodiesterase (RhPDE) for down-regulation of the second messenger cGMP and/or cAMP using light. The ultimate outcome will be a detailed understanding of a novel class of sensory photoreceptors with new perspectives for broad optogenetic applications.

Project End Date: **30-SEP-21**

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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-21**

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Project ID:	Project Acronym:	Evaluation Panel:
694996	**SIDSCA**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. KEITH CALDECOTT**
Host Institution: University Of Sussex, UK

Defective DNA Damage Responses in Dominant Neurodegenerative Diseases

DNA single-strand breaks (SSBs) are the most frequent DNA lesions arising in cells and are a major threat to cell survival and genome integrity, as indicated by the elevated genetic deletion, embryonic lethality, or neurological disease observed if single-strand break repair (SSBR) is attenuated. In particular, SSBR defects are associated with hereditary neurodegeneration in humans, as illustrated by the genetic diseases ataxia oculomotor apraxia-1 (AOA1), spinocerebellar ataxia with axonal neuropathy-1 (SCAN1), and microcephaly with early onset seizures (MCSZ). However, two major questions remain: what are the mechanisms by which SSBs trigger neurodegeneration, and to what extent do SSBs contribute to other genetic and/or sporadic neurodegenerative disease? Based on exciting new data we now propose that the impact of SSBs on neurodegeneration extends beyond rare SSBR-defective diseases to include more common motor neurone diseases (amyotrophic lateral sclerosis) and the genetically dominant spinocerebellar ataxias (SCAs). Ultimately, we suggest that SSBs might also be an etiological factor in normal human ageing. Finally, again based on new data, we propose that SSBs induce neurodegeneration by triggering over-activation of the SSB sensor protein, PARP1; thereby identifying inhibitors of this protein (currently licensed for cancer treatment) as a possible therapy for neurodegeneration. We will now address these hypotheses using a range of cutting edge molecular/cellular techniques. In particular we will (a), systematically examine all relevant amyotrophic lateral sclerosis/motor neurone disease (ALS/MND) and spinocerebellar ataxia (SCA) proteins for involvement in the DNA damage response, (b) Identify the mechanism/s by which ALS and SCA proteins engage in the DNA damage response, (c) Identify the role of ALS and SCA proteins in the DNA damage response, and (d) Explore PARP1 as a possible therapeutic target for treatment of neurodegenerative disease.

Project End Date: **30-SEP-21**

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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:
724040	**NascenTomiX**	**LS1** Molecular and Structural Biology and Biochemistry

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

Ribosome inhibition by nascent or antimicrobial peptides

During the translation of genetic information into protein by the ribosome, nascent peptides occasionally inhibit their own synthesis by interacting with the exit tunnel of the large ribosomal subunit. Known as nascent chain-mediated translational arrest, this process depends primarily upon the amino acid sequence of the arrest peptide. However, it can also rely upon the sensing of a low molecular weight ligand by the ribosome nascent chain complex, explaining its use for metabolite-dependent gene regulation in both bacteria and eukaryotes. Biochemical and structural studies of arrest peptides have yielded key insights into their mode of action, but their ability to sense different types of small molecules, their impact as regulators of gene expression in nature and the precise molecular details behind the arrest process are still largely unexplored.
The groundbreaking aim of this ERC Consolidator research program is to decipher the arrest code governing nascent chain-mediated translational arrest in bacteria. My approach will be based on a technique recently developed in my group, referred to here as inverse toeprinting, which precisely maps the position of an arrested ribosome nascent chain complex on the mRNA while retaining the entire peptide-coding region up to the point of stalling.

The overall aim will be achieved through four complementary objectives: (i) to assess the extent to which arrest peptides can act as small molecule sensors; (ii) to identify naturally occurring arrest peptides in bacteria; (iii) to develop trans-inhibitory peptides that target the ribosome; and (iv) to perform the structural characterization of new ribosome inhibitory peptides.

By addressing the natural diversity and molecular bases of the arrest process, this project will be the key to understanding a unique form of gene regulation and a fundamental aspect of ribosome function. It will also provide a handle for designing next-generation antibiotics.

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:
805230	**Orgasome**	**LS1** Molecular and Structural Biology and Biochemistry

Principal Investigator: **Dr. ALEXEY AMUNTS**
Host Institution: Stockholms Universitet, SE

Protein synthesis in organelles

Protein synthesis in mitochondria is essential for the bioenergetics, whereas its counterpart in chloroplasts is responsible for the synthesis of the core proteins that ultimately converts sunlight into the chemical energy that produces oxygen and organic matter. Recent insights into the mito- and chlororibosomes have provided the first glimpses into the distinct and specialized machineries that involved in synthesizing almost exclusively hydrophobic membrane proteins. Our findings showed: 1) mitoribosomes have different exit tunnels, intrinsic GTPase in the head of the small subunit, tRNA-Val incorporated into the central protuberance; 2) chlororibosomes have divaricate tunnels; 3) ribosomes from both organelles exhibit parallel evolution. This allows contemplation of questions regarding the next level of complexity: How these ribosomes work and evolve? How the ribosomal components imported from cytosol are assembled with the organellar rRNA into a functional unit being maturated in different compartments in organelles? Which trans-factors are involved in this process? How the chlororibosomal activity is spatiotemporally coupled to the synthesis and incorporation of functionally essential pigments? What are the specific regulatory mechanisms?

To address these questions, there is a need to first to characterize the process of translation in organelles on the structural level. To reveal molecular mechanisms of action, we will use antibiotics and mutants for pausing in different stages. To reconstitute the assembly, we will systematically pull-down pre-ribosomes and combine single particle with tomography to put the dynamic process in the context of the whole organelle. To understand co-translational operations, we will stall ribosomes and characterize their partner factors. To elucidate the evolution, we will analyze samples from different species.

Taken together, this will provide fundamental insights into the structural and functional dynamics of organelles.

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

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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:
677748	**Ubl-Code**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. YIFAT MERBL**
Host Institution: Weizmann Institute Of Science, IL

Revealing the ubiquitin and ubiquitin-like modification landscape in health and disease

Post-translational modifications (PTMs) of proteins are a major tool that the cell uses to monitor events and initiate appropriate responses. While a protein is defined by its backbone of amino acid sequence, its function is often determined by PTMs, which specify stability, activity, or cellular localization. Among PTMs, ubiquitin and ubiquitin-like (Ubl) modifications were shown to regulate a variety of fundamental cellular processes such as cell division and differentiation. Aberrations in these pathways have been implicated in the pathogenesis of cancer. Over the past decade high-throughput genomic and transcriptional analyses have profoundly broadened our understanding of the processes underlying cancer development and progression. Yet, proteomic analyses and the PTM landscape in cancer, remained relatively unexplored.

Our goal is to decipher molecular mechanisms of Ubl regulation in cancer. We will utilize the PTM profiling technology that I developed and further develop it to allow for subsequent MS analysis. Together with cutting-edge genomic, imaging and proteomic technologies, we will analyze novel aspects of PTM regulation at the level of the enzymatic machinery, the substrates and the downstream cellular network. We will rely on ample in-vitro and in-vivo characterization of Ubl conjugation to:a. Elucidate the regulatory principles of substrate specificity and reCoGnition. b. Understand signalling dynamics in the ubiquitin system. c. Reveal how aberrations in these pathways may lead to diseases such as cancer. Identifying both the Ubl modifying enzymes and the modified substrates will form the basis for deciphering the molecular pathways in which they operate in the cell and the principles of their dynamic regulation. Revealing the PTM regulatory code presents a unique opportunity for the development of novel therapeutics. More broadly, our approaches may provide a new paradigm for addressing other complex biological questions involving PTM regulation.

Project End Date: **30-APR-21**

European Research Council
Executive Agency

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Project ID:	Project Acronym:	Evaluation Panel:
694282	**LYSOSOMICS**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. ANDREA BALLABIO**
Host Institution: Fondazione Telethon, IT

Functional Genomics of the Lysosome

For a long time the lysosome has been viewed as a “static” organelle that performs “routine” work for the cell, mostly pertaining to degradation and recycling of cellular waste. My group has challenged this view and used a systems biology approach to discover that the lysosome is subject to a global transcriptional regulation, is able to adapt to environmental clues, and acts as a signalling hub to regulate cell homeostasis. Furthermore, an emerging role of the lysosome has been identified in many types of diseases, including the common neurodegenerative disorders Parkinson's and Alzheimer’s. These findings have opened entirely new fields of investigation on lysosomal biology, suggesting that there is a lot to be learned on the role of the lysosome in health and disease. The goal of LYSOSOMICS is to use “omics” approaches to study lysosomal function and its regulation in normal and pathological conditions. In this “organellar systems biology project” we plan to perform several types of genetic perturbations in three widely used cell lines and study their effects on lysosomal function using a set of newly developed cellular phenotypic assays. Moreover, we plan to identify lysosomal protein-protein interactions using a novel High Content FRET-based approach. Finally, we will use the CRISPR-Cas9 technology to generate a collection of cellular models for all lysosomal storage diseases, a group of severe inherited diseases often associated with early onset neurodegeneration. State-of-the-art computational approaches will be used to predict gene function and identify disease mechanisms potentially exploitable for therapeutic purposes. The physiological relevance of newly identified pathways will be validated by in vivo studies performed on selected genes by using medaka and mice as model systems. This study will allow us to gain a comprehensive understanding of lysosomal function and dysfunction and to use this knowledge to develop new therapeutic strategies.

Project End Date: **30-SEP-21**

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Project ID:	Project Acronym:	Evaluation Panel:
716024	**GLYCONOISE**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

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

Emergent properties of cell surface glycosylation in cell-cell communication

The surface of every living cell is covered with a dense matrix of glycans. Its particular composition and structure codes important messages in cell-cell communication, influencing development, differentiation, and immunological processes. The matrix is formed by highly complex biopolymers whose compositions vary from cell to cell, even between genetically identical cells. This gives rise to population noise in cell-cell communication. A second level of noise stems from glycans present on the same cell that disturb the decoding of the message by glycans binding receptors through competitive binding. Glycan-based communication is characterized by a high redundancy of both glycans and their receptors. Thus, noise and redundancy emerge as key properties of glycan-based cell-cell communication, but their extent and function are poorly understood.

By adapting a transmitter-receiver model from communication sciences and combining it with state-of-the-art experimental techniques from biophysics and cell biology, we will address two fundamental questions: What is the role of the redundancy in glycan-based communication? How much ‚noise' can it tolerate, before the message is lost?

To do so, we first establish a simplified model system for glycan-based communication. Biophysical rate constants are determined for lectin-glycan interactions and expanded to glycosylated microparticles that trigger a biological response in lectin expressing receiver cells. Next, single cell glycomes are reconstructed from ultra-high dimensional flow cytometry data using lectin mixtures enabled by recent advancements in instrumentation and glycobioinformatics software. Glycomes accessible on single cell level allow replacing the microparticles with transmitter cells and employ a cell-cell interaction model. Our transmitter-receiver model is used to quantify the noise and reveals how redundancy provides robustness of messaging by cell surface glycans in cellular communication.

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

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Project ID:	Project Acronym:	Evaluation Panel:
724226	**cis-CONTROL**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. STEIN AERTS**
Host Institution: Vib Vzw, BE

Decoding and controlling cell-state switching: A bottom-up approach based on enhancer logic

Cell-state switching in cancer allows cells to transition from a proliferative to an invasive and drug-resistant phenotype. This plasticity plays an important role in cancer progression and tumour heterogeneity. We have made a striking observation that cancer cells of different origin can switch to a common survival state. During this epigenomic reprogramming, cancer cells re-activate genomic enhancers from specific regulatory programs, such as wound repair and epithelial-to-mesenchymal transition.

The goal of my project is to decipher the enhancer logic underlying this canalization effect towards a common survival state. We will then employ this new understanding of enhancer logic to engineer synthetic enhancers that are able to monitor and manipulate cell-state switching in real time. Furthermore, we will use enhancer models to identify cis-regulatory mutations that have an impact on cell-state switching and drug resistance. Such applications are currently hampered because there is a significant gap in our understanding of how enhancers work.

To tackle this problem we will use a combination of in vivo massively parallel enhancer-reporter assays, single-cell genomics on microfluidic devices, computational modelling, and synthetic enhancer design. Using these approaches we will pursue the following aims: (1) to identify functional enhancers regulating cell-state switching by performing in vivo genetic screens in mice; (2) to elucidate the dynamic trajectories whereby cells of different cancer types switch to a common survival cell-state, at single-cell resolution; (3) to create synthetic enhancer circuits that specifically kill cancer cells undergoing cell-state switching.

Our findings will have an impact on genome research, characterizing how cellular decision making is implemented by the cis-regulatory code; and on cancer research, employing enhancer logic in the context of cancer therapy.

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

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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:
758757	**CENEVO**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. INES DRINNENBERG**
Host Institution: Institut Curie, FR

A new paradigm for centromere biology:
Evolution and mechanism of CenH3-independent chromosome segregation in holocentric insects

Faithful chromosome segregation in all eukaryotes relies on centromeres, the chromosomal sites that recruit kinetochore proteins and mediate spindle attachment during cell division. Fundamental to centromere function is a histone H3 variant, CenH3, that initiates kinetochore assembly on centromeric DNA. CenH3 is conserved throughout most eukaryotes; its deletion is lethal in all organisms tested. These findings established the paradigm that CenH3 is an absolute requirement for centromere function. My recent findings undermined this paradigm of CenH3 essentiality. I showed that CenH3 was lost independently in four lineages of insects. These losses are concomitant with dramatic changes in their centromeric architecture, in which each lineage independently transitioned from monocentromeres (where microtubules attach to a single chromosomal region) to holocentromeres (where microtubules attach along the entire length of the chromosome). Here, I aim to characterize this unique CenH3-deficient chromosome segregation pathway. Using proteomic and genomic approaches in lepidopteran cell lines, I will determine the mechanism of CenH3-independent kinetochore assembly that led to the establishment of their holocentric architecture. Using comparative genomic approaches, I will determine whether this kinetochore assembly pathway has recurrently evolved over the course of 400 million years of evolution and its impact on the chromosome segregation machinery.

My discovery of CenH3 loss in holocentric insects establishes a new class of centromeres. My research will reveal how CenH3 that is essential in most other eukaryotes, could have become dispensable in holocentric insects. Since the evolution of this CenH3-independent chromosome segregation pathway is associated with the independent rises of holocentric architectures, my research will also provide the first insights into the transition from a monocentromere to a holocentromere.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759139	**TarMyc**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. ELMAR WOLF**
Host Institution: Julius-Maximilians-Universitat Wurzburg, DE

Targeting the OnCoGenic Function of Myc in vivo

The transcription factor Myc plays a central role in tumourigenesis but was deemed undruggable due to it being an essential protein. However, recent proof-of-principle studies in mice using a dominant negative allele of Myc demonstrated the dependency of established tumours on Myc function and showed that mice tolerated Myc inhibition to a degree that allowed tumour regression. In line with these observations my group found Myc to regulate distinct sets of genes at low, physiological and high, onCoGenic levels, because promoters differ in their affinity for Myc. This notion implies the compelling possibility to specifically target the onCoGenic functions of Myc.

TarMyc aims to address four key questions required to bring this new concept from bench to bedside. Firstly, TarMyc will estimate the therapeutic window of Myc inhibition in vivo by expressing shRNAs against Myc in mice with established solid tumours. Secondly, TarMyc aims to identify in vivo Myc target genes crucial for tumourigenesis. Thirdly, this proposal aims to elucidate the role of Myc's differential promoter affinity in untransformed cells. Analysis of published gene expression datasets revealed Myc binding to low-affinity promoters during the process of tissue regeneration. Thus, by characterizing the regeneration programme induced by Myc we hope to gain further insight on the therapeutic window of Myc inhibition and assess potential side-effects in a Myc-targeting anticancer therapy. Fourthly, we aim to develop strategies to interfere with the onCoGenic functions of Myc by (i) developing a novel class of drugs that reduce Myc's cellular concentrations, and (ii) by testing the therapeutic potential of Myc target genes by inhibiting their function in tumour models.

Taken together, TarMyc takes on the challenge of inhibiting the onCoGenic functions of Myc in a highly multidisciplinary approach using state-of-the-art molecular biology, advanced tumour models and new concepts in drug development.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759366	**BioMeTRe**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. LUCA GIORGETTI**
Host Institution: Friedrich Miescher Institute For Biomedical Research, CH

Biophysical mechanisms of long-range transcriptional regulation

In mammals, transcriptional control of many genes relies on cis-regulatory elements such as enhancers, which are often located tens to hundreds of kilobases away from their CoGnate promoters. Functional interactions between distal regulatory elements and target promoters require mutual physical proximity, which is linked to the three-dimensional structure of the chromatin fiber. Chromosome conformation capture studies revealed that chromosomes are partitioned into Topologically Associating Domains (TADs), sub-megabase domains of preferential physical interactions of the chromatin fiber. Genetic evidence showed that TAD boundaries restrict the genomic range of enhancer-promoter communication, and that interactions between regulatory sequences within TADs are further fine-tuned by smaller-scale structures. However, the mechanistic details of how physical interactions translate into transcriptional outputs are totally unknown. Here we propose to explore the biophysical mechanisms that link chromosome conformation and long-range transcriptional regulation using molecular biology, genetic engineering, single-cell experiments and physical modeling. We will measure chromosomal interactions in single cells and in time using a novel method that relies on an enzymatic process in vivo. Genetic engineering will be used to establish a cell system that allows quantitative measurement of how enhancer-promoter interactions relate to transcription at the population and single-cell levels, and to test the effects of perturbations without confounding effects. Finally, we will develop physical models of promoter operation in the presence of distal enhancers, which will be used to interpret the experimental data and formulate new testable predictions. With this integrated approach we aim at providing an entirely new layer of description of the general principles underlying transcriptional control, which could establish new paradigms for research in epigenetics and gene regulation.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759579	**DualRP**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. FABRICIO LOAYZA-PUCH**
Host Institution: Deutsches Krebsforschungszentrum, DE

Exploring cell interactions in the tumor microenvironment with dual ribosome profiling

Cancers develop in very heterogeneous tissue environments. They depend on the tumor microenvironment (TME) for sustained growth, metastasis, and therapy resistance. Stromal cells are genetically stable and they have less likelihood to develop resistance than cancer cells. Therefore, targeting the TME represents an attractive approach for treating cancer. In order to develop new therapeutic strategies to reprogram the TME and inhibit tumor growth and resistance, it is essential to understand in detail the molecular mechanisms of the interactions between cancer and stromal cell populations. However, current methods to study these interactions require complete dissociation of the tumor, exposing the cells to severe stress and affecting dramatically gene expression patterns. Here, I propose to use Dual Ribosome Profiling (DualRP), a system that I recently developed, to study cell interactions in the TME. DualRP is an approach that allows not only simultaneous analysis of gene expression in two interacting cell populations in vivo, but also is able to uncover metabolic limitations in tumors. I aim to apply DualRP to mouse xenograft models where cancer cells interact with non-transformed fibroblasts and I'll explore the combined response of both populations to cancer therapy. Moreover, I'll utilize mouse genetic models tailored for DualRP to study cancer cell and macrophages/endothelial cells interactions. I will employ a combination of mouse genetic models, biochemical tools, deep sequencing, and bioinformatics. These studies will provide insight into how gene expression and metabolic programs define the interaction between cancer and stromal cells to promote tumor growth and metastasis, identify potential targets for therapeutic intervention, and provide maps of cell interactions in vivo. Therefore, this research has the potential to significantly advance our understanding of the molecular and metabolic mechanisms underlying the complex cell interactions in the TME.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771425	**NonChroRep**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. MAITE HUARTE**
Host Institution: Fundacion Para La Investigacion Medica Aplicada Fima, ES

Investigating the role of the long noncoding transcriptome in chromatin replication

A major shift in our conception of genome regulation has emerged in recent years. It is now obvious that the majority of cellular transcripts do not code for proteins, and a significant subset of them are long RNAs (lncRNAs). My lab and others have shown that lncRNAs regulate genome function and gene expression, and that alterations in lncRNAs are inherent to disease, including cancer. However, our understanding of the roles of lncRNAs and their underlying molecular mechanisms are still extremely poor.

Among all the mechanisms reported, the evident connection between lncRNAs and the chromatin places them at the center of cell biology. During their cycle, cells must undergo faithful DNA replication to ensure that an exact copy of their genetic content is passed on to their daughters. Throughout this tightly regulated process chromatin must be disrupted and reconstituted, and it determines where and when replication takes place. If replication is deregulated, cells can proliferate uncontrollably and suffer loss of genome integrity. Our recent findings implicate lncRNA in the process of DNA replication, representing a novel aspect of genome regulation that places lncRNAs at the focal point of cancer biology. To delve deeper into these findings I aim to:

1. Identify the role of lncRNAs in the replication of the chromatin
2. Dissect the molecular mechanism by which lncRNAs function in this process and
3. Explore the role of these lncRNAs as cancer drivers and their potential as therapeutic targets.

I will apply tools that we have generated in recent years, as well as new ones, including approaches to identify lncRNAs associated with replicating chromatin, novel lncRNA-tailored CRISPR applications, and the latest methodology for functional study and targeting of long noncoding transcripts in cancer. I am confident that we are in a unique position to address these life-essential and yet pending questions, setting up a basis for future lncRNA-based therapies.

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

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:
787611	**DeCRyPT**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. EILEEN FURLONG**
Host Institution: European Molecular Biology Laboratory, DE

Deciphering Cis-Regulatory Principles of Transcriptional regulation: Combining large-scale genetics and genomics to dissect functional principles of genome regulation during embryonic development

Understanding how genomic information is organised and interpreted to give rise to robust patterns of gene expression is a long-standing problem in genome biology, with direct implications for development, evolution and disease. Despite recent advances in locating regulatory elements in animal genomes, there is a general lack of functional data on elements in their endogenous setting – the bulk of our current knowledge comes from reporter assays examining elements out of context, giving insights on sufficiency but not necessity. The functional requirement of very few individual enhancers, and other elements, has been assessed by deletion, with even less known about how the action of multiple elements is integrated. To understand the functional effects of genetic variants, and how they are buffered during embryogenesis, it is imperative to genetically dissect regulatory domains to uncover functional rules of genome regulation within a well-characterised animal model. Here, by combining Drosophila population genetics, developmental genetics, and novel multiplexed genomic methods we will perform the first large-scale functional dissection of cis-regulatory landscapes during embryogenesis.

Extensive resources make Drosophila a unique model organism for this task, including (a) 500 fully sequenced inbred wild isolates for population genetics, (b) over 20,000 fly strains custom-built for genome engineering & (c) a wealth of cis-regulatory information on the location of enhancers. The proposal has three Aims: 1) Use population genetics as a perturbation tool to functionally link regulatory elements to their target genes; 2) Systematically delete cis-regulatory elements to dissect their role in gene expression and genome topology; 3) Manipulate cis-regulatory domains to generate new regulatory environments for developmental genes.These Aims will provide unique functional insights, enabling us to move from correlation to causation in our understanding of genome regulation.

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

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:
803063	**SCIPER**	**LS2** Genetics, Genomics, Bioinformatics and Systems Biology

Principal Investigator: **Dr. BEREND SNIJDER**
Host Institution: Eidgenoessische Technische Hochschule Zurich, CH

Studying Cancer Individuality by Personal and Predictive Drug Screening and Differential OMICs

The cellular and molecular systems that determine drug responses in cancer are complex, highly individual, and incompletely understood. As a result, many cancer patients receive ineffective or even harmful therapies, which endangers lives, burdens healthcare systems, and prevents new therapies from reaching clinical approval.

To address this problem, we are developing a platform that measures hundreds of ex vivo drug responses from small patient biopsies by immunofluorescence, automated confocal microscopy, single-cell image analysis, and machine learning. We preserve cellular memory and maximize physiological relevance by not culturing or sorting cells prior to drug exposure. Sub-cellular, single-cell, and cell population-wide image analysis reveals on-target drug responses and disentangles multicellular ones. In a first interventional clinical trial, this phenotypic information alone led to strongly improved treatment of patients with aggressive hematologic malignancies.

Enabled by this high-throughput, predictive, and phenotypic information, I here propose to identify the molecular and cellular systems that govern treatment response individuality in cancer. (Aim 1) We will combine drug response profiling with RNA sequencing and proteomic measurements of malignant and healthy cells from the same biopsies. Critically, the patient-internal comparisons in both screening and OMICs allow neutralizing complex confounding factors. (Aim 2) New multiplexed immunofluorescence and convolutional neural network-based analyses will identify multiclass cell-types and -states, and quantify non-cell-autonomous responses. (Aim 3) Computational integration and causal inference will identify the molecular determinants and governing principles of drug response individuality in cancer, amenable to further validation. This proposal will thus improve our mechanistic understanding of cancer individuality and develop powerful new tools for OMICs-based precision medicine.

Project End Date: **31-OCT-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:
681505	**CELLFUSION**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. SOPHIE MARTIN**
Host Institution: Universite De Lausanne, CH

Molecular dissection of the mechanisms of cell-cell fusion in the fission yeast

Cell fusion is critical for fertilization and development, for instance underlying muscle or bone formation. Cell fusion may also play important roles in regeneration and cancer. A conceptual understanding is emerging that cell fusion requires cell-cell communication, polarization of the cells towards each other, and assembly of a fusion machinery, in which an actin-based structure promotes membrane juxtaposition and fusogenic factors drive membrane fusion. However, in no single system have the molecular nature of all these parts been described, and thus the molecular basis of cell fusion remains poorly understood.

This proposal aims to depict the complete fusion process in a single organism, using the simple yeast model Schizosaccharomyces pombe, which has a long track record of discoveries in fundamental cellular processes. These haploid cells, which fuse to generate a diploid zygote, use highly conserved mechanisms of cell-cell communication (through pheromones and GPCR signaling), cell polarization (centred around the small GTPase Cdc42) and fusion. Indeed, we recently showed that these cells assemble an actin-based fusion structure, dubbed the actin fusion focus. Our five aims probe the molecular nature of, and the links between, signaling, polarization and the fusion machinery from initiation to termination of the process. These are:

1: To define the roles and feedback regulation of Cdc42 during cell fusion
2: To understand the molecular mechanisms of actin fusion focus formation
3: To identify the fusogen(s) promoting membrane fusion
4: To probe the GPCR signal for fusion initiation
5: To define the mechanism of fusion termination

By combining genetic, optogenetic, biochemical, live-imaging, synthetic and modeling approaches, this project will bring a molecular and conceptual understanding of cell fusion. This work will have far-ranging relevance for cell polarization, cytoskeletal organization, cell signalling and communication, and cell fate regulation.

Project End Date: **30-SEP-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694455	**ZMOD**	**LS3** Cellular and Developmental Biology

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

Blood Vessel Development and Homeostasis: Identification and Functional Analysis of Genetic Modifiers

The vascular system is a complex network of blood vessels that transports gases, nutrients and hormones throughout the organism. Most blood vessels that form during development and growth arise by the sprouting of new capillaries from pre-existing vessels, a process termed angiogenesis. An imbalance in angiogenesis contributes to the pathogenesis of numerous disease states: insufficient angiogenesis limits tissue recovery in ischemic disease, whereas stimulation of angiogenesis by cancer cells promotes tumor vascularization and growth. Angiogenesis inhibitors are already in clinical use for anti-tumor therapy; however, multiple reports of resistance are calling for the identification of additional targets. Furthermore, vascular malformations are a significant cause of morbidity and mortality. While the genetic basis for some vascular malformations is known, many genetic factors, including modifiers that affect the age-of-onset and severity of phenotypes, remain to be identified. Identifying modifier genes is important not only to fully assess genetic risk, but also to provide novel targets for therapy; however, identifying modifier genes has proven challenging. We recently uncovered a novel and simple way to identify modifier genes. By investigating gene and protein expression differences between knockout (mutant) and knockdown (antisense treated) zebrafish embryos, we found that mutations in specific genes, including some encoding angiogenic factors, lead to the upregulation of compensating (i.e., modifier) genes while knocking down these same genes does not. We hypothesize that the modifier genes identified through this approach in zebrafish also play important roles in humans. Thus, we will use this simple strategy to identify new genes that regulate vascular formation and homeostasis, and subsequently analyze their function in zebrafish as well as in mammalian models, as they are likely to play key roles in vascular development and disease.

Project End Date: **30-SEP-21**

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 Vzw, 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:
715441	**GasPlaNt**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. DANIEL GIBBS**
Host Institution: The University Of Birmingham, UK

Gas sensing in plants: Oxygen- and nitric oxide-regulated chromatin modification via a targeted protein degradation mechanism

Oxygen (O2) and nitric oxide (NO) are gases that function as key developmental and stress-associated signals in plants. Investigating the molecular basis of their perception has the potential to identify new targets for crop improvement. In previous ground breaking work I showed that the direct transcriptional response to O2/NO is mediated by controlled degradation of specialised 'gas-sensing' transcription factors. We have now linked this degradation mechanism to a new functional class of 'sensor', a chromatin modifying protein that regulates the epigenetic silencing of genes. Here we will investigate the hypothesis that this protein acts as a previously undiscovered link between O2/NO and chromatin dynamics, and that plants have evolved a unique system for transducing gaseous signals into rapid transcriptional responses, and longer term epigenetic changes, through targeting different types of protein to the same degradation pathway.

Using multidisciplinary genetic, biochemical and omics approaches we will investigate the molecular basis of this novel gas perception system, which appears to be a plant-specific innovation. We will identify its global gene targets (the 'gas-responsive epigenome'), and uncover its growth and stress-associated functions in Arabidopsis and barley. We will also investigate how manipulating this pathway using genome editing and synthetic biology techniques alters plant performance, focusing on traits of agronomic significance. This ambitious and timely research will take our knowledge of O2/NO-signaling and the control of chromatin dynamics beyond the current state of the art by offering insight into a completely novel signaling mechanism operating at the interface of gas-perception, protein degradation, and epigenetics. GasPlaNt will therefore provide a step-change in our understanding of how plants synchronise their gene expression in response to signals to optimise growth and development within a dynamic environment.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725268	**DissectPcG**	**LS3** Cellular and Developmental Biology

Principal Investigator: **Dr. DIEGO PASINI**
Host Institution: Istituto Europeo Di Oncologia Srl, IT

Dissecting the Function of Multiple Polycomb Group Complexes in Establishing Transcriptional Identity

The activities of the Polycomb group (PcG) of repressive chromatin modifiers are required to maintain correct transcriptional identity during development and differentiation. These activities are altered in a variety of tumours by gain- or loss-of-function mutations, whose mechanistic aspects still remain unclear.

PcGs can be classified in two major repressive complexes (PRC1 and PRC2) with common pathways but distinct biochemical activities. PRC1 catalyses histone H2A ubiquitination of lysine 119, and PRC2 tri-methylation of histone H3 lysine 27. However, PRC1 has a more heterogeneous composition than PRC2, with six mutually exclusive PCGF subunits (PCGF1–6) essential for assembling distinct PRC1 complexes that differ in subunit composition but share the same catalytic core.

While up to six different PRC1 forms can co-exist in a given cell, the molecular mechanisms regulating their activities and their relative contributions to general PRC1 function in any tissue/cell type remain largely unknown. In line with this biochemical heterogeneity, PRC1 retains broader biological functions than PRC2. Critically, however, no molecular analysis has yet been published that dissects the contribution of each PRC1 complex in regulating transcriptional identity.

We will take advantage of newly developed reagents and unpublished genetic models to target each of the six Pcgf genes in either embryonic stem cells or mouse adult tissues. This will systematically dissect the contributions of the different PRC1 complexes to chromatin profiles, gene expression programs, and cellular phenotypes during stem cell self-renewal, differentiation and adult tissue homeostasis. Overall, this will elucidate some of the fundamental mechanisms underlying the establishment and maintenance of cellular identity and will allow us to further determine the molecular links between PcG deregulation and cancer development in a tissue- and/or cell type–specific manner.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772426	**MECHEMGUI**	**LS3** Cellular and Developmental Biology

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

The integration of mechanical and chemical signals in neuronal guidance

During the development of the central nervous system (CNS), neurons extend axons through a crowded environment along well-defined pathways to reach their distant targets. It is evident that attractive and repulsive guidance cues in the tissue provide important biochemical signals to guide growing axons along their paths. This can only be part of the story, however, as it is still not possible to predict axonal growth patterns in vivo. In a recent breakthrough discovery, we provided in vivo evidence that neurons also respond to mechanical cues, such as local tissue stiffness, suggesting that mechanical signals are likely an important missing part of the puzzle. However, mechanically activated signaling pathways are currently poorly understood, and how neurons integrate mechanical and chemical signals to result in proper outgrowth is unknown.

By investigating how mechanical signals control neuronal growth and pathfinding, this proposal will close this comprehension gap. By combining state-of-the-art approaches in physics, engineering and biology, we will, for the first time, identify mechanosensitive molecular mechanisms that regulate neuronal growth and guidance in vitro and in vivo. In particular, we will investigate how mechanotransduction cascades (1) directly modulate axon growth by inducing local changes in cytoskeletal dynamics, and (2) indirectly lead to alterations in axon outgrowth by modulating chemical signalling pathways. Ultimately, we will develop a computational model based on our findings, which will lead to a predictive framework for understanding axon pathfinding in the developing brain.

The proposed research challenges current concepts in developmental biology and is very relevant to many other areas in biology. Our results will not only shed new light on the complex control mechanisms of cellular growth and motility, but could also lead to novel biomedical approaches aimed at facilitating neuronal re-growth and regeneration in the damaged CNS.

Project End Date: **31-MAY-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:
803565	**mitoUPR**	**LS3** Cellular and Developmental Biology

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

Cellular modulation by the mitochondrial unfolded protein response

Mitochondrial function is central for cellular metabolism and energy balance. However, many diseases, including cancer and neurodegenerative diseases, affect mitochondrial function and proteostasis. Upon mitochondrial protein misfolding, mitochondria activate the mitochondrial unfolded protein response (UPRmt) to restore proteostasis, a poorly characterized pathway in mammalian cells. Notably, the effects of the UPRmt on its direct environment – mitochondria – and on cytosolic homeostasis remain unknown. Strikingly, non-cell autonomous signaling of metabolism and folding state has been described in recent years, particularly in worms. However, the possible role of UPRmt in such processes is undescribed.

Using newly available tools to acutely induce the UPRmt in mammalian cells, combined with cutting-edge quantitative mass spectrometry, microscopy, next generation sequencing, and gene editing approaches, we propose to address these important open questions by studying the influence UPRmt exerts on the environments of i) mitochondria (including to study the composition and regulation of RNA granules), ii) cytosol (adjustments of translation, metabolism, and proliferation) and iii) neighboring cells (modification by non-cell autonomous signaling). Additionally, we aim to develop an iPSC-based UPRmt model.

On cellular and organismal level, there ought to be mechanisms to signal changes in metabolism and proteostasis to increase robustness in neighboring environments. Studying these effects will be crucial for a better understanding of human disease and carries severe implications: i) the possibility of therapeutic treatment by modulating neighboring compartments or cells and ii) the possibility that diseases inducing the UPRmt could have unknown paracrine and endocrine effects on the organism. This proposal holds the potential to uncover a novel layer of regulation of cellular stress with an extensive influence on our understanding of the UPRmt and disease.

Project End Date: **31-JAN-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 Vzw, 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:
648521	**PanCaT**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. DIETER SAUR**
Host Institution: Klinikum Rechts Der Isar Der Technischen Universitat Munchen, DE

Next-generation in vivo models for improved pancreatic cancer therapies

Maintenance and drug resistance of pancreatic ductal adenocarcioma (PDAC) depends on cancer cell intrinsic mechanisms and a stroma that supports tumor growth. Mouse models of human PDAC have provided important insights into the evolution of this highly lethal tumor, but there are no models that allow secondary genetic manipulation of autochthonous tumors, the tumor microenvironment or the metastatic host niche once the tumor has formed.

We generated an inducible dual-recombinase system by combining Flp/frt and Cre/loxP. This novel PDAC model permits spatial and temporal control of gene expression enabling unbiased genetic approaches to study the role of tumor cell-autonomous and non-autonomous functions in endogenous cancers. This tool provides unparalleled access to the native biology of cancer cells and their hosting stroma, and rigorous genetic validation of candidate therapeutic targets. We performed tumor cell-autonomous and non-autonomous targeting, uncovered hallmarks of human multistep carcinogenesis, validated genetic tumor therapy, and showed that mast cells in the tumor microenvironment, which had been thought to be key onCoGenic players, are in fact dispensable for tumor formation.

In the proposed research program, we will 1) develop and further improve next-generation PDAC models, 2) deploy these systems to identify and target key features of PDAC maintenance in tumor cells and their microenvironment, and 3) discover mechanisms of treatment resistance. The application of cutting edge genetic engineering and screening technologies will allow us to address biological questions that could not be addressed before. The PanCaT project will open new horizons for the functional understanding of pancreatic cancer biology with a strong impact on clinical management and prognosis of PDAC patients. It will also produce a unique set of highly versatile and widely applicable genetic tools that will facilitate the study of PDAC at an organismal level.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694717	**ImmunoBile**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. BART STAELS**
Host Institution: Universite De Lille, FR

Bile acid, immune-metabolism, lipid and glucose homeostasis

The role of chronic inflammation in obesity, metabolic and cardiovascular diseases is increasingly reCoGnized. Bile acids (BA), synthesized in the liver and modified by the gut flora, facilitate lipid absorption in the intestine. BA modulate lipid and glucose homeostasis by activating the nuclear receptor FXR and the GPCR TGR5. Intriguingly, peripheral BA concentrations are elevated in type 2 diabetes (T2D) and FXR mediates the beneficial metabolic response to gastric bypass in mice. The immune system plays an important role in the cross-talk with metabolic tissues, such as liver, intestine and adipose tissues. However, whether BA modulate immune cell function is unknown. Our unpublished results identifying FXR and TGR5 expression in lymphoid cells, prompt us to study their role in the regulation of glucose and lipid metabolism through immune cell modulation. Using reporter mice and specific ligands, we will characterize the immune cells expressing active FXR and TGR5. We will determine their role in metabolism and inflammation by immune cell-specific gene inactivation in models of obesity, T2D and elevated peripheral blood BA concentrations. Mass cytometry, cell sorting and single cell transcriptomic analysis will allow the identification of gene networks regulated by BA and their receptors. As microbiota generate biologically active secondary BA, we will assess the impact of microbiota depletion and subsequent BA acid pool modifications on immune cell populations. Translational studies in humans with altered BA metabolism and pharmacological treatment with anti-diabetic BA sequestrants will allow assessment of alterations in immune functions. This project aims to identify an hitherto unexplored role of BA through modulation of the immune system on T2D, NAFLD and dyslipidemia. Success of the project critically depends on an integrative approach uniquely undertaken in my laboratory through its unique multidisciplinary expertise in basic and translational biology.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714922	**iGBMavatars**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. GAETANO GARGIULO**
Host Institution: Max-Delbruck-Centrum Fur Molekulare Medizin In Der Helmholtz-Gemeinschaft, DE

Glioblastoma Subtype Avatar models for Target Discovery and Biology

The Glioblastoma Multiforme (GBM) is the most common primary brain tumor and it is incurable. Two major challenges affect GBM clinical management: its heterogeneity (which treatment will best fit this very patient?) and its resistance to available treatments (will the patient benefit in any way from the chosen therapy?). Here we approach these questions with a personalized entry point. First, we aim to create “humanized” experimental models of GBM accurately reflecting patients at molecular level. These GBM Subtype Avatars models (GSA) will be exploited as “targeted patients” in personalized biology and intervention studies. Since GBM exists as molecular subtypes with similar histopathology but mutually exclusive genetic lesions and molecular features, we will generate GSA by targeting mutations recurrently associated with Proneural, Classical or Mesenchymal GBM subtypes into adult human neural stem cells (NSC). Evidence supports that these cells can give rise to high-grade gliomas when engineered with the appropriate genetic lesions. Next, engineered NSC will be orthotopically implanted into immunocompromised rats and the resulting tumors profiled for gene expression, DNA methylation and copy number aberrations. These profiles will be compared to those generated in patient-derived xenografts and biopsies. Second, to identify drug targets favoring patients’ response to the current standard of care, we will exploit GSA for state-of-art genetic screens in vivo. Specifically, we will seek for synthetic lethal interactions between DNA damaging agents and the GSA transcriptome using an in vivo CRISPRi screening approach. Third, to investigate the molecular basis of GBM heterogeneity in GSA models, we will combine genetic and immunophenotypic tracing with gene expression and epigenomic profiling. Identifying tumor-specific vulnerabilities in a dismal disease urging for effective therapies and its molecular fingerprinting convey conceivably rapid Translation in Oncology.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715322	**EndoMitTalk**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. MARÍA MITTELBRUNN**
Host Institution: Universidad Autonoma De Madrid, ES

Endolysosomal-mitochondria crosstalk in cell and organism homeostasis

For many years, mitochondria were viewed as semiautonomous organelles, required only for cellular energetics. This view has been displaced by the concept that mitochondria are fully integrated into the life of the cell and that mitochondrial function and stress response rapidly affect other organelles, and even other tissues. A recent discovery from my lab demonstrated that mitochondrial metabolism regulates lysosomal degradation (Cell Metabolism, 2015), thus opening the way to investigate the mechanism behind communication between these organelles and its consequences for homeostasis. With this proposal, we want to assess how mitochondrial crosstalk with endolysosomal compartment controls cellular homeostasis and how mitochondrial dysfunction in certain tissues may account for systemic effects on the rest of the organism. EndoMitTalk will deliver significant breakthroughs on (1) the molecular mediators of endolysosomal-mitochondria communication, and how deregulation of this crosstalk alters cellular (2), and organism homeostasis (3). Our central goals are: 1a,b. To identify metabolic and physical connections mediating endolysosomal-mitochondria crosstalk; 2a. To decode the consequences of altered interorganelle communication in cellular homeostasis 2b. To study the therapeutic potential of improving lysosomal function in respiration-deficient cells; 3a. To assess how unresolved organelle dysfunction and metabolic stresses exclusively in immune cells affects organism homeostasis and lifespan. 3b. To decipher the molecular mediators by which organelle dysfunction in T cells contributes to age-associated diseases, with special focus in cardiorenal and metabolic syndromes. In sum, EndoMitTalk puts forward an ambitious and multidisciplinary but feasible program with the wide purpose of understanding and improving clinical interventions in mitochondrial diseases and age-related pathologies.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725790	**EpiFAT**	**LS4** Physiology, Pathophysiology and Endocrinology

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

Epigenomic Reprogramming of Adipose Tissue Function and Energy Metabolism in Type 2 Diabetes

Obesity is associated with adipose tissue dysfunction leading to the onset of several pathologies including type 2 diabetes (T2D). The mechanisms underlying the development of obesity and T2D include the hypertrophy and/or hyperplasia of adipocytes and adipose tissue inflammation together with an altered secretion of adipokines. However, the explanation of why individual obese (and some non-obese) humans differ in their susceptibility to develop T2D is still an issue that is currently not sufficiently addressed. This susceptibility to T2D is mainly associated with environmental factors. One link between environment and disease is epigenetics influencing gene expression and subsequently organ dysfunction. Epigenetic modifications in adipose tissue have been proposed to influence the susceptibility to T2D. However, the epigenomic mechanisms underpinning adipose tissue dysfunction are poorly known. In search for epigenomic modifiers that control adipose tissue function and also impact on T2D pathogenesis, we have recently identified the transcriptional coregulators GPS2 (G-Protein Pathway Suppressor 2) and KDM6B (Histone Lysine Demethylase 6B, also called JMJD3) as strong candidates..

Our hypothesis is that the clinically documented dysregulation of GPS2 (down) and KDM6B (up) expression and function during obesity leads to the closely linked epigenetic and transcriptional reprogramming of adipocytes and adipose tissue-macrophages, thereby enhancing the susceptibility to metabolic and inflammatory disturbances and the progression towards T2D.

We propose here to test this hypothesis using the combination of unique mouse models, genome-wide molecular and epigenomic analyses and human studies to dissect the epigenomic functions of GPS2 and KDM6B in adipose tissue, aiming at identifying mechanism involved in the development T2D. Thereby, we anticipate the discovery of novel epigenomic targets for future prevention and treatment strategies in metabolic dysfunction.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
741888	**CSI-Fun**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. ERWIN WAGNER**
Host Institution: Medizinische Universitaet Wien, AT

Chronic Systemic Inflammation: Functional organ cross-talk in inflammatory disease and cancer

Chronic Systemic Inflammation (CSI) resulting from systemic release of inflammatory cytokines and activation of the immune system is responsible for the progression of several debilitating diseases, such as Psoriasis, Arthritis and Cancer. Initially localised diseases can result in CSI with subsequent systemic spread to distant organs, a key patho-physiological phase responsible for major morbidity and even mortality. Despite the importance of CSI, a complete understanding of the molecular mechanisms, signalling pathways and cell types involved, as well as the chronological evolution of the systemic inflammatory response is still elusive. The classical approach to study inflammation has focused on investigating individual cell types or organs in the pathogenesis of a single disease, thereby neglecting important organ cross-talk and systemic interactions. Furthermore, understanding the temporal and spatial kinetics modulating the inflammatory response requires a detailed study of interactions between different immune and non-immune organs at various time points during disease progression in the context of the whole organism.

The aim of this research proposal is to substantially advance our understanding of whole organ physiology in relation to systemic inflammation as a cause or/and consequence of disease with the focus on Psoriasis/Joint Diseases and Cancer Cachexia. The goal is to elucidate the molecular mechanisms at the cellular and systemic level, and to decipher endocrine interactions and cross-talks between distant organs. Various model systems ranging from cell cultures to genetically engineered mouse models to human clinical samples will be employed. Genomic, proteomic and metabolomic data will be combined with functional in vivo assessment using mouse models to understand the multi-faceted role of systemic inflammation in chronic human diseases, such as Inflammatory Skin/Joint disease and Cachexia, a deadly systemic manifestation of Cancer.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758713	**ELIMINATE**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. SONJA LOGES**
Host Institution: Universitaetsklinikum Hamburg-Eppendorf, DE

Development of strategies to eliminate cancer cells from the bone marrow

The bone marrow (BM) represents the prime location in which cancer cells survive aggressive treatments. This poses a major health challenge because the mortality rate of patients with curable cancer doubles if tumor cells persist in the BM. One unresolved question is why the immune system fails to eradicate cancer cells from this microenvironment even though it represents a lymphatic organ. Surprisingly, despite the ongoing revolution in immune oncology, the regulation and potential therapeutic activation of the immune response in the BM still remains largely unexplored. In this grant application a new line of research is proposed with the overall objective of understanding the cellular and molecular mechanisms, which control anti-cancer immune responses in the BM. The originality of this proposal relates to the hypothesis that innate and adaptive immune cells are suppressed by stroma cells in the BM. Therefore, we will conduct a comprehensive phenotypic and functional profiling of immune and stroma cells in the BM of cancer patients with and without persisting tumor cells. Based on these insights we will develop novel strategies to harness the immune system to eliminate malignant cells from the BM. The ground-breaking nature of the project is that it will shed light on the unappreciated immune microenvironment in the BM. Its specific strength lies in the multidisciplinary design encompassing informative patient cohorts, state-of-the-art mouse models and cutting-edge technologies including Next-Generation-Sequencing as well as innovative drug candidates. Hereby I can build on my internationally reCoGnized expertise in the BM microenvironment field, which has already led to the successful development of a clinical-stage drug. Novel strategies to eliminate malignant cells from the bone marrow are of utmost medical importance because they would increase the cure rate of cancer patients.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759006	**TRANSREG**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. ATAMAN SENDÖL**
Host Institution: Universite De Lausanne, CH

Dissecting the role of Translational Regulation in Tumorigenesis

The control of translation is a key determinant of protein abundance, which in turn defines cellular states. The impact of translational regulation may be even greater during the transition from homeostasis to malignancy, as revealed by the surprisingly low correlations between mRNA and protein levels in human cancer databases. This raises the intriguing possibility that through an ability to generate aberrant downstream networks of translational regulators, onCoGenic drivers might impose altered protein synthesis programs that become the driving force for tumor formation and malignant progression.

We recently unveiled a hitherto unappreciated role for upstream open reading frame (uORF) translation in tumorigenesis and unearthed a novel switch from conventional EIF2 initiation factor-mediated to alternative EIF2A-mediated uORF translation. These observations suggest that uORFs constitute an exciting new frontier in the field of translational regulation with the potential to fundamentally impact cellular fate.

Here, I propose to systematically analyze the function of uORFs during tumorigenesis. First, we will conduct an in vivo CRISPR/CAS9-based screen in mice to elucidate the role of thousands of uORFs in development, differentiation and upon onCoGenic transformation. Second, focusing on select uORFs surfacing in the screen, we will document their role during tumor initiation and progression. Third, we will develop novel tools to detect uORF translation in vivo, exploit them to monitor uORF translation during different stages of tumorigenesis, gain mechanistic insight into their function and finally test the relevance of these findings in human cancer. Collectively, these approaches will provide unprecedented and comprehensive insight into the function of uORFs, unravel new paradigms in the control of gene expression and expose novel strategies for cancer diagnostics and treatment.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759921	**SymPAtHY**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. DANIELA CARNEVALE**
Host Institution: Universita Degli Studi Di Roma La Sapienza, IT

A neurosplenic pathway coupling Immunity and Hypertension

Hypertension (HTN) is a leading cause of morbidity and mortality worldwide. During past decades, several therapies have been developed to afford an optimal blood pressure (BP) regulation. However, the prevalence of uncontrolled HTN continues to rise, with a number of patients still resistant to all ongoing antihypertensive treatments, raising unsolved mechanistic challenges. In the last years, the most attractive novelty in HTN postulated that immune system has a crucial role in BP raising, as well as in end-organ damage. Several advances have been done in this field, but clear mechanistic explanations of how the immune system gets activated under hypertensive challenges is still unknown. It is becoming increasingly clear that, even in the regulation of body hemodynamic, the immune system and the autonomic nervous system serve as two major “sensory organs” capable to be activated upon manifold hits that perturb homeostasis. SymPAtHY is a multidisciplinary strategy aimed at discovering how nervous and immune systems couple in HTN. The concept of this project is to dissect the neuro-immune pathway responsible for BP rising and end-organ damage. The articulation in 3 MAIN AIMS will allow to afford the mechanistic insights from different perspectives. The overall objectives are as follows: 1) Central nervous system relay station coupling immunity and hypertension. 2) Splenic immune mechanisms: from sympathetic drive to T cell egress; 3) T cells in target organs: from the spleen to vessels and kidney. The results of this strategy will unravel important new mechanistic insights in HTN and particularly will have significant implications for understanding how immunity and autonomic nervous system cooperate to rise BP. Based on the emerging view of HTN as an “immune disorder”, we believe that this strategy will add decisive knowledge in this field that could pave the way for developing immunotherapies for the treatment of resistant HTN.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771083	**PhaseControl**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. TOM LUEDDE**
Host Institution: Universitaetsklinikum Aachen, DE

How cellular suicide programmes control phase transitions in fatty liver disease and liver cancer

The progression from a healthy liver towards non-alcoholic steatohepatitis (NASH) and hepatocellular carcinoma (HCC) serves as a model for chronic diseases in a solid organ, demonstrating how an initially stable stage undergoes critical transitions along several defined phases. Defining the molecular drivers of these phase transitions will open the road for the definition of warning signs, risk prediction approaches and prevention of disease decompensation in human liver disease. We recently made several ground-breaking findings indicating that the molecules RIPK3 and MLKL – which regulate a novel form of programmed cell death called necroptosis – are crucial mediators of these phase transitions, but they might have unexpected and cell-death-independent functions. Therefore, PhaseControl aims at exploring the specific functions of these molecules at the critical phase transitions towards NASH/HCC. Specifically, I propose to apply a systematic approach and innovative methods to

1) explore cell-type specific RIPK3- and MLKL-dependent regulatory networks in white adipose tissue (WAT), hepatocytes and myeloid cells in murine NASH development and define cell-death independent functions of MLKL in metabolic regulation;
2) explore how inflammatory pathways in hepatocytes modulate the reactivity and specific responses towards necroptosis at the transition towards hepatocellular carcinoma (HCC);
3) examine apoptosis- and necroptosis-specific genetic alterations and driver mutations that mediate the transition from chronic inflammation to HCC;
4) evaluate in a cohort of human patients if these newly discovered pathways can be used for risk-prediction approaches and might be chemoprevention targets against HCC.

The expected results will establish a novel concept how programmed cell death, inflammation and metabolic pathways functionally interact in hepatocarcinogenesis with fundamental relevance for risk prediction and chemoprevention of human liver cancer.

Project End Date: **31-OCT-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 Vzw, 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:
771945	**GENOMIA**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. BART LOEYS**
Host Institution: Universiteit Antwerpen, BE

Genomic Modifiers of Inherited Aortapathy

Thoracic aortic aneurysm and dissection (TAAD) is an important cause of morbidity and mortality in the western world. As 20% of all affected individuals have a positive family history, the genetic contribution to the development of TAAD is significant. Over the last decade dozens of genes were identified underlying syndromic and non-syndromic forms of TAAD. Although mutations in these disease culprits do not yet explain all cases, their identification and functional characterization were essential in deciphering three key aortic aneurysm/dissection patho-mechanisms: disturbed extracellular matrix homeostasis, dysregulated TGFbeta signaling and altered aortic smooth muscle cell contractility. Owing to the recent advent of next-generation sequencing technologies, I anticipate that the identification of additional genetic TAAD causes will remain quite straightforward in the coming years. Importantly, in many syndromic and non-syndromic families, significant non-penetrance and both inter- and intra-familial clinical variation are observed. So, although the primary genetic underlying mutation is identical in all these family members, the clinical spectrum varies widely from completely asymptomatic to sudden death due to aortic dissection at young age. The precise mechanisms underlying this variability remain largely elusive. Consequently, a better understanding of the functional effects of the primary mutation is highly needed and the identification of genetic variation that modifies these effects is becoming increasingly important. In this project, I carefully selected four different innovative strategies to discover mother nature's own modifying capabilities in human and mouse aortopathy. The identification of these genetic modifiers will advance the knowledge significantly beyond the current understanding, individualize current treatment protocols to deliver true precision medicine and offer promising new leads to novel therapeutic strategies.

Project End Date: **31-DEC-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:
787470	**IntraGutSex**	**LS4** Physiology, Pathophysiology and Endocrinology

Principal Investigator: **Dr. IRENE MIGUEL-ALIAGA**
Host Institution: Imperial College Of Science, Technology And Medicine, UK

Sex differences in intestinal plasticity

Sex differences in intestinal plasticity

Males and females often differ in their physiology and disease susceptibility. Sex hormones play key roles in sculpting and maintaining such sex differences, but increasing evidence points to a contribution of cell-intrinsic mechanisms. We are only beginning to understand the molecular mediators of these intrinsic mechanisms, and little is known about the organs where they function and their effects at the whole-organism level.

Our work in flies recently revealed the existence of intrinsic sex differences in intestinal stem cell proliferation. This work raised the possibility that other, more metabolically significant intestinal cell types have their own sexual identity, with potential consequences at the organ and whole-organism levels. This proposal will explore the nature and significance of this sexual identity in two such cell types: enterocytes and neurons.

We will first take advantage of our ability to genetically manipulate and sexually transform these cells in Drosophila in order to understand how their sexual identity is specified and whether it needs to be actively maintained. We will then explore the contribution of such sexual identity to organ features and whole-body physiology. Finally, we will investigate the evolutionary conservation of our findings by establishing organoids as a model to investigate enterocyte physiology, and then use them to explore whether intrinsic mechanisms are also active in the mouse intestinal epithelium.

Collectively, our multidisciplinary approach will shed light on the contribution of the intestine - an organ not previously known to have an intrinsic sexual identity - to sex differences in physiology. It will also pioneer the study of enterocyte physiology in organoids: an emerging and extremely powerful ex vivo system. Our work will also lay the foundations for future interventions aimed at tackling sex biases in disease susceptibility/prognosis.

Project End Date: **30-SEP-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:
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:
646671	**RobustSynapses**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. PATRIK VERSTREKEN**
Host Institution: Vib Vzw, BE

Maintaining synaptic function for a healthy brain: Membrane trafficking and autophagy in neurodegeneration

Neurodegeneration is characterized by misfolded proteins and dysfunctional synapses. Synapses are often located very far away from their cell bodies and they must therefore largely independently cope with the unfolded, dysfunctional proteins that form as a result of synaptic activity and stress. My hypothesis is that synaptic terminals have adopted specific mechanisms to maintain robustness over their long lives and that these may become disrupted in neurodegenerative diseases. Recent evidence indicates an intriguing relationship between several Parkinson disease genes, synaptic vesicle trafficking and autophagy, providing an excellent entry point to study key molecular mechanisms and interactions in synaptic membrane trafficking and synaptic autophagy. We will use novel genome editing methodologies enabling fast in vivo structure-function studies in fruit flies and we will use differentiated human neurons to assess the conservation of mechanisms across evolution. In a complementary approach I also propose to capitalize on innovative in vitro liposome-based proteome-wide screening methods as well as in vivo genetic screens in fruit flies to find novel membrane-associated machines that mediate synaptic autophagy with the ultimate aim to reveal how these mechanisms regulate the maintenance of synaptic health. Our work not only has the capacity to uncover novel aspects in the regulation of presynaptic autophagy and function, but it will also reveal mechanisms of synaptic dysfunction in models of neuronal demise and open new research lines on mechanisms of synaptic plasticity.

Project End Date: **31-DEC-20**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647051	**SENSOCOM**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. KATHARINA VON KRIEGSTEIN**
Host Institution: Technische Universitaet Dresden, DE

The tiny and the fast: the role of subcortical sensory structures in human communication

In Europe, approximately one hundred million people are impaired in their communication abilities. These include people with autism spectrum disorders (ca. 3 million) and individuals with dyslexia (ca. 50 million). Current neuroscience research typically associates CoGnitive functions including communication abilities with the cerebral cortex. By and large, this approach ignores the complex subcortical processing machinery before sensory signals reach the cortex. However, recent pioneering studies imply that dysfunction in tiny subcortical sensory structures can cause selective deficits in our ability to understand others. My goal is to (i) investigate the role of subcortical sensory structures in analysing communication signals and (ii) specify how dysfunction in subcortical-cortical interaction can cause human communication disorders. To do this we will combine very recently developed ultra-high-resolution neuroimaging with a cutting-edge multimodal approach including neurostimulation, and computational neuroimaging. The project will relate sensory subcortical responses to concrete communication behaviour, as observed in healthy individuals and individuals with communication disorders. I expect two key results: First, we will uncover the principles of how subcortical sensory structures operate for dynamic auditory and visual communication signals; this will lead to a novel model of subcortical-cortical interactions that can explain key functions in human communication. Second, the results will resolve long-standing puzzles about the nature of two of the most common hereditary communication deficits (developmental dyslexia and autism spectrum disorders). Immediate consequences of this proposal will include a translational project aimed at improving communication functions with behavioural interventions. Together, the findings may revolutionise our understanding of how sensory subcortical structures shape one of our most important CoGnitive functions—communication.

Project End Date: **31-DEC-20**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
671048	**MyeliNANO**	**LS5** Neurosciences and Neural Disorders

Principal Investigator:	**Dr. KLAUS-ARMIN NAVE**
Host Institution:	Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Myelinic nanochannels in neurodegenerative diseases

Myelin is made by highly specialized glial cells and enables fast axonal impulse propagation. We have discovered that oligodendrocytes in the CNS are, in addition to myelination, required for the integrity and survival of axons, independent of the presence or absence of myelin itself. More recently, we found the underlying mechanism and could show that glycolytic oligodendrocytes provide axons with pyruvate/lactate. These metabolites are transported through a system of myelinic nanochannels to the axonal compartment, in which mitochondria generate ATP. The finding was a paradigm-shift for the physiological function of axonassociated glia, and opens now the intriguing possibility that oligodendrocytes are important modifiers of neurological diseases in which myelinated axons are lost. This includes, in addition to multiple sclerosis, also classical neuropsychiatric disorders. We will generate novel genetic tools in mice that allow us to study the role myelin and secondary axonal loss in higher brain functions. We will test the challenging hypothesis that reducing oligodendroglial support of axonal metabolism is a risk for differen neurodegenerative disorders.
These involve the previously neglected ultrastructure of CNS myelin with cytosolic (20-300 nanometer wide) channels within the myelin sheath. These 'nanochannels' couple the oligodendrocyte soma metabolically to the adaxonal space, but are vulnerable to aging and physical injury. We hypothesize that cellular mechanisms as diverse as neuroinflammation and the aggregation of misfolded proteins in myelinic nanochannels cause perturbations of the axonal energy metabolism. When combined, the findings of MyeliNANO will shed new light on previously unknown functions of CNS myelin and will pave the way for metabolic neuroprotection as a therapeutic approach to a range of neurodegenerative diseases.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
678307	**WIRELESS**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. LUCA BONINI**
Host Institution: Universita Degli Studi Di Parma., IT

Motor and CoGnitive functions of the monkey premotor cortex during free social interactions

A number of studies demonstrated that the primates' premotor cortex (PM) plays a crucial role not only in organizing movement, but also in perceptual and socio-CoGnitive functions. However, these studies have been carried out in laboratory settings, which deeply limit the possibility to understand the neural mechanisms underlying natural behaviours. To solve this problem, I propose a new approach consisting in a two-steps chronic recording of monkey PM neurons: first, single neurons response properties will be characterized in a traditional, head-restrained laboratory setting; then, in the same session, the same neurons activity will be recorded wirelessly during free interactions of the monkey with its physical and social environment. The project will initially focus on neurons belonging to the forelimb representation of the ventral (i.e. areas F4 and F5) and dorsal (area F2vr) PM, putatively well known for their role in sensorimotor transformations, goal coding, representation of space, and reCoGnition of other's observed actions. The same paradigm will then be applied to the study of the mesial pre-supplementary area F6, a crucial bridge between prefrontal and PM regions whose role in socio-CoGnitive functions remains still virtually unknown. Finally, by simultaneous, chronic recording of neuronal activity from lateral and mesial PM, we will first assess the functional interactions between these areas in both laboratory and natural settings, and then we will probe causality in these interactions by chemically manipulating neuronal activity of one region (i.e. F6) while recording from the other one (i.e. F5). The project will reveal the role of premotor cortex in motor and social functions during natural behaviours. In addition, it might open up new possibilities for future studies of neural plasticity and reorganization of ethologically-relevant motor, CoGnitive and social functions following chemical manipulation of neural activity and virtual brain lesions.

Project End Date: **30-SEP-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681607	**SolutionSleep**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. PENNY LEWIS**
Host Institution: Cardiff University, UK

Understanding creativity and problem solving through sleep-engineering

Innovative problem solving is critical for all spheres of organised endeavour, including science and industry, and thus forms the cornerstone of a successful society. Such creative thinking often requires suppression of preconceptions and restructuring of existing knowledge. Pioneering work has shown that sleep facilitates problem solving, but exactly how, and which sleep characteristics are important, remain to be determined. We know that recent experiences are replayed in sleep, and that in Slow Wave Sleep (SWS) this replay integrates new knowledge with old. The role of such replay in Rapid Eye Movement (REM) sleep, a stage which is strongly linked to creativity, is unknown. Here, I propose a model which combines physiology, behavioural studies, and computational modelling to make testable predictions about the complimentary contributions of memory replay in REM and SWS to problem solving. I will test this model through explicit manipulation of memory replay in sleep. I will use a very recently developed technique to explicitly trigger memory replay, a pioneering method for quantifying this replay, and cutting-edge approaches for manipulation of neural oscillations during sleep. I expect two key results: first, I will uncover the principles of how memory replay in REM and SWS combines with specific neural oscillations to promote both long-term memory and creative problem solving. This will involve development of a computational model which will enable optimised experimental design, paving the way for efficient future investigation of how to enhance innovation through manipulation of sleep. Second, I will develop methods for boosting key sleep processes in a selective, targeted manner. Immediate consequences will include a translational project to facilitate everyday problem solving. My findings will revolutionist the understanding of sleep and how it impacts upon some of our most important CoGnitive abilities—memory and problem solving.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682345	**EPITOR**	**LS5** Neurosciences and Neural Disorders

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

NEUROBIOLOGY OF EPILEPSY GENES

Ion channel genes have long been linked to Mendelian focal epilepsies, but my recent finding of frequent mutations in DEPDC5 opens completely new perspectives. DEPDC5 is an inhibitor of the mTORC1 (mammalian target of rapamycin) signaling pathway, the master regulator of cell proliferation and growth. Mutations of this gene are found in a wide spectrum of focal epilepsy syndromes, with or without cortical malformations. I propose to examine the links between DEPDC5 and the mTORC1 pathway in cortical development and the genesis of epileptic activity.

My proposal work will combine high-throughput sequencing, in vivo proteomics, biochemistry, electrophysiology, and animal behavior testing (video-EEG). Functional analyses will be made on human postoperative tissue and neuronal cultures from human iPSC and specific rodent models. These approaches will enable me to (1) ask if and how the mTORC1 signaling pathway may contribute to epileptogenesis and seizures in patients with DEPDC5 mutations, (2) attempt to explain the diversity of phenotypes, in particular the presence of cortical lesion by searching for somatic brain mutations in the gene, (3) explore neurobiology pathways and partners of DEPDC5, and (4) identify novel actors for inherited focal epilepsies.

Our results will help us understand the genesis of epileptic networks, and more generally how defects in mTORC1 signaling cascade cause neurologic conditions. We anticipate genetic studies on germline and somatic mutations will have a significant clinical impact for genetic counseling and improved prognosis. The molecules and pathways that will be studied in this proposal differ completely from ion channels and receptors that have been so far associated with focal epilepsies. Thus I hope to provide a new orientation for the field, to identify novel genetic mechanisms and to provide an unbiased route to new molecular therapeutic targets.

Project End Date: **30-SEP-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
683154	**AstroWireSyn**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. NATHALIE ROUACH**
Host Institution: College De France, FR

Wiring synaptic circuits with astroglial connexins: mechanisms, dynamics and impact for critical period plasticity

Brain information processing is commonly thought to be a neuronal performance. However recent data point to a key role of astrocytes in brain development, activity and pathology. Indeed astrocytes are now viewed as crucial elements of the brain circuitry that control synapse formation, maturation, activity and elimination. How do astrocytes exert such control is matter of intense research, as they are now known to participate in critical developmental periods as well as in psychiatric disorders involving synapse alterations. Thus unraveling how astrocytes control synaptic circuit formation and maturation is crucial, not only for our understanding of brain development, but also for identifying novel therapeutic targets.

We recently found that connexin 30 (Cx30), an astroglial gap junction subunit expressed postnatally, tunes synaptic activity via an unprecedented non-channel function setting the proximity of glial processes to synaptic clefts, essential for synaptic glutamate clearance efficacy. Our work not only reveals Cx30 as a key determinant of glial synapse coverage, but also extends the classical model of neuroglial interactions in which astrocytes are generally considered as extrasynaptic elements indirectly regulating neurotransmission. Yet the molecular mechanisms involved in such control, its dynamic regulation by activity and impact in a native developmental context are unknown. We will now address these important questions, focusing on the involvement of this novel astroglial function in wiring developing synaptic circuits.

Thus using a multidisciplinary approach we will investigate:

1) the molecular and cellular mechanisms underlying Cx30 regulation of synaptic function
2) the activity-dependent dynamics of Cx30 function at synapses
3) a role for Cx30 in wiring synaptic circuits during critical developmental periods

This ambitious project will provide essential knowledge on the molecular mechanisms underlying astroglial control of synaptic circuits.

Project End Date: **30-SEP-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715148	**CoSI**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. EWELINA KNAPSKA**
Host Institution: Instytut Biologii Doswiadczalnej Im. M. Nenckiego Polskiej Akademii Nauk, PL

Functional connectomics of the amygdala in social interactions of different valence

Understanding how brain controls social interactions is one of the central goals of neuroscience. Whereas social interactions and their effects on the emotional state of an individual are relatively well described at the behavioral level, much less is known about neural mechanisms involved in these very complex phenomena, especially in the amygdala, a key structure processing emotions in the brain.

Recent investigations, mainly on fear learning and extinction, have shown that there are highly specialized neuronal circuits within the amygdala that control specific behaviors. However, a high density of interconnections, both among amyg¬dalar nuclei and between amygdalar nuclei and other brain regions, and the lack of a predictable distribution of functional cell types make defining behavioral functions of the amygdalar neuronal circuits challenging. Therefore, to understand how different neuronal circuits in the amygdala produce different behaviors tracing anatomical connections between activated neurons, i.e., the functional anatomy is needed.

Published data and our preliminary results suggest that within the amygdala there exist different neuronal circuits mediating social interactions of different valence (positive or negative affective significance) and that circuits controlling social and non-social emotions differ. Combining our recently developed behavioral models of adult, non-aggressive, same-sex social interactions with the methods of tracing anatomical connections between activated neurons, we plan to identify neural circuitry underlying social interactions of different emotional valence. This goal will be achieved by: (1) Characterizing functional anatomy of neuronal circuits in the amygdala underlying socially transferred emotions; (2) Examining role of the identified neuronal subpopulations in control of social behaviors; (3) Verifying role of matrix metalloproteinase-9-dependent neuronal subpopulations within the amygdala in social motivation.

Project End Date: **30-NOV-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716846	**RewardedPerception**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. AREZOO POORESMAEILI**
Host Institution: Universitaetsmedizin Goettingen - Georg-August-Universitaet Goettingen - Stiftung Oeffentlichen Rechts, DE

Functional circuits mediating the effects of reward value on perception within and across sensory modalities

Our perceptual system needs to maintain a balance between selectivity and sensitivity, so that redundant information is dismissed, but novel and important information does not go unnoticed. Selective attention and reward value are among mechanisms that adjust this balance, by exerting top-down control over bottom-up sensory processing. Excessive reliance on top-down signals has been suggested to underlie pathologic conditions, such as hallucinations. In contrast, controlled boosting of top-down signals is a potential tool to rehabilitate impaired sensory functions. Despite their importance, key aspects of top-down and bottom-up interactions have remained unknown: We do not know how abstract, non-sensory signals, such as reward value, could exert specific sensory effects; it is unclear how they are transmitted across sensory modalities and what the underlying neural mechanisms are.

Here, I will try to provide answers to these questions by combining behavioural testing, neuroimaging, and non-invasive brain stimulation techniques in humans. I will use a novel approach, where abstract reward value of a stimulus is linked to a sensory modality label. This enables me to trace how value-driven, top-down signals are communicated to sensory areas and how they impact on different aspects of perception: from detection of external signals to perception of illusory associations. Using brain imaging techniques, I will distinguish between regions where the sensory modality label is represented, and regions where reward value signals are coded, regardless of their sensory modality. Finally, I will test whether non-invasive perturbation of regions containing sensory modality labels impairs perception in the respective modalities, thereby testing if these regions play a causal role in selective top-down interactions. This project will therefore provide a mechanistic understanding of functional circuits that underlie the effects of reward value on sensory perception in humans.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725729	**FUNCOPLAN**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. MATTHEW GRUBB**
Host Institution: King'S College London, UK

Functions of plasticity in adult-born neurons

The major objective of FUNCOPLAN is to examine groundbreaking questions on the functional role of newly-generated neurons in the adult brain. Using a combination of innovative approaches, our aim is to discover how plasticity in adult-born cells shapes information processing in neuronal circuits.

Adult neurogenesis produces new neurons in particular areas of the mammalian brain throughout life. Because they undergo a transient period of heightened plasticity, these freshly-generated cells are believed to bring unique properties to the circuits they join – a continual influx of new, immature cells is believed to provide a level of plasticity not achievable by the mature, resident network alone. But what exactly is the function of the additional plasticity provided by adult-born neurons? How does it influence information processing in neuronal networks?

These questions are vital for our fundamental understanding of how the brain works. We will address them by studying a unique population of cells that is continually generated throughout life: dopaminergic neurons in the olfactory bulb. These cells play a key role in the modulation of early sensory responses and are renowned for their plastic capacity. However, the role of this plasticity in shaping sensory processing remains completely unknown. FUNCOPLAN's first objectives, therefore, are to discover novel experience-dependent plastic changes in the cellular features and sensory response properties of adult-born neurons. We will then go much further than this, however, by integrating our discoveries with state-of-the-art techniques for precisely manipulating activity in these cells in vivo. This wholly innovative approach will allow us to mimic the effects of plasticity in naïve circuits, or cancel the effects of plasticity in experience-altered networks. In this way, we will break new ground, demonstrating a unique contribution of plasticity in adult-born cells to the fundamental function of neuronal circuitry.

Project End Date: **31-MAY-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:
741744	**ImmuneCheckpointsAD**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. MICHAL SCHWARTZ**
Host Institution: Weizmann Institute Of Science, IL

Immune checkpoint blockade for fighting Alzheimer's disease

Understanding, and ultimately treating Alzheimer's disease (AD) is a major need in Western countries. Currently, there is no available treatment to modify the disease. Several pioneering discoveries made by my team, attributing a key role to systemic immunity in brain maintenance and repair, and identifying unique interface between the brain's borders through which the immune system assists the brain, led us to our recent discovery that transient reduction of systemic immune suppression could modify disease pathology, and reverse CoGnitive loss in mouse models of AD (Nature Communications, 2015; Nature Medicine, 2016; Science, 2014). This discovery emphasizes that AD is not restricted to the brain, but is associated with systemic immune dysfunction. Thus, the goal of addressing numerous risk factors that go awry in the AD brain, many of which are -as yet-unknown, could be accomplished by immunotherapy, using immune checkpoint blockade directed at the Programmed-death (PD)-1 pathway, to empower the immune system. In this proposal, we will adopt our new experimental paradigm to discover mechanisms through which the immune system supports the brain, and to identify key/novel molecular and cellular processes at various stages of the disease that are responsible for CoGnitive decline long before neurons are lost, and whose reversal or modification is needed to mitigate AD pathology, and prevent CoGnitive loss. Achieving our goals requires the multidisciplinary approaches and expertise at our disposal, including state-of-the art immunological, cellular, molecular, and genomic tools. The results will pave the way for developing a novel next-generation immunotherapy, by targeting additional selective immune checkpoint pathways, or identifying a specific immune-based therapeutic target, for prevention and treatment of AD. We expect that our results will help attain the ultimate goal of converting an escalating untreatable disease into a chronic treatable one.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
755745	**iMove**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. MATI JOSHUA**
Host Institution: The Hebrew University Of Jerusalem., IL

Translating rewards to eye movements

The drive for rewards controls almost every aspect of our behavior, from stereotypic reflexive behaviors to complex voluntary action. It is therefore not surprising that the symptoms of neurological disorders that interrupt reward processing, such as those stemming from drug-abuse and depression, include deficits in the capacity to make even simple movements. Accordingly, how do rewards drive and shape movements? The brain uses two major subcortical networks to drive behavior: the basal ganglia and the cerebellum. Both areas are essential for the control of movement as damage to either structure leads to severe motor disabilities. Research on the basal ganglia has highlighted their importance in the control of reward-driven behavior-but how the reward information interacts with sensorimotor signals to drive the motor periphery is unknown. By contrast, research on the cerebellum has focused primarily on how sensory error signals are used to optimize motor commands but has mostly ignored the modulatory factors that influence behavior, such as reward. My goal is to unify research on the basal ganglia and cerebellum in order to understand how the computations underlying the influence of reward on action are implemented in the brain. I hypothesize that rewards drive and shape the motor commands in both subcortical networks, albeit with differing behavioral functions. While in the basal ganglia, information about reward is used to mediate selection between multiple actions; I predict that, in the cerebellum, reward potentiates movements to drive more accurate behavior. I will use the monkey smooth pursuit eye movement system as a powerful model motor system to study the neural mechanisms by which reward influences motor processing. I will combine the use of novel behavioral paradigms together with novel application of neural recording and optogenetic stimulation in primates to probe activity of neurons in the cerebral cortex, basal ganglia, and cerebellum.

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

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:
772242	**ARTTOUCH**	**LS5** Neurosciences and Neural Disorders

Principal Investigator: **Dr. ROCHELLE ACKERLEY**
Host Institution: Centre National De La Recherche Scientifique Cnrs, FR

Generating artificial touch: from the contribution of single tactile afferents to the encoding of complex percepts, and their implications for clinical innovation

Somatosensation encompass a wide range of processes, from feeling touch to temperature, as well as experiencing pleasure and pain. When afferent inputs are degraded or removed, such as in neuropathies or amputation, exploring the world becomes extremely difficult. Chronic pain is a major health issue that greatly diminishes quality of life and is one of the most disabling and costly conditions in Europe. The loss of a body part is common due to accidents, tumours, or peripheral diseases, and it has instantaneous effects on somatosensory functioning. Treating such disorders entails detailed knowledge about how somatosensory signals are encoded. Understanding these processes will enable the restoration of healthy function, such as providing real-time, naturalistic feedback in prostheses. To date, no prosthesis currently provides long-term sensory feedback, yet accomplishing this will lead to great quality of life improvements. The present proposal aims to uncover how basic tactile processes are encoded and represented centrally, as well as how more complex somatosensation is generated (e.g. wetness, pleasantness). Novel investigations will be conducted in humans to probe these mechanisms, including peripheral in vivo recording (microneurography) and neural stimulation, combined with advanced brain imaging and behavioural experiments. Preliminary work has shown the feasibility of the approach, where it is possible to visualise the activation of single mechanoreceptive afferents in the human brain. The multi-disciplinary approach unites detailed, high-resolution, functional investigations with actual sensations generated. The results will elucidate how basic and complex somatosensory processes are encoded, providing insights into the recovery of such signals. The knowledge gained aims to provide pain-free, efficient diagnostic capabilities for detecting and quantifying a range of somatosensory disorders, as well as identifying new potential therapeutic targets.

Project End Date: **31-DEC-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:
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:
788259	**SVNeuroTrans**	**LS5** Neurosciences and Neural Disorders

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

Mechanisms of neurotransmitter uptake and storage by synaptic vesicles

Summary

In presynaptic nerve endings, neurotransmitters are stored in synaptic vesicles (SVs) before they are released by exocytosis. SVs contain specific transporters that sequester and concentrate transmitters from cytoplasmic pools. All known vesicular transporters belong to the solute carrier (SLC) superfamily of proteins. They draw the energy for transport from an electrochemical proton gradient created by a V-ATPase across the vesicle membrane. However, despite recent progress it is still largely unclear how synaptic vesicles are filled with hundreds of mM transmitter within less than a minute. Open questions include (1) how exactly transport is linked to the proton gradient and which ions are coupled to solute transport, (2) how two different transmitters can be accommodated by the same SV, and (3) how much transmitter can be loaded into an SV and how the stored transmitter is kept inside and prevented from leaking out.

Here we will focus on the vesicular transporters for glutamate (VGLUTs) and GABA/glycine (VGAT or VIAAT), the main excitatory and inhibitory transmitters in the CNS, and on the vesicular transporter for ATP (VNUT). Primarily we will use biochemical approaches employing purified SVs and artificial vesicles, recombinant proteins (either purified and reconstituted in liposomes or using vesicles isolated from transfected cells), in combination with quantitative in vitro assays, for characterizing the features of transport and storage. To achieve this, we plan to develop advanced methods involving adaptation of new fluorescent probes and microscopic analysis of loading and unloading using microfluidic devices. For these experiments, vesicles will be captured by affinity ligands such as antibodies printed on glass surfaces. This allows for analyzing small numbers of vesicles such as SVs derived from primary cultured neurons or transport vesicles from transfected cells that are tagged and labeled with fluorescent reporters before isolation.

Project End Date: **30-SEP-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:
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: Universitat 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:
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:
616986	**UbInflam**	**LS6** Immunity and Infection

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

Regulation of inflammasome activity through NLRP3 ubiquitination level

The innate immunity constitutes an efficient barrier by rapidly detecting pathogens and tissue damages through pattern reCoGnition receptors including NLRP3. On the other hand, inappropriate NLRP3 activation causes deleterious inflammation and contributes to various conditions including atherosclerosis, diabetes, gout and Alzheimer's diseases. Therefore NLRP3 requires tight regulation that remains poorly characterized. Activated NLRP3 assembles a multimeric inflammasome complex serving as activation platform for caspase-1 that controls processing and release of cytosolic cytokines including IL-1β. We recently evidenced that inflammasome assembly requires NLRP3 deubiquitination by the deubiquitinase BRCC3. The aim of this proposal is to decipher this new ubiquitin-dependent regulatory pathway critical for NLRP3 activation. We propose to identify stimuli, signaling pathways and enzymatic complexes controlling NLRP3 ubiquitination level. Using both cell biology and biochemistry approaches, we will decipher the molecular mechanisms beneath the regulation of the deubiquitinase and ubiquitin ligase complex activity, as well as the loss of activity of ubiquitinated NLRP3. Lastly, we will test the in vivo relevance of NLRP3 ubiquitination using both mouse models, patients study and pharmacological approach. Altogether, this project will thoroughly characterize this new pathway controlling inflammasome activity and provide new therapeutic targets against inflammation related diseases that are highly prevalent in the European Union.

Project End Date: **31-DEC-20**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677623	**RELYUBL**	**LS6** Immunity and Infection

Principal Investigator: **Dr. YOGESH KULATHU**
Host Institution: University Of Dundee, UK

Regulation of lymphocyte biology by ubiquitin and ubiquitin like modifiers

T lymphocytes are key cells of the adaptive immune system that protect us against pathogens and malignant cells. T cell activation and differentiation are tightly controlled processes and deregulation can result in lymphomas, autoimmunity and inflammation. Hence, the biochemical events regulating lymphocyte biology have long been a topic of intense research, which has been focussed predominantly on protein phosphorylation. I hypothesize that there are crucial roles undiscovered in T cells for other posttranslational modifications (PTMs) such as ubiquitin (Ub) and Ub-like proteins (UBLs). The importance of ubiquitylation in adaptive immunity is implied by the severe immunological disorders observed when components of the Ub system are disrupted in lymphocytes. Genetic approaches in mice give a limited understanding about the roles of these modifiers and do not reveal the full extent to which Ub and UBLs regulate lymphocyte biology. Deterred by the complexity of the Ub system, the field has not yet tackled the daunting challenge of systematically investigating these modifiers in vivo. The goal of this proposal is to define how T cell function and immune responses are regulated by Ub and UBL signalling networks. To pioneer substantial progress in this area, we will develop new methods to identify and characterize currently unknown reCoGnition modules for the different modifications. We will elucidate the Ub and UBL modified proteome in lymphocytes and characterize dynamic changes of these PTMs during T cell activation. By focussing on enzymes that remove the modifications we will discover how these PTMs are regulated and define Ub and UBL-dependent signalling nodes. Each phase of the work will deliver fundamentally novel mechanistic insights into these PTMs while rewriting current concepts of signalling in lymphocytes. Ultimately, this work will inform therapies seeking to target lymphocyte activity in disease.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695596	**ToxoPersist**	**LS6** Immunity and Infection

Principal Investigator: **Dr. DOMINIQUE SOLDATI-FAVRE**
Host Institution: Universite De Geneve, CH

Molecular Basis of Toxoplasma gondii Encystation and Persistence

Toxoplasma gondii is the most successful obligate intracellular parasites infecting virtually all warm-blooded animals. A infection initiates with the dissemination of the fast-replicating tachyzoites. At the onset of the immune response tachyzoites convert into slow-growing bradyzoites that form cysts in the central nervous system and in striated and heart muscles. Encystation ensures life-long persistence and poses a significant threat of reactivation during immunosuppression and can lead to encephalitis and severe clinical manifestations. Despite the importance of encystation for pathogenesis and transmission, our insight into how T. gondii defies the immune responses to take up permanent residence in the immunocompetent hosts is rudimentary. We propose to determine the molecular mechanisms governing cyst wall formation and parasite adaption to encystation. We will capitalize on the increased sensitivity of -omics approaches, the power of the CRISPR/Cas9 genome editing, the high-resolution microscopy, and on the ex-vivo tissue examination by MALDI imaging mass spectrometry and NanoSIMS technologies.The specific objectives are to:

1. Identify the components of the Cyst Wall (CW), Parasitophorous Vacuole (PV) and PMV Membrane (PVM) of the cyst
2. Determine the parasite factors responsible for CW formation and maturation via targeted and unbiased approaches
3. Define the metabolic network of parasite that is able to initiate encystation and ensure persistence
4. Measure subversion of host metabolic functions by parasite effectors during encystation and persistence

We anticipate fundamental discoveries on i) the regulatory and trafficking circuits that govern CW formation as a biological barrier during encystation ii) metabolic adaptation and subversion of host cellular functions during encystation. Ultimately, understanding parasite strategies and versatilities that ensures its parasitism in immunocompetent hosts and bottlenecks as new targets for intervention.

Project End Date: **30-SEP-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695714	**IMMUNOALZHEIMER**	**LS6** Immunity and Infection

Principal Investigator: **Dr. GABRIELA CONSTANTIN**
Host Institution: Universita Degli Studi Di Verona, IT

The role of immune cells in Alzheimer's disease

Alzheimer’s disease is the most common form of dementia affecting more than 35 million people worldwide and its prevalence is projected to nearly double every 20 years with tremendous social and economical impact on the society. There is no cure for Alzheimer's disease and current drugs only temporarily improve disease symptoms.

Alzheimer's disease is characterized by a progressive deterioration of CoGnitive functions, and the neuropathological features include amyloid beta deposition, aggregates of hyperphosphorylated tau protein, and the loss of neurons in the central nervous system (CNS). Research efforts in the past decades have been focused on neurons and other CNS resident cells, but this "neurocentric" view has not resulted in disease-modifying therapies.

Growing evidence suggests that inflammation mechanisms are involved in Alzheimer's disease and our team has recently shown an unexpected role for neutrophils in Alzheimer's disease, supporting the innovative idea that circulating leukocytes contribute to disease pathogenesis.

The main goal of this project is to study the role of immune cells in animal models of Alzheimer's disease focusing on neutrophils and T cells. We will first study leukocyte-endothelial interactions in CNS microcirculation in intravital microscopy experiments. Leukocyte trafficking will be then studied inside the brain parenchyma by using two-photon microscopy, which will allow us to characterize leukocyte dynamic behaviour and the crosstalk between migrating leukocytes and CNS cells. The effect of therapeutic blockade of leukocyte-dependent inflammation mechanisms will be determined in animal models of Alzheimer's disease. Finally, the presence of immune cells will be studied on brain samples from Alzheimer's disease patients. Overall, IMMUNOALZHEIMER will generate fundamental knowledge to the understanding of the role of immune cells in neurodegeneration and will unveil novel therapeutic strategies to address Alzheimer’s disease.

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

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:
725038	**FATE**	**LS6** Immunity and Infection

Principal Investigator:	**Dr. MATTEO IANNACONE**
Host Institution:	Ospedale San Raffaele, IT

Functional Biology of Hepatic CD8+ T cells

CD8+ T cells have a key role in eliminating intracellular pathogens and tumors that affect the liver. The protective capacity of these cells relies on their ability to migrate to and traffic within the liver, reCoGnize pathogen- or tumor-derived antigens, get activated and deploy effector functions. While some of the rules that characterize CD8+ T cell behavior in the infected and cancerous liver have been characterized at the population level, we have only limited knowledge of the precise dynamics of intrahepatic CD8+ T cell conduct at the single-cell level. In preliminary data for this project we have developed several advanced imaging techniques that allow us to dissect the interactive behavior of CD8+ T cells within the mouse liver at an unprecedented level of spatial and temporal resolution. We predict that this approach, combined with unique models of hepatitis B virus pathogenesis and a new model of hepatocellular carcinoma created ad hoc for this proposal, will generate novel mechanistic insights into the spatiotemporal determinants that govern the capacity of CD8+ T cells to home and function in the virus- or tumor-bearing liver. Specifically, we plan to pursue two main goals: 1) To assess how the anatomical, hemodynamic and environmental cues that characterize hepatocellular carcinomas shape CD8+ T cell behavior and function; 2) To characterize intrahepatic T cell priming events that induce functionally defective T cell responses. Results emerging from these studies will advance our knowledge on how adaptive immunity mediates pathogen clearance and tumor elimination. This new knowledge may lead to improved vaccination and treatment strategies for immunotherapy of infectious diseases and cancer.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725126	**PlasmoCycle**	**LS6** Immunity and Infection

Principal Investigator: **Dr. CATHERINE JILL MERRICK**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

DNA dynamics in the unusual cell cycle of the malaria parasite Plasmodium falciparum

This proposal promises to transform our understanding of the basic biology of the malaria parasite Plasmodium, and of how that biology affects virulence. Remarkably little is known about the Plasmodium cell cycle, despite a wealth of knowledge on the subject in model cells. This project will reveal, with unprecedented resolution, how DNA replication is organised in Plasmodium and how changing conditions in the human host and exposure to antimalarial drugs affect it.

Plasmodium is an early-diverging protozoan with a complex lifecycle & unusual cell-biological features. It replicates in its human host by 'schizogony': a single parasite generates many nuclei via independent, asynchronous rounds of genome replication prior to cytokinesis. This occurs over ~24hrs inside infected erythrocytes. However, the genome can also be copied extremely rapidly during the sexual cycle in the malaria-transmitting mosquito. Here 8 male gametes are produced from a single gametocyte in less than 10mins, necessitating extraordinarily rapid DNA synthesis.

This project will first elucidate the spatio-temporal dynamics of DNA replication in these contrasting cell cycles. To do this, I have developed a method for labelling nascent DNA replication, which was not previously possible in Plasmodium. It will permit: a) a detailed characterisation, at the whole-cell level, of the asynchronous genome replication that occurs in schizogony; b) a study of replication origin spacing & DNA synthesis speed at single-molecule resolution on DNA fibres, comparing these parameters in schizogony & gametogenesis; c) mapping sequences with replication origin activity in the Plasmodium genome; d) investigation of cell-cycle checkpoints & replicative responses to the changing environment in the human host and to antimalarial drugs. These are crucial issues for understanding parasite virulence and drug-resistance, and the work will inform vital new research into transmission-blocking interventions for malaria.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
742720	**Ub-BAC**	**LS6** Immunity and Infection

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

Dissecting and targeting ubiquitin networks in the course of bacterial infections

Ubiquitination represents one of the most versatile post-translational modifications in eukaryotes and is involved in regulation of numerous cellular processes. Despite prokaryotes lacking this system, facultative intracellular bacteria like Salmonella, Shigella and Legionella have evolved multiple strategies to manipulate the host ubiquitin (Ub) system to their own benefit. This proposal is focussed on gaining a fundamental understanding of the Ub system in the course of bacterial infections. We will employ advanced quantitative proteomics to perform a global analysis of the dynamic changes in the ubiquitinome and phosphoproteome of epithelial cells and macrophages upon infection with Salmonella, Shigella and Legionella. The comprehensive datasets will constitute an invaluable resource freely available to the scientific community. We expect to identify novel pathways triggered by selected bacterial ligases and will characterise their contribution to pathogenicity and virulence, as well as their suitability for being targeted in a therapeutic setting. Both medicinal chemistry and structural biology approaches will be exploited to identify inhibitors for NEL-type bacterial ligases. Hypothesis-driven projects within the work program focus on (i) a novel chemical modification of Ub controlling Legionella infections and (ii) the observation that Ub chains on Salmonella can form nanoscale clusters that recruit and activate multiple signalling pathways within the host cell. Super-resolution microscopy and single-molecule imaging will be used to visualise and dissect these Ub-triggered complexes.

Taken together, the combination of unbiased global proteome analysis and hypothesis-driven projects creates a unique scientific program within the biomedical field of understanding and combatting bacterial infections. Along the same lines, this proposal holds a great potential for the future development of novel strategies for antibacterial therapies.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759226	**ANTIViR**	**LS6** Immunity and Infection

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

Molecular mechanisms of interferon-induced antiviral restriction and signalling

Interferons (IFNs), which are signalling proteins produced by infected cells, are the first line of defence against viral infections. IFNs induce, in infected and neighbouring cells, the expression of hundreds of IFN-stimulated genes (ISGs). The ISGs in turn induce in cells a potent antiviral state, capable of preventing replication of most viruses, including Human Immunodeficiency Virus type 1 (HIV-1) and influenza A virus (FLUAV). Identifying the antiviral ISGs and understanding their mechanisms of action is therefore crucial to progress in the fight against viruses.

ISGs playing a role in the antiviral state have been identified, such as human MX1, a well-known antiviral factor able to restrict numerous viruses including FLUAV, and MX2, an HIV-1 inhibitor. Both proteins bind to viral components but their detailed mechanisms of action, as well as the consequences of restriction on the activation of the innate immune system, remain unclear. Moreover, our preliminary work shows that additional anti-HIV-1 and anti-FLUAV ISGs remain to identify.

In this context, this proposal seeks an ERC StG funding to explore 3 major aims: 1) unravelling the mechanisms of antiviral action of MX proteins, by taking advantage of their similar structure and engineered chimeric proteins, and by using functional genetic screens to identify their cofactors; 2) investigating the consequences of incoming virus reCoGnition by MX proteins on innate immune signalling, by altering their expression in target cells and measuring the cell response in terms of gene induction and cytokine production; 3) identifying and characterizing new ISGs able to inhibit viral replication with a combination of powerful approaches, including a whole-genome CRISPR/Cas9 knock-out screen.

Overall, this proposal will provide a better understanding of the molecular mechanisms involved in the antiviral effect of IFN, and may guide future efforts to identify novel therapeutic targets against major pathogenic viruses.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771534	**PneumoCaTChER**	**LS6** Immunity and Infection

Principal Investigator:	**Dr. JAN-WILLEM VEENING**
Host Institution:	Universite De Lausanne, CH

The role of cell-to-cell variability in pneumococcal virulence and antibiotic resistance

Within clonal bacterial populations not all cells exhibit the same phenotype, even though they grow in the same environment. The molecular sources contributing to phenotypic variation are diverse and can originate from noise in gene expression to heterogeneity in growth rates or cell cycle state. Phenotypic variation helps pathogenic bacteria to elude the host immune response or resist antibiotic pressure. Vice versa, there is cell-to-cell variability in the host's response towards pathogens that can be exploited by bacteria. How the combined cellular heterogeneity of both host and microbe contribute to infection outcome is poorly understood. The role of phenotypic variation on antibiotic resistance development is also unclear.

Recently, we developed novel single cell imaging systems as well as genetic engineering and screening platforms for application to the important opportunistic human pathogen Streptococcus pneumoniae. In addition, we generated a dual-transcriptomics overview of pneumococcal infection of human lung epithelial cells and setup collaborations to perform several infection models. This now places us in an excellent position to investigate the mechanisms and the importance of single cell behaviour for pneumococcal virulence and antibiotic resistance.

The driving hypothesis of this application is that the combined heterogeneity of host cells and pneumococci influences infection and antibiotic therapy outcome. To test this, we will use innovative approaches for infection biology by combining synthetic biology and quantitative single cell biology including single cell RNA-seq, CRISPRi, engineered bistable switches and microfluidics. We will reveal the molecular mechanisms underlying cell-to-cell variability and its importance in virulence and antibiotic resistance.

Insights obtained in this project will lead to a better understanding of phenotypic variation and might result in new treatment strategies for pneumococcal infections.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
786142	**E-T1IFNs**	**LS6** Immunity and Infection

Principal Investigator: **Dr. YANICK CROW**
Host Institution: The University Of Edinburgh, UK

Elaboration of the type I interferonopathies

Type I interferons represent both key molecules in anti-viral defence and mediators of inflammatory disease, so that the induction, transmission and resolution of the interferon response are tightly regulated - balancing protection against infection versus the risk of immunopathology. Monogenic type I interferonopathies (T1IFNs), and related 'complex' phenotypes such as systemic lupus erythematosus and dermatomyositis, represent examples of a disturbance of the homeostatic control of this system, where a constitutive upregulation of type I interferon activity is considered directly relevant to pathology.

Set against the absence of a routine assay in clinical medicine for the detection of upregulated type I interferon, the current application addresses major questions in the developing T1IFN field. Analogous to other screening strategies (e.g. using mouse ENU mutagenesis or yeast gene deletion series), we have established a pipeline for the systematic identification of human mutant states predisposing to upregulated type I interferon signalling. Such an approach will allow for the comprehensive definition of important themes in interferon biology, informing our understanding of anti-viral signalling and self-non-self discrimination. Furthermore, these studies will have direct translational benefit - since the identification of a phenotype as a T1IFN implies the possibility of therapy to reduce type I interferon levels and / or block interferon signalling.

Project End Date: **31-OCT-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:
805143	**DDRMac**	**LS6** Immunity and Infection

Principal Investigator: **Dr. ANTIGONI TRIANTAFYLLOPOULOU**
Host Institution: Charite - Universitaetsmedizin Berlin, DE

DNA Damage Response-instructed Macrophage Differentiation in Granulomatous Diseases

Macrophage differentiation programs are critical for the outcome of immunity against infection, chronic inflammatory diseases and cancer. How diverse inflammatory signals are translated to macrophage programs in the large range of human pathologies is largely unexplored. In the last years we focused on macrophage differentiation in granulomatous diseases. These affect millions worldwide, including young adults and children and tend to run a chronic course, with a high socioeconomic burden. Their common hallmark is the formation of granulomas, macrophage-driven structures of organized inflammation that replace healthy tissue. We revealed that macrophage precursors in granulomas experience a replication block and trigger the DNA Damage Response (DDR), a fundamental cellular process activated in response to genotoxic stress. This leads to the formation of multinucleated macrophages with tissue-remodelling signatures (Herrtwich, Cell 2016). Our work unravelled an intriguing link between genotoxic stress and granuloma-specific macrophage programs. The molecular pathways regulating DDR-driven macrophage differentiation and their role in chronic inflammatory pathologies remain however a black box. We hypothesize that the DDR promotes macrophage reprogramming to inflammation-maintaining modules. Such programs operate in granulomatous diseases and in chronic arthritis. Using state-of-the art genetic models, human tissues and an array of techniques crossing the fields of immunology, cell biology and cancer biology, our goal is to unravel the macrophage-specific response to genotoxic stress as an essential regulator of chronic inflammation-induced pathologies. The anticipated results will provide the scientific community with new knowledge on the role of genotoxic stress in immune dysregulation and will carry tremendous implications for the therapeutic targeting of macrophages in the context of chronic inflammatory diseases and cancer.

Project End Date: **31-MAR-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:
817798	**ProDAP**	**LS6** Immunity and Infection

Principal Investigator: **Dr. ANDREAS PICHLMAIR**
Host Institution: Technische Universitaet Muenchen, DE

Protein Dynamics in Antiviral Processes

The innate antiviral defense system is of central importance to protect from viral pathogens. Its ability to mitigate a detrimental outcome of an infectious event relies on interactions that happen between viral and host-derived proteins as well as on signalling cascades that regulate the cellular response. However, despite the importance of these interactions, the involved processes and proteins are not yet fully understood.

We established state of the art mass spectrometry techniques and statistical modelling to characterise protein-protein interactions that are affected by viruses. We identified a class of proteins we name “viral affected proteins changing their interaction” (iVAPs). In addition, we established protein turnover rates of >6900 proteins in virus infected cells and identified a group of “viral affected proteins changing turnover rates” (tVAPs). tVAPs are regulated on basis of protein stabilisation, degradation or translation. Preliminary experiments show critical importance of iVAPs and tVAPs in antiviral immunity, suggesting functional similarities to Interferon stimulated genes (ISGs). Alike ISGs, VAPs therefore represent a critical component of the immune system.

ProDAP will establish the function of iVAPs and tVAPs in the antiviral immune response. Systematic screens employing depletion and overexpression experiments, integration of these data in functional networks and mechanistic follow up studies will be performed. Already identified and new candidate proteins will be tested mechanistically for their immune-regulatory capacity and their influence on virus infections in vitro and in vivo.

ProDAP will allow insights in yet unstudied modulators of host-pathogen interplay and will influence our current understanding of immune regulation in general. It is well established that ISGs are of central importance to defend virus infections and we hypothesize that VAPs may fulfil a similarly important protective function that has yet not been elucid

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
640643	**SEGWAY**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. STEPHANIE DEBETTE**
Host Institution: Universite De Bordeaux, FR

Study on Environmental and GenomeWide predictors of early structural brain Alterations in Young students

Mounting evidence suggests that early life factors have an important impact on the occurrence of late-life neurological diseases. From a public health perspective this is of particular relevance for dementia, the prevalence of which is increasing drastically, with no available preventive treatment, and epidemiological data suggesting that pathological processes may begin many years before clinical diagnosis. MRI-defined structural brain phenotypes are powerful intermediate markers for dementia, and can already show measurable alterations in young and middle-aged adults. These include global and regional brain volumes, gray matter volume and cortical thickness, and markers of white matter integrity. The SEGWAY project aims to: (i) explore the heritability and genetic determinants of structural brain phenotypes in young adults in their early twenties participating in the i-Share study, the largest ongoing student cohort; (ii) take a lifetime perspective by examining the shared genetic contribution to structural brain alterations in young adulthood (i-Share) and late-life, among participants of a large French population-based study (3C-Dijon); (iii) explore the interaction between genetic variants and vascular risk factors with established impact on structural brain phenotypes, in both age groups; (iv) examine the clinical significance of genetic risk variants for structural brain alterations by testing their association with CoGnitive performance in young and older adults. Replication and of our findings will be sought in the multigenerational Framingham Heart Study and other independent samples. Identifying common biological mechanisms underlying both early and late-life structural brain changes would provide important information on the mechanisms and timecourse of brain aging throughout a lifetime and could be of major importance for identifying of molecular drug targets and characterizing high risk populations most likely to benefit from early interventions.

Project End Date: **30-NOV-20**

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-20**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
676904	**NanoSCAN**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. JASON HOLLAND**
Host Institution: Universitaet Zuerich, CH

Developing multi-modality nanomedicines for targeted annotation of onCoGenic signaling pathways

Nanomedicine is the medical application of nanotechnology to diagnose or treat disease. In light of the recent introduction of tools like Positron Emission Tomography/Magnetic Resonance Imaging (PET/MRI) scanners, there is an urgent need to develop new molecular imaging (MI) agents that can simultaneously take advantage of the functional and anatomic information available from hybrid imaging. Nanoparticles offer a unique opportunity for designing novel multi-modality MI agents. However, at present there are no general methods available for rapid, facile and versatile radiolabelling of nanoparticles using a variety of different radionuclides. Developing new radiolabelling methods is vital to advancing nanomedicine. The projects outlined in this interdisciplinary ERC Proposal are designed to address this critical need by advancing two new radiolabelling methods and exploring their potential for PET/MRI imaging of changes in onCoGenic signaling in prostate cancer in response to chemotherapy.

Objective 1. Develop new radiochemical methods for chelate-free labelling of nanoparticles containing metal-based cores
Objective 2. Explore the potential of metal-fluoride bond formation as a tool for rapid fluorine-18 radiolabelling of nanomedicines
Objective 3. Evaluate the potential of radiolabelled nanoparticles and M-18F tracers for multi-modality imaging of AR-mediated signaling in prostate cancer

The long-term goals are to expand the chemical scope of radiolabelling technologies and use of hybrid imaging for measuring changes in onCoGenic signaling by i) developing chelate-free labelling methods for nanoparticles, ii) introducing new reactions for metal-mediated radiolabelling with 18F, and iii) biological PET/MRI studies on treatment response in androgen-receptor mediated prostate cancer. Successful completion of this ERC Proposal has the potential to transform the clinical management of cancer patients via advanced PET/MRI detection of onCoGenic signaling processes.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677582	**KILLCANCER**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. SABRINA OLIVEIRA**
Host Institution: Universiteit Utrecht, NL

Nanobody-targeted photodynamic therapy to kill cancer

Current cancer therapies often fail to cure patients. Ideally, therapy should locally eradicate cancer and should be capable of inducing long term protection, through activation of the immune system. Photodynamic therapy (PDT) is a treatment approach in which cancer cells are killed with compounds, named photosensitizers that are activated locally through light exposure. Importantly, PDT eradication of cancers commonly involves the immune system. However, current photosensitizers lack cancer specificity, which limits therapeutic efficacy and prolongs photosensitivity in patients.

Recently, I have developed an improved version of targeted PDT that uses very small antibodies i.e. nanobodies that distribute homogenously, bind rapidly and specifically to cancer cells, and a photosensitizer that can be traced by optical imaging to guide the application of PDT.

The aims of this proposal are to better understand and to advance nanobody-targeted PDT to ensure complete cancer eradication, and to facilitate its clinical translation. This will be achieved by:

1) Exploring the increased accumulation of photosensitizer through development of novel nanobody-photosensitizer conjugates to bind to cancer cells, cancer stem cells, and endothelial cells. These combinations will be evaluated for their efficacy in mice bearing human carcinomas;

2) Investigating the immune system activation to determine if, as other PDT, nanobody-targeted PDT triggers a systemic immune response, or if additional triggers are needed;

3) Studying the effect of nanobody-targeted PDT in dogs entering the veterinary clinic with oral or colorectal cancers. Treatment efficacy will be evaluated by monitoring cancer regression or disappearance.

The outcome of this research will scientifically advance the new field of nanobody-targeted PDT, by providing essential information on its mechanism of action and the feasibility of this approach in human cancer patients, to ultimately improve current cancer treatment.

Project End Date: **30-JUN-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677661	**ProFatMRI**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. DIMITRIOS KARAMPINOS**
Host Institution: Klinikum Rechts Der Isar Der Technischen Universitat Munchen, DE

Magnetic resonance imaging platform for probing fat microstructure

Metabolic syndrome and osteoporosis are the two metabolic diseases with the highest and most rapidly growing prevalence, transforming them into a major global health and socioeconomic concern. Metabolic syndrome can be diagnosed with established biomarkers, but the selection of optimal prevention strategies for each individual patient is still problematic. Osteoporosis can be treated, but its current early diagnosis remains insufficient. The two diseases have been linked through the role of fat. Fat is central to their incidence and progression, and the probing of fat cellular properties can provide groundbreaking solutions for overcoming the existing challenges in the diseases early diagnosis and prevention.

In metabolic syndrome, there is evidence supporting a role of brown fat in preventing the disease. Brown fat has different microstructure than white fat. However, there is no established non-invasive biomarker to measure brown fat. In osteoporosis, there is evidence supporting a role of marrow fat, in combination with bone mineral density, for monitoring fracture risk. However, there is no non-invasive biomarker to measure marrow fat cellular changes in osteoporosis.

Magnetic resonance imaging (MRI) is the ideal modality for non-invasively measuring fat throughout the body. In order to differentiate brown from white fat and characterize the relationship between bone mineral and marrow fat cells, the employed MR methodology needs a technical breakthrough, shifting from the state-of-the-art water-centered paradigm to a fat-centered microstructural MRI paradigm. ProFatMRI describes an innovative research program that aims to develop and ex vivo validate diffusion and susceptibility MRI biomarkers of fat microstructure, and in vivo apply them at clinical MRI systems.

The resulting technologies will provide novel ways for selecting optimal individualized prevention strategies in metabolic syndrome and for achieving reliable risk fracture prediction in osteoporosis.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694968	**PREMSOT**	**LS7** Diagnostic Tools, Therapies and Public Health

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

Precision Multi-Spectral Optoacoustic Tomography for Discovery Diagnosis and Intervention

The 2008 ERC Advanced Grant multispectral optoacoustic tomography (MSOT) yielded a novel modality for post-genomic small animal optical imaging, >110 peer-reviewed publications and several major awards including the 2014 Germany's Innovation award. Since 2011 spin-off iThera Medical GmbH commercialized and placed MSOT systems in European, Asian and North American laboratories, making MSOT an international term. MSOT brought unprecedented optical imaging performance now enabling independent discovery and publications from researchers throughout the world.

Compared to other imaging modalities, MSOT uniquely images tissue oxygenation and other vascular and pathophysiology parameters in label-free and portable mode, using safe non-ionizing energy. Therefore, MSOT can impact real-time interventional guidance and longitudinal vascular diagnostics and enable a next level of discovery based on quantitative observations in humans, within the novel requirements of precision and personalized medicine. PREMSOT considers the next steps in the MSOT development and will ❶ design and develop label-free portable hybrid MSOT and ultrasound imaging (US) for human use, ❷ research novel theory and hardware to address remaining MSOT limitations and improve the sensitivity and quantification accuracy, a necessary step for improving MSOT precision, ❸ i) validate quantitative MSOT imaging of tissue oxygenation and hypoxia, (micro)-vascular morphology and function, ii) research label-free imaging of inflammation and metabolism and iii) relate MSOT contrast to tissue and disease pathophysiology metrics and ❹ introduce label-free MSOT/US to discovery and clinical care. MSOT contrast features will be investigated as biomarkers in vascular medicine and surgery and in exploratory measurements within neurology, ambulatory/bedside care or sepsis, addressing unmet discovery and clinical needs.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695313	**STRATIFY**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. GUNTER SCHUMANN**
Host Institution: King'S College London, UK

Brain network based stratification of mental illness

To reduce the burden of mental disorders it is a formidable aim to identify widely applicable disease markers based on neural processes, which predict psychopathology and allow for targeted interventions. We will generate a neurobehavioural framework for stratification of psychopathology by characterising links between network properties of brain function and structure and reinforcement–related behaviours, which are fundamental components of some of the most prevalent mental disorders, major depression, alcohol use disorder and ADHD. We will assess if network configurations define subtypes within and if they correspond to comorbidity across these diagnoses. We will identify discriminative data modalities and characterize predictors of future psychopathology. To identify specific neurobehavioural clusters we will carry out precision phenotyping of 900 patients with major depression, ADHD and alcohol use disorders and 300 controls, which we will investigate with innovative deep machine learning methods derived from artificial intelligence research. Development of these methods will optimize exploitation of a wide range of assessment modalities, including functional and structural neuroimaging, CoGnitive, emotional as well as environmental measures. The neurobehavioural clusters resulting from this analysis will be validated in a longitudinal population-based imaging genomics cohort, the IMAGEN sample of over 2000 participants spanning the period from adolescence to adulthood and integrated with information generated from genomic and imaging-genomic meta-analyses of >300.000 individuals. By targeting specific neural processes the resulting stratification markers will serve as paradigmatic examples for a diagnostic classification, which is based upon quantifiable neurobiological measures, thus enabling targeted early intervention, identification of novel pharmaceutical targets and the establishment of neurobehaviourally informed endpoints for clinical trials.

Project End Date: **30-SEP-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695376	**TAROX**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. THOMAS HELLEDAY**
Host Institution: Karolinska Institutet, SE

Targeting oxidative repair proteins for treatment of cancer and inflammation

DNA repair and reactive oxygen species (ROS) are both critical in the aetiology of many diseases, e.g., cancer, atherosclerosis, ischemia/reperfusion injury, neurodegenerative disorders, rheumatoid arthritis, viral diseases and ageing. Extensive biochemical insights into oxidative DNA lesions, associated repair proteins and their link to disease have been made to date. Yet, a thorough understanding of the underlying pathogenic mechanisms is largely missing, and therapies targeting proteins involved in repair of oxidative DNA damage have so far been unexplored. Here, we will increase our knowledge into oxidative DNA damage and repair, by generating tools and make use of 'omics' approaches to explore the function of the Nudix and glycosylases family enzymes in relation to oxidative metabolism. Furthermore, we will progress and understand the basic mechanisms how oxidative DNA lesions are processed and kill cells. Importantly, we will develop small molecule inhibitors targeting Nudix and glycosylases, e.g. MTH1, NUDT15 and OGG1, and use our newly developed inhibitors to increase our knowledge of these enzymes in oxidative metabolism and disease. We will further optimize these inhibitors into drugs and explore therapeutic approaches in cancer and inflammation as well as in exploratory studies in a variety of diseases involving oxidative stress. Altogether, in this programme we contribute to deepen our knowledge into the fundamental biology of oxidative stress and its links with disease, and providing the scientific community with an innovative repertoire of selective inhibitors for numerous enzymes involved in repair of oxidative lesions. This will enable exploratory basic science discoveries as well as potential novel therapeutic interventions 'outside the box'. The programme will also generate high value to the industrial competitiveness of Europe in form of novel inhibitors for treatment of diseases.

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

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 WP 2A: Validate the model and compare hiPS derived cardiomyocytes and endothelial cells from PPCM and healthy sisters on transcriptome level; WP 2B: Validate the model and compare hiPS derived cardiomyocytes from both patients with high susceptibility and resilience to develop HF after anthracyclins on transcriptome level; WP 3: Integration of transcriptome data from WP 2A+2B; WP 4: 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**

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:
740469	**onCOMBINE**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. YOSEF YARDEN**
Host Institution: Weizmann Institute Of Science, IL

Towards evidence-based combinations of approved and novel cancer drugs

Background: Molecular targeted therapy (TT; e.g., monoclonal antibodies, mAbs, and protein kinase inhibitors, PKIs) intercepts onCoGene and other addictions of tumours. However, unlike chemotherapy, which employs cocktails of drugs, only rarely does TT harness poly-pharmacology. Because lung cancer is the major cause of oncology related fatalities and many driver mutations are known, this disease offers opportunities for establishing and generalizing novel TT combinations and their interface with the immune system.

Working hypothesis: High granularity maps of compensatory loops evoked by TT, along with deeper understanding of mechanisms underlying drug action, resistance and interactions with lymphoid/myeloid cells, will conceptualize drug combinations able to persistently inhibit tumours, while inducing only limited toxicities.

Goal and specific aims: Addressing resistance to TT, potential synergies and the immune system, we will employ lung cancer models driven by mutant EGFR, HER2, MET or AXL. Phosphoproteomics, transcriptomics and RNA interference, will enable mapping adaptations evoked by specific drugs. Once identified, we will test combinations of interceptors able to inhibit the primary target as well as the emerging, resistance-conferring route(s). Next, we will determine the mechanisms of action of selected interceptors (e.g., apoptosis, immunological cytotoxicity and senescence) as bases for optimising effective combinations. Homo-combinations of antibodies (i.e., antibodies reCoGnising distinct epitopes of a receptor), hetero-combinations targeting distinct signalling and immune receptors, and combinations with PKIs will be examined in animal models.

Significance: More than 30 PKIs and >25 mAbs are approved in oncology, but most are used as monotherapies. Detailed knowledge of adaptation-driven resistance, mechanisms of drug action and immune effectors, will guide the long awaited application of TT combinations in oncology, including lung cancer.

Project End Date: **30-SEP-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:
757922	**BugTheDrug**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. INES THIELE**
Host Institution: National University Of Ireland, Galway, IE

Predicting the effects of gut microbiota and diet on an individual's drug response and safety

Precision medicine is an emerging paradigm that aims at maximizing the benefits and minimizing the harm of drugs. Realistic mechanistic models are needed to understand and limit heterogeneity in drug responses. Consequently, novel approaches are required that explicitly account for individual variations in response to environmental influences, in addition to genetic variation. The human gut microbiota metabolizes drugs and is modulated by diet, and it exhibits significant variation among individuals. However, the influence of the gut microbiota on drug failure or drug side effects is under-researched. In this study, I will combine whole-body, genome-scale molecular resolution modeling of human metabolism and human gut microbial metabolism, which represents a network of genes, proteins, and biochemical reactions, with physiological, clinically relevant modeling of drug responses. I will perform two pilot studies on human subjects to illustrate that this innovative, versatile computational modeling framework can be used to stratify patients prior to drug prescription and to optimize drug bioavailability through personalized dietary intervention. With these studies, BugTheDrug will advance mechanistic understanding of drug-microbiota-diet interactions and their contribution to individual drug responses. I will perform the first integration of cutting-edge approaches and novel insights from four distinct research areas: systems biology, quantitative systems pharmacology, microbiology, and nutrition. BugTheDrug conceptually and technologically addresses the demand for novel approaches to the study of individual variability, thereby providing breakthrough support for progress in precision medicine.

Project End Date: **31-MAR-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:
759108	**HISTOID**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. FRANCESCO SAVERIO TEDESCO**
Host Institution: University College London, UK

A Human iPS Cell-Derived Artificial Skeletal Muscle for Regenerative Medicine, Disease Modelling and Drug Screening

Skeletal muscle is the most abundant human tissue and contains mainly post-mitotic nuclei. It also expresses the largest gene known in nature – dystrophin – whose mutations cause Duchenne muscular dystrophy, the most frequent and incurable childhood muscle disorder. These characteristics create hurdles that negatively impact on the development of therapies for muscle diseases, ranging from acute tissue loss to chronic neuromuscular disorders. Moreover, a lack of humanised models of muscle regeneration delays the understanding of its regenerative dynamics.

My work has pioneered the use of human induced pluripotent stem (iPS) cells to generate genetically corrected myogenic cells for the autologous cell therapy of muscular dystrophies. Here I propose to exploit this technology together with biocompatible materials to develop three dimensional, iPS cell-derived, patient-specific artificial muscles. These bioengineered skeletal muscles will provide a model to study human muscle regeneration and a platform for tissue engineering and therapy development for severe muscle diseases.

The project will be developed in two phases. First we will develop the iPS cell-derived muscle in vitro, introducing cell types and stimuli necessary to obtain a functional tissue. In the second phase we will exploit the muscle “organoids” for regenerative medicine and drug development. Specifically, we will investigate the artificial muscle potential for tissue replacement in vivo and then model different muscular dystrophies in vitro to screen drugs with therapeutic relevance. Finally, we will combine the tools and knowledge developed in the two aforementioned areas into a novel platform to optimise skeletal muscle gene and cell therapies. This project will bring together tissue engineering, drug development and cell therapy under the same translational technology, advancing the understanding of pathogenesis and the development of therapies for muscle diseases.

Project End Date: **31-AUG-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:
771427	**TREAT-PD**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. MALIN PARMAR**
Host Institution: Lunds Universitet, SE

Patient-specific treatment for Parkinson's disease using reprogrammed skin cells

Cellular reprogramming is a new and rapidly emerging field where somatic cells can be turned into pluripotent stem cells or other somatic cell types simply by overexpression of specific combinations of genes. This remarkable discovery allows for the generation of patient specific cell lines that will serve as major tools for understanding how diseases arise and develop, and they may also prove useful for drug screens, diagnostics and other biomedical applications.

We have developed a reprogramming technique that directly converts human fibroblasts to functional dopamine (DA) neurons, which is the subtype that is affected in Parkinson's Disease (PD). This opens up for possibilities to generate therapeutic neurons, including patient specific neurons on demand. These neurons, and the techniques for producing them, will become valuable tools for understanding and treating neurodegenerative diseases such as PD. Direct cell conversion is of particular interest for cell replacement therapy as the reprogramming does not involve a proliferating cell intermediate, and thus the risk of uncontrolled proliferation and tumor formation after transplantation is minimized. This project integrates mechanistic studies based on single cell sequencing to improve the technology and control of cell fate such that a large number of authentic DA neurons are obtained. Induced DA neurons will be generated from individuals with PD and age matched healthy donors and subjected to comparative assessments in vitro and in vivo in order to investigate whether any potential PD-associated pathology emerges in the patient derived cells. This will then guide future decisions regarding autologous vs. allogeneic donors. The cells will be extensively validated using pre-clinical animal models of PD. The studies will include direct comparison with primary fetal and hESC-derived DA neurons on criteria important for clinical use such as midbrain subtype identity and in vivo potency and efficacy.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772244	**Pros-RODAM**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. CHARLES AGYEMANG**
Host Institution: Academisch Medisch Centrum Bij De Universiteit Van Amsterdam, NL

Hypertension Susceptibility in African Migrants: Solving the puzzle through transcontinental prospective cohort study design

This study will be the first to identify the key environmental exposures, together with epigenetic factors, responsible for the increased burden of hypertension in migrants through establishment of a novel transcontinental prospective cohort study of a homogeneous Sub-Saharan African (SSA) migrants living in Europe and their compatriots living in Africa, alongside the European host population. Hypertension is the single most important modifiable risk factor for cardiovascular disease, a global leading cause of death. Migrants, especially those with SSA origin, are disproportionately affected for reasons that are unclear due to lack of prospective studies. Moreover, migrant health research has so far focussed on socio-environmental explanations, largely neglecting the role of genetic predispositions.

Building on my research, I will first transform our previous EC funded cross-sectional RODAM study into state-of-the-art transcontinental prospective cohort study. Second, I will examine and identify the key changes in modifiable environmental factors influencing the high risk of hypertension. Third, I will apply the most cutting-edge techniques in epigenomics to examine changes in epigenetic modifications and their effects on hypertension risk including: the first longitudinal analysis of genome-wide DNA methylation, and mRNA expression in migrants. Fourth, I identify the key environmental factors that are driving the epigenetic changes. Fifth, I will estimate for the first time the individual and combined effect of environmental factors, and epigenetic modifications to the high risk of hypertension in migrants relative to non-migrant Europeans and SSA counterparts living in Africa.

This transdisciplinary study will identify the key relevant factors driving the high burden of hypertension and provide a sound basis for targeting hypertension prevention and treatment and thereby delivering major breakthroughs in addressing the problem head-on in migrants and beyond.

Project End Date: **28-FEB-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:
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:
786575	**RxmiRcanceR**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. EITHAN GALUN**
Host Institution: The Hebrew University Of Jerusalem., IL

Tumor suppressive microRNAs for cancer therapy

The challenge for cancer therapy involves hampering the mechanisms by which the normal gene expression machinery is taken over to allow the aberrant appearance of cancer driving genes. I propose exploiting the therapeutic potential of a special class of tumor microRNAs (miRs) that function as natural post-transcriptional tumor suppressive regulators of many genes in key pathways. These anti-cancer effectors represent an inherent organismal property that I propose to augment and thereby translate into a form of systemic anti-cancer therapy. First, focusing on hepatocellular carcinoma (HCC), I shall perform high throughput screening to identify preferred HCC tumor suppressive miRs. Second, I shall search for small molecules capable of elevating the level of those relevant miRs in tumor cells and tissues. Increasing miR expression will potentially also enhance their secretion into the circulation in exosomes thereby suppressing gene expression at remote tissue sites as well. Third, I shall test the potential of these miRs to better target and inhibit the growth of tumor cells both, in culture and in vivo. This unprecedented conceptual strategy should stimulate the organism's self-healing potential by enhancing inherent anti-tumor mechanisms. This project is built on robust preliminary findings that show promiscuous anti-cancer effects and predictably fewer side effects due to its completely host-based nature, with the administered miR inducer being the only foreign element. Additionally, due to the fact that each miR simultaneously targets a number of molecular pathways as well as multiple steps within a given pathway, it could help to overcome the major problem of cancer therapy – resistance. This strategy of harnessing these efficient and robust miRs and exosomes for delivery of anti-cancer therapeutics may overcome the high-risk challenge involved and enable high gain value.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787552	**vAMRes**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. RINO RAPPUOLI**
Host Institution: Fondazione Toscana Life Sciences, IT

Vaccines as a remedy for antimicrobial resistant bacterial infections

Antimicrobial Resistance (AMR) is perhaps the most emerging alarm in health. It already causes 700,000 deaths per year and the forecast for 2050 is 10 million deaths, more than cancer today. WHO, UN General Assembly, World Bank, G20, EU, UK and USA governments call for new antibiotics, but the pipeline for new antibiotics is not very promising. Here we propose to use new technologies to develop human monoclonal antibodies and vaccines against three AMR bacteria such as gonococcus, pneumococcus and E.coli. The technology defined as reverse vaccinology 2.0, already successful for viral infections, will be used for bacterial vaccines. Taking advantage of the recent possibility of high throughput cloning of human B cells from convalescent or vaccinated people we aim to find targets difficult or impossible to be discovered using conventional technologies. B cells will be cloned from people convalescent from target infections and from people vaccinated with Men B vaccine which confers some protection against gonococcus. The antibodies produced by the clones will be screened for their ability to bind, intoxicate or kill bacteria using a novel high-throughput microscopy platform that rapidly captures digital images and also with conventional, lower throughput technologies such as bactericidal, opsono-phagocytosis and FACS assays. The selected antibodies, will be expressed as full length and used for passive immunization in animal models and tested for protection in vivo. Finally, those antibodies that will provide the best protection in the above assays, will be used to identify the reCoGnized antigens. Selected antigens will be expressed and tested in vaccine formulations. Fab fragments can be used to make co-crystals with the antigen and determine the crystal structure of the new antigens, for the development of structure-based antigen design. In conclusion we expect to enable development of human monoclonal antibodies and vaccines against AMR.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802778	**ENDOMICS**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. MADS SYLVEST BERGHOLT**
Host Institution: King'S College London, UK

Raman Endoscopic Proteo-lipidomics of Bladder Cancer

The goal of ENDOMICS is to drive forward a new paradigm of Raman endoscopic technology that enables proteomic and lipidomic analysis for diagnosis of bladder cancers in vivo. Raman endoscopy is a label-free optical technique that can provide a point-wise vibrational molecular fingerprint of tissue “optical biopsy” for cancer diagnosis in vivo. State-of-the-art Raman endoscopy, however, does not offer specific compositional analysis or insights into molecular biology of tissue. This is because the vibrational Raman bands are overlapping and cannot be deciphered into the myriad of biomolecules in complex tissue.

We will introduce a ground-breaking new methodology to enable Raman proteomic and lipidomic analysis in vivo. To this end, heterospectral co-registered Raman and mass spectrometry imaging will be used to develop a multivariate regression model “Rosetta Stone” for translating vibrational structural information (Raman spectroscopy) into compositional information. To meet the unmet clinical needs in urology we will tailor the first fibre-optic Raman endoscopic technology that can measure depth-dependent molecular profiles to simultaneously enable detection, grading and staging of bladder cancers. We will finally conduct a clinical trial by applying the technique to measure a comprehensive molecular database of bladder pathologies in vivo. The latter will allow for the identification of proteomic and lipidomic biomarkers to develop novel algorithms for real-time diagnosis of bladder cancers.

The synergy between scientific and technological advances in ENDOMICS will break ground for shedding new light on the molecular biology of bladder cancer in vivo including new insights into clinical diversity and identification of biomarkers for diagnostics, prognostics and novel therapeutic targets.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804326	**NEUROPRECISE**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. INGA KOERTE**
Host Institution: Ludwig-Maximilians-Universitaet Muenchen, DE

Precision medicine in traumatic brain injury using individual neurosteroid response

Traumatic brain injury (TBI) is very common and affects 1.8 million Europeans seeking medical help each year. TBI is a major challenge for healthcare providers and poses an enormous economic burden. For decades, TBI has been characterized by severity of symptoms for diagnosis, prognosis, and therapy. However, this classification system is limited since it does not allow to predict long-term outcome after TBI. This state of affairs thus hinders the advancement of TBI research and the development of therapies. The field is thus in dire need of a novel understanding and classification of the individual's response to brain injury and, most importantly, a fresh perspective on potential targets for effective treatment and prevention of long-term impairment.

My main hypothesis is that brain injury leads to a neurosteroid response with inter-individual variability and that this response is associated with the trajectory of recovery. I further hypothesize, that the most vulnerable patient cohorts, such as adolescent girls, show distinct patterns of neurosteroid response associated with an increased risk for persistent symptoms.

NEUROPRECISE proposes a longitudinal cohort study 1) to characterize neurosteroid response with respect to age and sex in children and adolescents with TBI, 2) to evaluate the association of the neuroimaging derived individual injury profile with neurosteroid response, and 3) to explore individual differences in neurosteroid response as a potential target for acute therapy and prevention of chronic symptoms with respect to age and sex in a rodent model.

NEUROPRECISE will overcome a critical barrier towards the treatment of TBI by establishing a novel, biological-driven way to stratify TBI patients based on inter-individual differences in the response to TBI. By exploring the individual neurosteroid response as potential therapeutic target, NEUROPRECISE will bring the power of precision medicine to neurotrauma research.

Project End Date: **29-FEB-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:
819531	**iHEAR**	**LS7** Diagnostic Tools, Therapies and Public Health

Principal Investigator: **Dr. AXEL SCHAMBACH**
Host Institution: Medizinische Hochschule Hannover, DE

Gene therapy of inherited and acquired hearing loss

To address the substantial financial and social burden caused by hearing loss in 360 million people world-wide, I aim to improve hearing via gene therapy to correct inherited and protect from acquired hearing loss. In vitro experiments will establish the best vector configurations for transfer of therapeutic genes and miRNAs into inner ear hair cells (HC) and spiral ganglion neurons (SGN). The efficiency of the best-performing vector designs will then be explored in vivo using fluorescent marker proteins. Cell-type specific and inducible promoters as well as receptor-targeted vectors will be employed as a safety measure and to ensure transgene expression in HC and SGN target cells. Once efficient transduction of appropriate target cells and proper expression of therapeutic proteins are demonstrated, I will perform proof-of-concept studies in hearing loss models, incl. established mouse models, to correct (WP1) or protect (WP2) from impaired hearing. To ensure translatability of these findings, I will generate human induced pluripotent stem cells (iPSC) from patients with hearing loss (WP3), so that I can test optimized constructs in human otic cells. Moreover, I have access to a collection of well-characterized samples from over 600 hearing loss patients, including children with congenital hearing loss in whom many novel monogenetic alterations were identified. These resources provide the unique opportunity to generate a novel toolbox for the treatment of hearing loss. In addition to lentiviral and adeno-associated viral (AAV) vector delivery of corrective or protective genes to treat hearing loss, I will apply state-of-the-art genome editing tools to model and correct mutations causative for hearing loss in cell lines, primary cells from murine models, human patients and patient-derived iPSC. This work will contribute to development of clinically translatable approaches for precision medicine strategies to improve hearing loss treatment.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647916	**CODOVIREVOL**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. IGNACIO GONZÁLEZ BRAVO**
Host Institution: Centre National De La Recherche Scientifique Cnrs, FR

Evolution of viral codon usage preferences:manipulation of translation accuracy and evasion of immune response

Fidelity during information transfer is essential for life, but it pays to be unfaithful if it provides an evolutionary advantage. The immune system continuously generates diversity to put up with recurrent pathogen challenges, and many viruses, in its turn, have evolved mechanisms to generate diversity to evade immune restrictions, even at the cost of enduring high mutation rates.

Synonymous codons are not used at random and are not translated with similar efficiency. A large proportion of viruses infecting humans, especially those causing chronic infections, display a poor adaptation to the codon usage preferences of their host. This observation is a paradox, as viral genes completely depend upon the cellular translation machinery for protein synthesis. The poor match between codon usage preferences of virus and host negatively affects speed and accuracy of viral protein translation. We propose here that maladaptation of codon usage preferences in human viruses may have an adaptive value as it decreases translational fidelity, results in the synthesis of an ill-defined population of viral proteins and provides a way to escape immune surveillance.

We will address the fitness effects of codon usage bias at the molecular and cellular levels, and later at the organism level in a rabbit model of papillomavirus infection. We will apply experimental evolution to analyse genotypic changes by means of next generation sequencing and will monitor phenotypic changes through real-time cell monitoring techniques, comparative proteomics, and anatomopathological analysis of virus-induced lesions.

Our results will help solve the evolutionary puzzle of codon usage bias, and will have implications for the development of therapeutic vaccines to guide the immune response towards the identification and targeting of the main protein species, avoiding the chemical noise generated by protein mistranslation.

Project End Date: **31-DEC-20**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677139	**MULTIATTACK**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. ERIK POELMAN**
Host Institution: Wageningen Universiteit, NL

Plant adaptations to unpredictable attack by dynamic insect communities

Individual plants are exposed to many stresses with insect herbivores being a prominent one. The occurrence of insect herbivores may be unpredictable in terms of when, by which species, and in which order the attack will take place. To deal with unpredictability of attack, plants are phenotypically plastic in their defence. They respond to attackers with the induction of specific defences and saving costs of defence in their absence. However, the induced plant phenotype may attract additional herbivores, alter the entire community composition of attackers and limit physiological capabilities of plant responses to subsequent attackers. An optimal response to one attacker should thus anticipate these consequences of induced responses. To understand the adaptive nature of plant plasticity to herbivore attack, it is essential to assess fitness consequences of an induced response when plants are exposed to multi-herbivory by their entire insect community. This requires a novel approach of comparing plant species adaptations in defence plasticity to the level of predictability in the dynamics of their insect community, such as order of herbivore arrival. To do so, this research proposal has three objectives: 1) Identifying the predictability of dynamic attacker communities of Brassicaceae species, 2) Understanding physiological adaptations to (un)predictable multi-herbivore attack, and 3) Identifying consistency in responses of insect herbivores to induced phenotypes of different Brassicaceae. By integrating community ecology with network inference modelling of insect communities, the nature of predictability of insect communities of nine annual Brassicaceae plant species will be identified and linked to species-specific physiological adaptations to multi-herbivory. This multidisciplinary community approach will provide novel insights into the evolution of plant phenotypic plasticity in defence, which is a central paradigm in the field of plant-insect interactions.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677774	**TEMPO**	**LS8** Evolutionary, Population and Environmental Biology

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

Terrestrial vertebrates and the evolutionary origins of morphological diversity

Explaining the great disparity of organismal form is a central goal of biological research. However, despite many decades of inquiry, there is little understanding of how evolution gave rise to this disparity. Key hypotheses predict changes in macroevolutionary modes through geological time: rates of evolution may either have decreased as global niche space became crowded, or increased due to accumulation of key innovations that improve body plan versatility. The absence of data to test these hypotheses a major knowledge gap that severely limits our understanding of evolution on Earth.

TEMPO is an ambitious project to quantify patterns of phenotypic evolution on an unprecedented scale (>300 million years), by generating a large, detailed morphological dataset. Using the evolutionary radiation of land vertebrates as a model system, TEMPO will address these fundamental, unresolved questions:

(1) How have rates and constraints of phenotypic evolution varied through geological time?

(2) Are these patterns consistent with the occurrence of global niche-filling?

(3) Can evolutionary versatility enabled by key innovations explain these patterns?

(4) What modes of lineage evolution generated observed trends of morphological disparity?

Previous large-scale studies lacked the temporal and phenotypic scope to address these questions, analysing only body size in only extant taxa. TEMPO will overcome these limitations to provide a step-change in understanding, by: (1) Using 21st century 3D data-capture methods on specimens from the mammalian and bird/crocodile evolutionary lineages. (2) Combining living with fossil taxa to extend our knowledge far into deep time; and (3) Analysing multiple aspects of form in a multivariate framework, using cutting-edge phylogenetic model-fitting approaches. By doing this, TEMPO will unify palaeontology and evolutionary biology, transforming knowledge of how phenotype evolves and the processes generating animal disparity on geological timescales.

Project End Date: **30-APR-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679056	**HOTSPOT**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. LEVI YANT**
Host Institution: The University Of Nottingham, UK

Genomic hotspots of adaptation to whole genome duplication

Whole genome duplication (WGD) occurs in all eukaryotic kingdoms and is implicated in organismal complexity, adaptation and speciation. WGD is an especially important force in plant evolution and domestication. Nevertheless, despite the evolutionary potential of WGD, a sudden duplication of all chromosomes poses challenges to key processes, especially the reliable segregation of chromosomes at meiosis. Nonetheless, nature reveals solutions: the many polyploid species with diploid-like meiosis show that difficulties can be overcome. However, the molecular basis of this is mysterious: only one causal gene has been cloned to date. Our work in autotetraploid Arabidopsis arenosa revealed clear WGD-associated selective sweeps on meiosis genes with roles in crossover regulation. Natural variation in at least one of these genes has a dramatic effect on meiotic chromosome pairing. Here we assess whether species that independently adapted to the challenges attending WGD evolved similar solutions, whether crossover regulation is a common target of WGD-associated adaptation and whether standing variation in diploid populations contributes to adaptation to WGD. Aims of this programme are to: 1) produce quality reference genome assemblies for Cardamine amara and Arabis pumila, both of which harbor extant intraspecific ploidy variation; 2) test for the repeatability of adaptation mechanisms to WGD by genome scanning both species as well as three other independent WGDs in Arabidopsis lyrata and Mimulus guttatus; and 3) determine the causes and consequences of divergence of meiosis genes using functional analyses. We will utilize diverse genetic, genomic, and cytological approaches to understand repeatability and constraint in the context of intense selection on a conserved process. Further, this will provide insight into how organisms adapt to the altered cellular environment following WGD, a prevalent ongoing force in evolution and in the domestication of globally important crops.

Project End Date: **31-DEC-20**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681484	**ANGI**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. BENOIT PUJOL**
Host Institution: Centre National De La Recherche Scientifique Cnrs, FR

Adaptive significance of Non Genetic Inheritance

Our ability to predict adaptation and the response of populations to selection is limited. Solving this issue is a fundamental challenge of evolutionary ecology with implications for applied sciences such as conservation, and agronomy. Non genetic inheritance (NGI; e.g., ecological niche transmission) is suspected to play a foremost role in adaptive evolution but such hypothesis remains untested. Using quantitative genetics in wild plant populations, experimental evolution, and epigenetics, we will assess the role of NGI in the adaptive response to selection of plant populations. The ANGI project will follow the subsequent research program: (1) Using long-term survey data, we will measure natural selection in wild populations of Antirrhinum majus within its heterogeneous array of micro-habitats. We will calculate the fitness gain provided by multiple traits and stem elongation to plants growing in bushes where they compete for light. Stem elongation is known to depend on epigenetic variation. (2) Using a statistical approach that we developed, we will estimate the quantitative genetic and non genetic heritability of traits. (3) We will identify phenotypic changes caused by fitness that are based on genetic variation and NGI and assess their respective roles in adaptive evolution. (4) In controlled conditions, we will artificially select for increased stem elongation in clonal lineages, thereby excluding DNA variation. We will quantify the non genetic response to selection and test for a quantitative epigenetic signature of selection. (5) We will build on our results to generate an inclusive theory of genetic and non genetic natural selection. ANGI builds on a confirmed expertise in selection experiments, quantitative genetics and NGI. In addition, the availability of survey data provides a solid foundation for the achievement of this project. Our ambition is to shed light on original mechanisms underlying adaptation that are an alternative to genetic selection.

Project End Date: **28-FEB-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682394	**NIRV_HOST_INT**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. MARIANGELA BONIZZONI**
Host Institution: Universita Degli Studi Di Pavia, IT

Population genomics of co-evolution between non-retroviral RNA viruses and their hosts

Viruses and their hosts share a complex evolutionary history, evidenced by viruses acting as genetic parasites or being exapted by the host. Horizontal gene transfer between viruses and hosts has been widely studied for DNA viruses and retroviruses. Recent discoveries expand the range of viral types that can transfer genetic material to their hosts to non-retroviral RNA viruses. The frequency of non-retroviral RNA virus integrations (NIRVs) in nature and their impact on the hosts are unknown.

The objectives of this proposal are to:
• analyze NIRV distributions in natural host populations and characterize mechanisms of integrations
• assess NIRV impact on the biology of the host

This study will be conducted on the model system “Aedes albopictus and Flavivirus” because:
• Ae. albopictus is known vector of pathogenic non-retroviral RNA viruses, including dengue viruses highly relevant for public health
• NIRVs phylogenetically related to flaviviruses have been identified in the mosquito genome
• if NIRVs affect mosquito vector competence, they could be manipulated for novel vector control strategies. Such strategies are essential due to the lack of vaccines and drugs for dengue viruses.

First, I will use a population genomic approach to characterize the distribution of NIRVs in the genomes of different Ae. albopictus populations, the mechanisms of integrations and to correlate the presence of NIRV and viral infection. Secondly, I will study tissue-specificity of the NIRVs, their heritability and impact on mosquito biology in a controlled laboratory environment.

Somatic integrations could contribute to acquired immunity to their respective viruses and establishment of persistent infection. Germ-line integrations could have an evolutionary impact on the host genome.
The results of this proposal will lay the foundation for identifying the interactions between non-retroviral RNA viruses and their hosts and could provide new models for co-evolutionary studies.

Project End Date: **30-APR-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682580	**BEAL**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. PIERRE CARDOL**
Host Institution: Universite De Liege, BE

Bioenergetics in microalgae : regulation modes of mitochondrial respiration, photosynthesis, and fermentative pathways, and their interactions in secondary algae

During the course of eukaryote evolution, photosynthesis was propagated from primary eukaryotic algae to non-photosynthetic organisms through multiple secondary endosymbiotic events. Collectively referred to as “secondary algae”, these photosynthetic organisms account for only 1-2% of the total global biomass, but produce a large part (~30-50%) of the global annual fixation of carbon on Earth.

ATP is the universal chemical energy carrier in living cells. In photosynthetic eukaryotes, it is produced by two major cellular processes: photosynthesis and respiration taking place in chloroplasts and mitochondria, respectively. Both processes support the production of biomass and govern gas (O2 and CO2) exchanges. On the other hand, anaerobic fermentative enzymes have also been identified in several primary and secondary algae. The regulation modes and interactions of respiration, photosynthesis and fermentation are fairly well understood in primary green algae. Conversely, the complex evolutionary history of secondary algae implies a great variety of original regulatory mechanisms that have been barely investigated to date.

Over the last years my laboratory has developed and optimized a range of multidisciplinary approaches that now allow us, within the frame of the BEAL (BioEnergetics in microALgae) project, to (i) characterize and compare the photosynthetic regulation modes by biophysical approaches, (ii) use genetic and biochemical approaches to gain fundamental knowledge on aerobic respiration and anaerobic fermentative pathways, and (iii) investigate and compare interconnections between respiration, photosynthesis, and fermentation in organisms resulting from distinct evolutionary scenarios. On a long term, these developments will be instrumental to unravel bioenergetics constraints on growth in microalgae, a required knowledge to exploit the microalgal diversity in a biotechnological perspective, and to understand the complexity of the marine phytoplankton.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
693030	**BARRIERS**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. ROGER BUTLIN**
Host Institution: The University Of Sheffield, UK

The evolution of barriers to gene exchange

Speciation is a central process in evolution that involves the origin of barriers to gene flow between populations. Species are typically isolated by several barriers and assembly of multiple barriers separating the same populations seems to be critical to the evolution of strong reproductive isolation. Barriers resulting from direct selection can become coincident through a process of coupling while reinforcement can add barrier traits that are not under direct selection. In the presence of gene flow, these processes are opposed by recombination. While recent research using the latest sequencing technologies has provided much increased knowledge of patterns of differentiation and the genetic basis of local adaptation, it has so far added little to understanding of the coupling and reinforcement processes.

In this project, I will focus on the accumulation of barriers to gene exchange and the processes underlying increasing reproductive isolation. I will use the power of natural contact zones, combined with novel manipulative experiments, to separate the processes that underlie patterns of differentiation and introgression. The Littorina saxatilis model system allows me to do this with both local replication and a contrast between distinct spatial contexts on a larger geographic scale. I will use modelling to determine how processes interact and to investigate the conditions most likely to promote coupling and reinforcement. Overall, the project will provide major new insights into the speciation process, particularly revealing the requirements for progress towards complete reproductive isolation.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694368	**Gradual_Change**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. MATTHIAS RILLIG**
Host Institution: Freie Universitaet Berlin, DE

Gradual and abrupt environmental change: connecting physiology, evolution and community composition

A major goal in ecology is to predict how environmental changes, including drivers of global change, affect communities and ecosystem functioning, with society demanding answers to these pressing questions. A key limitation of virtually all experimental approaches addressing such questions is that treatments are delivered abruptly, while many changes occurring in nature are gradual. Here I propose to comprehensively study consequences of environmental change when delivered abruptly vs. gradually. In order to understand and model effects of gradual vs. abrupt changes, we need to simultaneously consider physiological effects (e.g. acclimation), evolutionary changes (e.g. adaptation) and changes in community composition and functioning. Even though changes at these levels likely interact, there is no study in which physiology, evolutionary changes and community shifts have been studied in response to a changing environmental factor. This research program thus enters unchartered territory of empirical environmental research in proposing work at this nexus of physiology, environmental change and community composition/ function. I focus on soil fungi, key players in terrestrial ecosystems, testing a range of gradually vs. abruptly changing environmental factors, in a range of soils, in the field and in microcosms. We connect differential responses to species traits, apply modeling and employ data syntheses across all biomes and organisms to achieve high external validity. We carry out a set of core experiments that will afford unprecedented insight into the nature of change in a community context in response to warming, focusing on soil fungi. In these we follow evolutionary change (phenotype and genotype), test physiological shifts by re-isolation of fungi and monitor community changes. This work will have transformative character in providing not only new mechanistic insights into effects of environmental change, but will also represent a step change in fungal ecology.

Project End Date: **30-SEP-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694578	**IsoMet**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. COLIN MURRELL**
Host Institution: University Of East Anglia, UK

Bacterial isoprene metabolism: a missing link in a key global biogeochemical cycle

Isoprene is a very important climate-active biogenic volatile organic compound with both global warming and cooling effects. Globally, terrestrial plants emit huge amounts (~500-750 million tonnes) of isoprene per year. This is approximately the same quantity as methane released to the amosphere. Isoprene emissions are predicted to rise due to global warming and increased use of isoprene-emitting trees (oil palm, poplar) for biofuel production but almost nothing is known about its biogeochemical cycle. Microbes are a sink for isoprene and through their activity in soils and on the leaves of isoprene-emitting plants, they will be important in removal of isoprene in the biosphere before it gets released to the atmosphere.

The aim of the project is to obtain a critical, fundamental understanding of the metabolism and ecological importance of biological isoprene degradation and to test the hypothesis that isoprene degrading bacteria play a crucial role in the biogeochemical isoprene cycle, thus helping to mitigate the effects of this important but neglected climate-active gas. Key objectives are to elucidate the biological mechanisms by which isoprene is metabolised, establish novel methods for the study of isoprene biodegradation and to understand at the mechanistic level how isoprene cycling by microbes is regulated in the environment. Bacteria that metabolise isoprene will be isolated from a range of terrestrial and marine environments and characterised using a multidisciplinary approach and a wide range of cutting edge techniques. We will elucidate the pathways of isoprene metabolism and their regulation by characterising genes/enzymes catalysing key steps in isoprene degradation, use innovative molecular ecology methods to determine distribution, diversity and activity of isoprene degraders and assess the contribution that microbes make in the removal of isoprene from the biosphere, thereby mitigating the effects of this climate-active compound.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715300	**GRAVIBONE**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. ALEXANDRA HOUSSAYE**
Host Institution: Centre National De La Recherche Scientifique Cnrs, FR

How Bone Adapts to Heavy Weight?
Bone Morphological and Microanatomical Adaptation to the Mechanical Constraints Imposed by Graviportality

Heavy animals, said to be graviportal, are under strong mechanical constraints. Their skeleton, notably their limb bones, show convergent morpho-functional adaptations that surprisingly remain very poorly studied. Understanding the convergent and specific adaptations of bone to weight bearing in taxa with various morphologies, sizes, habitats and locomotor behaviours is essential to understand how bone responds to biomechanical constraints. In palaeontology, it will allow determining how giant fossil animals could move and support their weight. The study of graviportality provides an ideal case-study to analyse form-function relationship in a macro-evolutionary context.

GRAVIBONE proposes a broad and modern comparative investigation of the biomechanical adaptations of the outer and inner bone anatomy of long bones observable in different modern and fossil taxa that have converged on graviportality. It combines various approaches using recently developed powerful methods and tools (notably the innovative integration of the whole 3D external and internal bone anatomy in biomechanical modelling) and uses these in an explicit phylogenetic context. Characterizing the various adaptive traits observed in extant taxa and understanding the link between specific isolated microanatomical, morphological and mechanical parameters will enable to: a) define degrees/types of adaptations to graviportality, b) make palaeoecological and paleofunctional inferences, and c) explain adaptations to graviportality in amniote evolutionary history. This new and highly integrative approach will increase our knowledge on the adaptation of the vertebrate skeleton and thereby of the organisms, to environmental demands.

GRAVIBONE will serve as a reference and provide methods and results fruitful to diverse research teams in various scientific domains. It will institute a new combination of approaches and enable to take the lead in modern comparative bone functional anatomy and microanatomy.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716575	**MetaPG**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. NICOLA SEGATA**
Host Institution: Universita Degli Studi Di Trento, IT

Culture-free strain-level population genomics to identify disappearing human-associated microbes in the westernized world

Investigating symbiotic gut microbes with large-scale comparative genomics would allow gaining crucial insights into the “epidemiology”, genetic diversity, and population structure of hundreds of scarcely characterized microorganisms. However, cultivation-based approaches are ineffective at targeting the large fraction of the gut microbial diversity that is hard be grown in vitro. They are also expensive and time consuming, as they need sampling specific bacteria from geographically separated subjects. On the other hand, cultivation-free metagenomic data is now available for thousands of stool samples collected worldwide, but they are not currently exploited for strain-level microbial population genomics because of the lack of suitable computational methods. In Aim1, we leverage our expertise in computational biology to bridge the gap between the fields of metagenomics and population genomics by developing novel and highly innovative methodologies to extract strain-level genomic and genetic profiles from metagenomic samples with the resolution needed by comparative genomics. Such paradigmatic shift will put us in the position of reusing in Aim2 the thousands of available metagenomes and unravel for the first time the population structure of hundreds of uncultivable gut microbes. Among the novel tasks enabled, we will focus in Aim3 on identifying those microbial strains that are currently disappearing in westernized populations as a consequence of urbanization, industrialization, high-fat diets. We will complement the available data with gut metagenomes from novel targeted cohorts of both westernized and non-westernized populations. Our project defines the foundation for cultivation-free strain-level population genomics, provides comparative genomics results with unprecedented resolution for hundreds of under-investigated microbes, and compiles a catalogue of strains undergoing or at risk of primary, secondary, or ecological extinction in westernized populations.

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:
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:
725848	**CORALASSIST**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. JAMES GUEST**
Host Institution: University Of Newcastle Upon Tyne, UK

Assisting Coral Reef Survival in the Face of Climate Change

CORALASSIST spans the disciplines of evolutionary biology, restoration ecology and proteomics and examines the role assisted gene flow (AGF) can play in sustaining biodiversity and ecosystem services in the face of climate change. AGF involves the deliberate movement of individuals or gametes within their natural range to facilitate adaptation to environmental change. Corals reefs provide an excellent model for testing AGF as a conservation tool because reef building corals are foundation species and are highly vulnerable to thermal stress. Selective breeding and translocation of thermotolerant individuals may lead to reductions in recipient population fitness due to resource trade-offs with other fitness traits, such as growth and fecundity. The overall aim of CORALASSIST is to establish the feasibility of implementing AGF in coral reef ecosystems using a combination of selective breeding, proteomics and innovative translocation techniques. CORALASSIST will address four primary questions: 1) Are there resource trade-offs between increased thermotolerance and other fitness traits in corals? 2) Which physiological and proteomic traits correlate with increased individual thermotolerance in corals? 3) Are phenotypic traits for thermotolerance heritable? 4) Can AGF and selective breeding lead to persistent shifts in thermotolerance in recipient populations? Phenotypic traits will be measured in permanently tagged individuals within selected coral populations to examine the relationships between thermotolerance and key fitness attributes. For the first time, state of the art proteomic approaches will be used to elucidate the physiological basis for increased levels of thermotolerance in corals. Innovative translocation methods will be used in tandem with selective breeding techniques to carry out the first long term assessment of heritability of thermotolerance and to test the feasibility of large scale AGF to assist conservation of coral reef ecosystems.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
726116	**EcoLipid**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. YIN CHEN**
Host Institution: The University Of Warwick, UK

Ecophysiology of membrane lipid remodelling in marine bacteria

Membrane lipids form the structural basis of all cells. In bacteria Escherichia coli uses predominantly phosphorus-containing lipids (phospholipids) in its cell envelope, including phosphatidylethanolamine and phosphatidylglycerol. However, beyond E. coli a range of lipids are found in bacterial membranes, including phospholipids as well as phosphorus (P)-free lipids such as betaine lipids, ornithine lipids, sulfolipids and glycolipids. In the marine environment, it is well established that P availability significantly affects lipid composition in the phytoplankton, whereby non-P sulfur-containing lipids are used to substitute phospholipids in response to P stress. This remodeling offers a significant competitive advantage for these organisms, allowing them to adapt to oligotrophic environments low in P. Until very recently, abundant marine heterotrophic bacteria were thought to lack the capacity for lipid remodelling in response to P deficiency. However, recent work by myself and others has now demonstrated that lipid remodelling occurs in many ecologically important marine heterotrophs, such as the SAR11 and Roseobacter clades, which are not only numerically abundant in marine waters but also crucial players in the biogeochemical cycling of key elements. However, the ecological and physiological consequences of lipid remodeling, in response to nutrient limitation, remain unknown. This is important because I hypothesize that lipid remodeling has important knock-on effects restricting the ability of marine bacteria to deal with both abiotic and biotic stresses, which has profound consequences for the functioning of major biogeochemical cycles. Here I aim to use a synthesis of molecular biology, microbial physiology, and "omics" approaches to reveal the fitness trade-offs of lipid remodelling in cosmopolitan marine heterotrophic bacteria, providing novel insights into the ecophysiology of lipid remodelling and its consequences for marine nutrient cycling.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
726176	**FRAGCLIM**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. JOSE MARIA MONTOYA TERAN**
Host Institution: Centre National De La Recherche Scientifique Cnrs, FR

The Combined Effects of Climatic Warming and Habitat Fragmentation on Biodiversity, Community Dynamics and Ecosystem Functioning

Climatic warming and habitat fragmentation are the largest threats to biodiversity and ecosystems globally. To forecast and mitigate their effects is the environmental challenge of our age. Despite substantial progress on the ecological consequences of climatic warming and habitat fragmentation individually, there is a fundamental gap in our understanding and prediction of their combined effects.

The goal of FRAGCLIM is to determine the individual and combined effects of climatic warming and habitat fragmentation on biodiversity, community dynamics, and ecosystem functioning in complex multitrophic communities. To achieve this, it uses an integrative approach that combines the development of new theory on metacommunities and temperature-dependent food web dynamics in close dialogue with a unique long-term aquatic mesocosm experiment. It is articulated around five objectives. In the first three, FRAGCLIM will determine the effects of (i) warming, (ii) fragmentation, and (iii) warming and fragmentation combined, on numerous facets of biodiversity, community structure, food web dynamics, spatial and temporal stability, and key ecosystem functions. Then, it will (iv) investigate the extent of evolutionary thermal adaptation to warming and isolation due to fragmentation, and its consequences for biodiversity dynamics. Finally, (v) it will provide creative solutions to mitigate the combined effects of warming and fragmentation.

FRAGCLIM proposes an ambitious integrative and innovative research programme that will provide a much-needed new perspective on the ecological and evolutionary consequences of warming and fragmentation. It will greatly contribute to bridging the gaps between theoretical and empirical ecology, and between ecological and evolutionary responses to global change. FRAGCLIM will foster links with environmental policy by providing new mitigation measures to climate change in fragmented systems that derive from our theoretical and empirical findings.

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

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Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
755659	**MALEPREG**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. OLIVIA ROTH**
Host Institution: Helmholtz Zentrum Fur Ozeanforschung Kiel, DE

Male pregnancy – Unravelling the coevolution of parental investment and immune defence

The question of how sex roles and parental investment have evolved belongs to the most controversial unresolved issues in evolutionary biology. The costliest form of reproduction regarding parental investment is viviparity. Its independent evolution in most vertebrate groups has required drastic morphological and genomic reorganisations in the sex bearing the young. Yet our knowledge is heavily biased towards mammals, where changes in the immune system and microbial composition are associated with pregnancy and placentation. Which factors have caused the selection and accompanied evolution of viviparity in other vertebrates remains severely understudied.

As the evolution of viviparity is a textbook model of convergent evolution, I plan on using a comparative approach to identify selection and fitness benefits leading to the evolution of viviparity.

I propose analysing mating system evolution, focusing on the unique evolution of male pregnancy in sex-role reversed syngnathids (pipefishes and seahorses) that show a gradient from external fertilisation to full viviparity and are, thus, ideal to study the evolution of viviparity. Only this genus allows the role of egg production and viviparity to be disentangled, as both traits co-occur in the female in most other species. As immunological tolerance is fundamentally associated with the evolution of pregnancy, I will investigate how male pregnancy has coevolved with adaptive immune system rearrangements and the broodpouch specific microbiota. Comparative genomics, transcriptomics and genetic engineering utilizing CRISPR/Cas9 will elucidate the genetic basis of trait loss and gain required for male pregnancy. In particular, I will assess whether new functions arose via gene duplication and neo-functionalization, via gene co-option or via de novo gene emergence.

This proposal will pave the way for studying viviparity evolution beyond the mammalian model and will provide a fresh look at sex roles and parental investment.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757440	**PLASREVOLUTION**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. ALVARO SAN MILLAN**
Host Institution: Servicio Madrileno De Salud, ES

Understanding the evolution of plasmid-mediated antibiotic resistance in real life scenarios

Antibiotics are essential tools in modern medicine and are indispensable not only for the treatment of infectious diseases but also to support other key interventions such as surgery and cancer chemotherapy. However, the extensive and inappropriate use of antibiotics has fuelled the spread of resistance mechanisms in pathogenic bacteria, leading to the dawn of a post-antibiotic era. Plasmids play a pivotal role in the evolution of antibiotic resistance (AR) because they drive the horizontal transfer of resistance genes between pathogenic bacteria by conjugation. Some of these plasmid-bacterium associations become particularly successful, creating superbugs that spread uncontrollably in clinical settings. The rise of these clones is mainly constricted because plasmids entail a fitness cost when they arrive in a new bacterial host. This cost can be subsequently alleviated through compensatory adaptation during plasmid-bacterium coevolution. Despite the importance of this cost-compensation dynamic in the evolution of plasmid-mediated AR, it remains completely unexplored in clinical contexts. In this project I plan to bridge this gap by exploring the genetic basis underlying the evolution of plasmid-mediated AR in clinically relevant scenarios. We will study, for the first time, the intra-patient transmission, fitness cost and adaptation of AR plasmids in the gut microbiome of hospitalized patients (obj. 1). We will analyse the molecular mechanisms that determine the success of AR plasmids and bacterial clone associations (obj. 2). Finally, we will develop new technology to test how antibiotic treatments affect AR plasmids dynamics in the gut microbiome at an unprecedentedly high-resolution (obj. 3). This ground-breaking project will allow a new understanding of the evolution of plasmid-mediated AR in real life, opening new research avenues and providing a major step towards meeting one of the central challenges facing our society: controlling the spread of AR.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758161	**Multicellularity**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. LASZLO NAGY**
Host Institution: Magyar Tudomanyos Akademia Szegedibiologiai Kutatokozpont, HU

The genetic basis of the convergent evolution of fungal multicellularity

The evolution of multicellularity (MC) has been one of the major transitions in the history of life. Despite immense interest in its evolutionary origins, the genomic changes leading to the emergence of MC, especially that of complex MC (differentiated 3-dimensional structures) are poorly known. Previous comparative genomics projects aiming to understand the genetic bases of MC in one way or another relied on gene content-based analyses. However, a pattern emerging from these studies is that gene content provides only an incomplete explanation for the evolution of MC even at ancient timescales. We hypothesize that besides gene duplications, changes to cis-regulatory elements and gene expression patterns (including protein isoforms) have significantly contributed to the evolution of MC. To test this hypothesis, we will deploy a combination of computational methods, phylogenomics, comparative transcriptomics and genome-wide assays of regulatory elements. Our research focuses on fungi as a model system, where complex MC evolved convergently and in subsequent two steps. Fungi are ideal models to tackle this question for several reasons: a) multicellularity in fungi evolved multiple times, b) there are rich genomic resources (>500 complete genomes), c) complex multicellular structures can be routinely grown in the lab and d) genetic manipulations are feasible for several cornerstone species. We set out to examine which genes participate in the building of simple and complex multicellular structures and whether the evolution of regulome complexity and gene expression patterns can explain the evolution of MC better than can traditionally assayed sources of genetic innovations (e.g. gene duplications). Ultimately, our goal is to reach a general synthesis on the genetic bases of the evolution of MC and that of organismal complexity.

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: The Chancellor, Masters And Scholars Of The University Of Cambridge, 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:
759817	**EMERG-ANT**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. ANTOINE WYSTRACH**
Host Institution: Centre National De La Recherche Scientifique Cnrs, FR

Ant navigation: how complex behaviours emerge from mini-brains in interaction with their natural habitats

Navigation is one of the most crucial and most challenging problems animals face. Behavioural analyses have shown that animals make use of a number of different mechanisms to navigate, but very little is known of how spatial information is processed and integrated by the brain. This project will exploit the stunning ability of ants in learning long visual routes to investigate the mechanisms of navigation in a brain numerically much simpler than vertebrate. We will combine an ecological approach with state-of-the-art technologies to enable a thorough control of sensory-motor cues while the ant is navigating in virtual-reality reconstructions of its natural environments. This new and powerful method will enable us to dissect the mechanisms underlying the emergence of navigational behaviours by performing straightforward manipulations. The results will be modelled in the light of insect neurobiology and integrated into an increasingly complete neural architecture. This neural architecture will be embedded into an agent navigating in the same virtual-reality environment as the real ants for testing. The advantage of such an inter-disciplinary approach is that failures of our agent will help us identify gaps in our knowledge and thus fuel new experimentation. Reciprocally, our agent will become increasingly refined in the light of incoming experimental results. This will create a positive feedback towards a complete, multi-level understanding of navigation in the wild. The findings will inspire new robust solutions for navigational problems that can be applied to bio-robotics.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771349	**DEFEAT**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. MICHAEL THOMAS-POULSEN**
Host Institution: Kobenhavns Universitet, DK

DiseasE-FreE social life without Antibiotics resisTance

The application of antimicrobial compounds produced by hosts or defensive symbionts to counter the effects of diseases has been identified in a number of organisms, but despite extensive studies on their presence, we know essentially nothing about why antimicrobials do not trigger rampant resistance evolution in target parasites. In stark contrast to virtually any other organism, fungus-farming termites have evolved a sophisticated agricultural symbiosis that pre-dates human farming by 30 million years without suffering from specialised diseases. I will capitalise on recent pioneering work in my group on proximate evidence for antimicrobial defences in the termites, their fungal crops, and their complex gut bacterial communities, by proposing to develop the farming symbiosis as a major model to test three novel concepts that may account for the evasion of resistance evolution. First, the antimicrobial compounds may have properties and evolve in ways that preclude resistance evolution in pathogens. Second, resistance is only possible towards individual compounds and not natural antimicrobial cocktails. Third, pathogens can only successfully invade and proliferate if they bypass several consecutive lines of defence, analogous to the six hallmarks of metazoan defence against cancer development. Addressing these concepts will allow fundamental insights into the remarkable success of complementary symbiont contributions to defence, and they will clarify the forces of multilevel natural selection that have allowed long-lived insect societies to evolve sustainability. Documenting and understanding these disease management principles is fundamentally important for several branches of evolutionary biology, and strategically important for adjusting human practices for future antimicrobial stewardship.

Project End Date: **31-MAY-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:
789240	**AdaptiveResponse**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. FRANJO WEISSING**
Host Institution: Rijksuniversiteit Groningen, NL

The evolution of adaptive response mechanisms

In an era of rapid climate change there is a pressing need to understand whether and how organisms are able to adapt to novel environments. Such understanding is hampered by a major divide in the life sciences. Disciplines like systems biology or neurobiology make rapid progress in unravelling the mechanisms underlying the responses of organisms to their environment, but this knowledge is insufficiently integrated in eco-evolutionary theory. Current eco-evolutionary models focus on the response patterns themselves, largely neglecting the structures and mechanisms producing these patterns. Here I propose a new, mechanism-oriented framework that views the architecture of adaptation, rather than the resulting responses, as the primary target of natural selection. I am convinced that this change in perspective will yield fundamentally new insights, necessitating the re-evaluation of many seemingly well-established eco-evolutionary principles.

My aim is to develop a comprehensive theory of the eco-evolutionary causes and consequences of the architecture underlying adaptive responses. In three parallel lines of investigation, I will study how architecture is shaped by selection, how evolved response strategies reflect the underlying architecture, and how these responses affect the eco-evolutionary dynamics and the capacity to adapt to novel conditions. All three lines have the potential of making ground-breaking contributions to eco-evolutionary theory, including: the specification of evolutionary tipping points; resolving the puzzle that real organisms evolve much faster than predicted by current theory; a new and general explanation for the evolutionary emergence of individual variation; and a framework for studying the evolution of learning and other general-purpose mechanisms. By making use of concepts from information theory and artificial intelligence, the project will also introduce various methodological innovations.

Project End Date: **30-NOV-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:
803151	**Macro-EpiK**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. LAURA EME**
Host Institution: Centre National De La Recherche Scientifique Cnrs, FR

The macroevolutionary impact of epigenetics and lateral gene transfer on eukaryotic genomes

Multicellular organisms (e.g., animals, fungi and plants) are the best-studied eukaryotes but their ancestors and the vast majority of eukaryotic diversity correspond to microbial species ("protists"). The evolutionary history of protists is closely connected to the evolution of the eukaryotic cell itself.

However, most protist diversity is still genomically unexplored, limiting our investigation of eukaryotic evolution. For example, while the importance of lateral gene transfer (LGT) in prokaryotic evolution is well reCoGnized, its role in eukaryotic evolution is still debated. In addition, although epigenetic mechanisms represent a hallmark of eukaryotic genome regulation, we know surprisingly little about the evolution of these mechanisms across eukaryotic diversity.

The overarching goal of my project is to understand how epigenetic mechanisms and LGT have shaped the macroevolution of eukaryotic genomes. This project has several inter-related intermediate objectives, which each in themselves will bring crucial insights into eukaryotic evolution: 1) reconstructing a robust phylogeny of eukaryotes; 2) inferring the gene content of the Last Eukaryotic Common Ancestor; 3) tracing the evolution of genes involved in epigenetic mechanisms and obtaining epigenomic maps from under-studied protists; 4) investigating the intriguing hypothesis of a possible interplay between epigenetic regulation and horizontal gene transfer and its influence on eukaryotic genome evolution: Have genes involved in epigenomic mechanisms been transferred between eukaryotes? Do epigenomic modifications affect the frequency of LGT in different lineages?

To achieve this, I will characterize the transcriptomes, genomes, methylomes and small RNAs of understudied eukaryotic microbes selected for their key phylogenetic position, and to analyse them using state-of-the-art bioinformatic methods. I will target uncultivated protists, using single-cell techniques and novel genome-scaffolding approaches.

Project End Date: **29-FEB-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:
805189	**BABE**	**LS8** Evolutionary, Population and Environmental Biology

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

Why is the world green: testing top-down control of plant-herbivore food webs by experiments with birds, bats and ants

Why is the world green? Because predators control herbivores, allowing plants to flourish. This >50 years old answer to the deceptively simple question remains controversial. After all, plants are also protected from herbivores physically and by secondary chemistry. My goal is to test novel aspects of the "green world hypothesis": ● How the importance of top-down effects varies with forest diversity and productivity along a latitudinal gradient? ● How the key predators, birds, bats and ants, contribute to top-down effects individually and in synergy? I strive to understand this because: ● While there is evidence that predators reduce herbivore abundance and enhance plant growth, the importance of top-down control is poorly understood across a range of forests. ● The importance of key predatory groups, and their antagonistic and synergic interactions, have been rarely studied, despite their potential impact on ecosystem dynamics in changing world. I wish to achieve my goals by: ● Factorial manipulations of key insectivorous predators (birds, bats, ants) to measure their effects on lower trophic levels in forest understories and canopies, accessed by canopy cranes, along latitudinal gradient spanning 75o from Australia to Japan. ● Studying compensatory effects among predatory taxa on herbivore and plant performance. Why this has not been done before: ● Factorial experimental exclusion of predatory groups replicated on a large spatial scale is logistically difficult. ● Canopy crane network along a latitudinal gradient has only recently become available. I am in excellent position to succeed as I have experience with ● foodweb experiments along an elevation gradient in New Guinea rainforests, ● study of bird, bat and arthropod communities. If the project is successful, it will: ● Allow understanding the importance of predators from temperate to tropical forests. ● Establish a network of experimental sites along a network of canopy cranes open for follow-up research.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818416	**TE_INVASION**	**LS8** Evolutionary, Population and Environmental Biology

Principal Investigator: **Dr. ANDREA J BETANCOURT**
Host Institution: The University Of Liverpool, UK

The evolutionary genetics of transposable element invasions

Transposable elements play major roles in the genome evolution of eukaryotes, and cause harmful mutations, deleterious side effects, and disease. These costs drive their eukaryotic hosts to evolve counter-adaptations, which are so effective that TEs are thought to only survive long term by invading new naïve species. These transposable element invasions appear to occur via horizontal transfer, and can result in the rapid, selfish spread of the element through a species. Despite the evolutionary importance of the host-transposable element relationship, there are still major gaps in our knowledge of how they evolve and persist. Host resistance can evolve astonishingly rapidly, but the evolutionary mechanism by which this happens is unknown. Some horizontal transfer events result in successful invasions, but we have little idea of what factors favour success, or, except in rare cases, how the transfer events occur.

This proposal outlines a four-part research programme to address these gaps, examining both sides of the coevolutionary equation. Specifically, I will examine the rapid evolution of suppression from the host side, to understand the population genetics of this process. I will study invasions from the perspective of the transposable element, and ask what genetic factors contribute to their success. To accomplish these objectives, I will take advantage of a unique opportunity-- an ongoing invasion of a model transposable element in a close relative of the genetic model fly. Finally, I will examine the role of parasites as vectors of TEs ,to understand mechanisms of horizontal transfer between species.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
639123	**SCENT**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. ANA ROQUE**
Host Institution: Nova Id Fct - Associacao Para A Inovacao E Desenvolvimento Da Fct, PT

SCENT: Hybrid Gels for Rapid Microbial Detection

Antimicrobial resistant bacteria are a global threat spreading at an alarming pace. They cause over 25,000 annual deaths in the EU, and represent an economic burden exceeding €1.5 billion a year. Current methods for microbial detection in clinical settings take about 24-36 h, but for slow-growing bacteria, as those causing tuberculosis, it can take more than a week. Early-detection and confinement of the infected individuals are the only ways to provide adequate therapy and control infection spread. Thus, tools for rapid identification of bacterial infections are greatly needed.

The analysis of microbial volatile metabolites is an area of increasing interest in diagnostics. Recent works demonstrate that fast microbial identification is possible with chemical nose sensors. These sensors usually present limited stability and selectivity, and require aggressive conditions during processing and operation. Bioinspired nose sensors employing biological olfactory receptors are an alternative. Unfortunately, their complexity and low stability are a limitation. My group recently discovered a new class of stimulus-responsive gels which tackle these key challenges. Our gels are customisable and have a low environmental footprint associated. I intend to further explore their potential to advance the field of odour detection, while providing new tools for the scientific community. I will focus specifically in fast microbial detection. To accomplish this, I propose to 1) build libraries of hybrid gels with semi-selective and selective properties, 2) generate odorant specific peptides mimicking olfactory receptors, 3) fully characterise the gels, 4) assemble artificial noses for analysis of microbial volatiles, 5) create databases with organism-specific signal signatures, 6) identify pathogenic bacteria, including those with acquired antimicrobial-resistances. This project is a timely approach which will place Europe in the forefront of infectious disease control.

Project End Date: **30-NOV-20**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
678461	**AcetyLys**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. EYAL ARBELY**
Host Institution: Ben-Gurion University Of The Negev, IL

Unravelling the role of lysine acetylation in the regulation of glycolysis in cancer cells through the development of synthetic biology-based tools

Synthetic biology is an emerging discipline that offers powerful tools to control and manipulate fundamental processes in living matter. We propose to develop and apply such tools to modify the genetic code of cultured mammalian cells and bacteria with the aim to study the role of lysine acetylation in the regulation of metabolism and in cancer development. Thousands of lysine acetylation sites were recently discovered on non-histone proteins, suggesting that acetylation is a widespread and evolutionarily conserved post translational modification, similar in scope to phosphorylation and ubiquitination. Specifically, it has been found that most of the enzymes of metabolic processes—including glycolysis—are acetylated, implying that acetylation is key regulator of cellular metabolism in general and in glycolysis in particular. The regulation of metabolic pathways is of particular importance to cancer research, as misregulation of metabolic pathways, especially upregulation of glycolysis, is common to most transformed cells and is now considered a new hallmark of cancer. These data raise an immediate question: what is the role of acetylation in the regulation of glycolysis and in the metabolic reprogramming of cancer cells? While current methods rely on mutational analyses, we will genetically encode the incorporation of acetylated lysine and directly measure the functional role of each acetylation site in cancerous and non-cancerous cell lines. Using this methodology, we will study the structural and functional implications of all the acetylation sites in glycolytic enzymes. We will also decipher the mechanism by which acetylation is regulated by deacetylases and answer a long standing question – how 18 deacetylases reCoGnise their substrates among thousands of acetylated proteins? The developed methodologies can be applied to a wide range of protein families known to be acetylated, thereby making this study relevant to diverse research fields.

Project End Date: **30-JUN-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
680040	**EVOLOR**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. ENIKO KUBINYI**
Host Institution: Eötvös Loránd Tudományegyetem, HU

CoGnitive Ageing in Dogs

The aim of this project is to understand the causal factors contributing to the CoGnitive decline during senescence and to develop sensitive and standardized behaviour tests for early detection in order to increase the welfare of affected species. With the rapidly ageing population of Europe, related research is a priority in the European Union.

We will focus both on characterising the ageing phenotype and the underlying biological processes in dogs as a well-established natural animal model. We develop a reliable and valid test battery applying innovative multidisciplinary methods (e.g. eye-tracking, motion path analysis, identification of behaviour using inertial sensors, EEG, fMRI, candidate gene, and epigenetics) in both longitudinal and cross-sectional studies. We expect to reveal specific environmental risk factors which hasten ageing and also protective factors which may postpone it. We aim to provide objective criteria (behavioural, physiological and genetic biomarkers) to assess and predict the ageing trajectory for specific individual dogs. This would help veterinarians to reCoGnise the symptoms early, and initiate necessary counter actions.

This approach establishes the framework for answering the broad question that how we can extend the healthy life of ageing dogs which indirectly also contributes to the welfare of the owner and decreases veterinary expenses. The detailed description of the ageing phenotype may also facilitate the use of dogs as a natural model for human senescence, including the development and application of pharmaceutical interventions.

We expect that our approach offers the scientific foundation to delay the onset of CoGnitive ageing in dog populations by 1-2 years, and also increase the proportion of dogs that enjoy healthy ageing.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694426	**BISON**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. EHUD GAZIT**
Host Institution: Tel Aviv University, IL

Bio-Inspired Self-Assembled Supramolecular Organic Nanostructures

Peptide building blocks serve as very attractive bio-inspired elements in nanotechnology owing to their controlled self-assembly, inherent biocompatibility, chemical versatility, biological reCoGnition abilities and facile synthesis. We have demonstrated the ability of remarkably simple aromatic peptides to form well-ordered nanostructures of exceptional physical properties. By taking inspiration from the minimal reCoGnition modules used by nature to mediate coordinated processes of self-assembly, we have developed building blocks that form well-ordered nanostructures. The compact design of the building blocks, and therefore, the unique structural organization, resulted in metallic-like Young's modulus, blue luminescence due to quantum confinement, and notable piezoelectric properties. The goal of this proposal is to develop two new fronts for bio-inspired building block repertoire along with co-assembly to provide new avenues for organic nanotechnology. This will combine our vast experience in the assembly of aromatic peptides together with additional structural modules from nature. The new entities will be developed by exploiting the design principles of small aromatic building blocks to arrive at the smallest possible module that form super helical assembly based on the coiled coil motifs and establishing peptide nucleic acids based systems to combine the worlds of peptide and DNA nanotechnologies. The proposed research will combine extensive design and synthesis effort to provide a very diverse collection of novel buildings blocks and determination of their self-assembly process, followed by broad chemical, physical, and biological characterization of the nanostructures. Furthermore, effort will be made to establish supramolecular co-polymer systems to extend the morphological control of the assembly process. The result of the project will be a large and defined collection of novel chemical entities that will help reshape the field of bioorganic nanotechnology.

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

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:
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:
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:
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:
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:
773067	**The insect cochlea**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. FERNANDO MONTEALEGRE-Z**
Host Institution: University Of Lincoln, UK

The Insect cochlea: a non-invasive path towards enhanced sound detectors

There is a critical need for high-resolution acoustic sensors for numerous applications in engineering/medicine. The human cochlea has been a source of inspiration for acoustic sensors due its improved sensitivity, higher frequency range, and sharp frequency discrimination. Current methods for measuring cochlear mechanics are inherently invasive, and deep understanding of its process remains elusive, proving challenging its simulation in electromechanical devices. Yet cochlear organ for frequency selectivity is not unique to mammalian audition. A simpler analogous mechanism for frequency analysis was recently found in the ears of bush-crickets (insects). These insects are endowed with outer middle and inner ear, but unlike mammals their cochlea is small (~0.6 mm), uncoiled, and exceptionally accessible through transparent cuticle. These attributes facilitate the clean measurements of complex auditory processes impossible to attain in the mammalian cochlea, and open an exceptional opportunity for miniaturization and simplification of artificial acoustic sensors.

Using bush-crickets and relatives as model systems this project is designed to fulfil the following two main objectives: (1) to dissect the three ear components to i) identify the elements involved in acute hearing sensitivity, ii) characterise the role of multiple sound inputs in directional hearing, iii) associate the activation patterns of auditory afferents with mechanical waves in the insect cochlea. (2) Use experimental data to produce computer models and theoretical analogues of the insect cochlea to propose innovative alternatives in the design of acoustic sensors. By using a multi-disciplinary approach between biology, engineering, physics and mathematics, this project is designed to develop new technological improvements that constitute the grounds of the next-generation of miniature, super-sensitive acoustic sensors.

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:
801954	**PhytoTrace**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. EVA OBURGER**
Host Institution: Universitaet Fuer Bodenkultur Wien, AT

Wanted: Micronutrients! Phytosiderophore-mediated acquisition strategies in grass crops

Understanding how plants respond to micronutrient deficiency and which biogeochemical processes are induced at the root-soil interface, i.e. the rhizosphere, is crucial to improve crop yield and micronutrient grain content for high quality food and feed. Iron nutrition by grass species relies on the release and re-uptake of phytosiderophores, which are root exudates that form stable complexes with Fe but also other trace metals such as Zn and Cu. However, neither the importance of phytosiderophores under Zn and Cu deficient conditions nor the interplay of plant responses and rhizosphere processes are well understood as the majority of studies in the past was carried out under 'soil-free' hydroponic conditions. In this project, I aim to elucidate the mechanisms controlling phytosiderophore-mediated micronutrient acquisition of barley (Hordeum vulgare) under Zn, Cu, and as reference, Fe deficient conditions, with particular emphasis on soil environments. Barley is the fifth most produced crop worldwide and of great importance in regions that are characterized by harsh living conditions. In a holistic approach, my team and I will apply innovative soil-based and traditional hydroponic root exudation sampling approaches in combination with advanced plant molecular techniques to study the phytosiderophore release and uptake system under different experimental conditions. The chemical synthesis of otherwise commercially unavailable phytosiderophores in their natural and 13C-labelled form will allow us to trace their decomposition and metal solubilizing efficiency in the plant-microbe-soil system to uncover the interplay of plant genetic responses and rhizosphere processes affecting the time-window of PS-mediated MN acquisition. Moving beyond 'soil-free' experimental designs of the past, this project will generate key knowledge to improve selection of crops with highly efficient micronutrient acquisition traits to alleviate micronutrient malnutrition of people world-wide.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802736	**MORPHEUS**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator:	**Dr. CHRISTINE BEEMELMANNS**
Host Institution:	Leibniz-Institut Fur Naturstoff-Forschung Und Infektionsbiologie Ev Hans-Knoll-Istitut, DE

Deciphering Bacteria-induced Morphogenesis and Protection in marine Eukaryotes

Symbiotic bacteria play critical roles in animal evolution, development and metabolism. The molecular and cellular mechanisms underlying these fundamental interactions, however, are largely unknown.

To fill this major knowledge gap, I will establish the bacteria-Hydractinia symbiosis as a new model system to fully characterize key cross-kingdom signalling molecules and response mechanisms. The results of my ERC proposal (MORPHEUS) will lead to ground-breaking insights into molecular drivers of eukaryotic morphogenesis, illuminate the evolutionary history of developmental signals for animals – including humans – and provide new chemical scaffolds with intrinsic biological activities that are urgently needed for drug discovery.

The marine colonial hydroid Hydractinia belongs to an early branching metazoan lineage, dating back more than 500 million years. The organism reproduces through a larval stage, which upon perception of yet unidentified bacterial morphogenic signals, produced within marine bacterial biofilms, undergoes transformation into the mature organism. In the absence of the bacterial signals, the larva fails to settle and eventually dies. This fundamental process is the basis of this proposal. Capitalizing from my recent pioneering work, I will address the following pressing research questions: Which bacterial signals ensure larval recruitment and metamorphosis? How are bacterial signalling molecules perceived? How is the system protected against alien species? I will apply an innovative combination of state-of-the-art methodologies developed within the fields of natural product and synthetic organic chemistry, microbiology and molecular biology to pursue an in-depth biochemical analysis of this paradigmatic system. Results of MORPHEUS will be transformative for many scientific branches across biological and chemical disciplines, and directly impact the development of sustainable anti-biofouling and drug discovery strategies.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803363	**FuncMAB**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. KLAUS EYER**
Host Institution: Ecole Superieure De Physique Et Dechimie Industrielles De La Ville Deparis, FR

High-throughput single-cell phenotypic analysis of functional antibody repertoires

Antibodies play an important role ensuring successful protection after vaccination. Upon injection, antigen-binding antibodies are generated to prime the host's immune system for future encounters with the threat. These responses are highly heterogeneous, with each cell contributing with a single antibody variant to the complexity. Each antibody variant furthermore can reCoGnize a different antigen/epitope with varying specificity and affinity. The immunological function induced is related to those parameters.

Depending on the nature of the threat, required protective functional antibodies vary. Therefore, also each vaccination against those threads needs to trigger a specific functional antibody repertoire. Presently, induced functional antibody repertoires have not yet been studied sufficiently, mostly due to the lack of technologies that enable analysing these repertoires with high enough throughput and resolution. Consequently, the mechanisms behind the evolution of these functional repertoires, and the influence of vaccination on these repertoires remain poorly understood.

An innovative technology combined with a methodical approach to vaccinations will enable the FuncMab research team to generate data sets needed for the understanding of immunological processes that result in different functional antibody repertoires. Herein, antibodies are analysed on the individual cell level in high-throughput using specific bioassays that target various antibody functions and their biophysical parameters, generating high-resolution data. These functional repertoires are followed over time and evolutionary changes can be linked to introduced vaccine variations, allowing a quantitative approach to study the changes within the repertoires. These in-depth data sets will not only allow understanding interactions between vaccine components and their generated immune responses, but also propels this project to the forefront of creating a new generation of successful vaccines

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803894	**Microrobots**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. BERTRAM DAUM**
Host Institution: The University Of Exeter, UK

Engineering Biohybrid MicroRobots from Magnetic Swimmers and S-layers

Biohybrid MicroRobots (BMRs) are conceptual microscopic robotic devices that combine synthetic and biological components and can be remote controlled to a specific destination, attach to a target and perform a bespoke biochemical operation at nanoscale precision. Within the 5-year Microrobots project, I intend to develop innovative BMRs by combining magnetic swimmers (MSs) with prokaryotic S-layers (SLs). MSs are microscopic devices that consist of two flexibly linked metallic beads with different magnetic properties and can be remote controlled through liquid media, simply by applying oscillating magnetic fields. SLs are highly stable 2-dimensional protein arrays that form resilient cell wall components in archaea and bacteria and can be genetically modified and reassembled on inorganic surfaces. I will introduce affinity tags into selected archaeal and bacterial SLs and reassemble them on the surfaces of MSs. This will coat MSs with unique affinity matrices, on which bioactive molecules can be conjugated at regular arrays, high density and defined distance. Through this strategy, I will generate BMRs that can be equipped with any bioactive functionality provided by nature, such as adhesive filaments, enzymes, antibodies, reporters, drug cargo or any other thinkable functional molecule. The BMRs that I will develop will elegantly miniaturise robotics and enable us to deliver bioactivity at nanometre precision. This will provide a revolutionary platform technology that will be applicable in a plethora of fields, such as medicine, nanotechnology, environmental engineering or scientific exploration and generate a real step change in the ways in which we build new materials, engineer our environment, fight disease and explore the universe in the 21st century.

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

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:
815379	**AutoCAb**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. SAREL FLEISHMAN**
Host Institution: Weizmann Institute Of Science, IL

Automated computational design of site-targeted repertoires of camelid antibodies

We propose to develop the first high-throughput strategy to design, synthesize, and screen repertoires comprising millions of single-domain camelid antibodies (VHH) that target desired protein surfaces. Each VHH will be individually designed for high stability and target-site affinity. We will leverage recent methods developed by our lab for designing stable, specific, and accurate backbones at interfaces, the advent of massive and affordable custom-DNA oligo synthesis, and machine learning methods to accomplish the following aims:

Aim 1: Establish a completely automated computational pipeline that uses Rosetta to design millions of VHHs targeting desired protein surfaces. The variable regions in each design will be encoded in DNA oligo pools, which will be assembled to generate the entire site-targeted repertoire. We will then use high-throughput binding screens followed by deep sequencing to characterize the designs' target-site affinity and isolate high-affinity binders.

Aim 2: Develop an epitope-focusing strategy that designs several variants of a target antigen, each of which encodes dozens of radical surface mutations outside the target site to disrupt potential off-target site binding. The designs will be used to isolate site-targeting binders from repertoires of Aim 1.

Each high-throughput screen will provide unprecedented experimental data on target-site affinity in millions of individually designed VHHs.

Aim 3: Use machine learning methods to infer combinations of molecular features that distinguish high-affinity binders from non binders. These will be encoded in subsequent designed repertoires, leading to a continuous "learning loop" of methods for high-affinity, site-targeted binding.

AutoCAb's interdisciplinary strategy will thus lead to deeper understanding of and new general methods for designing stable, high-affinity, site-targeted antibodies, potentially revolutionizing binder and inhibitor discovery in basic and applied biomedical research.

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

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:
820124	**DeCoCt**	**LS9** Applied life Sciences and Non-Medical Biotechnology

Principal Investigator: **Dr. ERIC KEMEN**
Host Institution: Eberhard Karls Universitaet Tuebingen, DE

Knowledge based design of complex synthetic microbial communities for plant protection

Complex microbial communities ("microbiota") that populate surfaces of higher organisms critically impact health of their hosts: They contribute to vital functions such as host fitness, nutrient acquisition, stress tolerance and pathogen resistance but are, at the same time, reservoirs for facultative pathogens or can promote pathogenesis. How and why communities shift from a beneficial to a detrimental state is largely unknown and we are far from utilizing identified mechanisms.

In order to cure detrimental microbiota, that were damaged or reverted through stress factors including previous diseases, decoding the complex processes governing microbiota dynamics is a key challenge. To develop durable probiotics, communal stability or the ability of a community to return to a steady state following perturbation is a key factor.

Our lab has broad expertise in studying microbial communities through lab experiments and analyzing factors that shape the microbiota of Arabidopsis thaliana plants under natural conditions and common garden experiments. We have discovered a hierarchical order in microbial community networks with hub microbes as key elements. A recent breakthrough was the discovery of microbial taxa that persist throughout the life of A. thaliana plants and their importance in network stability.

In this project we will use our expertise to identify key stability factors and drivers of communal dynamics to reconstitute synthetic communities. How to seed microbial communities that develop into functional probiotics is a key challenge. We will use knowledge based assembly of complex communities to seeds protective microbiota. We will challenge those through pathogens and abiotic factors to refine and test the predictive power of our analyses. Therefore, DeCoCt represents a highly innovative approach that holds the potential to gain novel insights beyond the current scope of microbiota and probiotics research.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
648509	**LaDIST**	**PE1** Mathematics

Principal Investigator:	**Dr. DANIEL KRAL**
Host Institution:	Masarykova Univerzita, CZ

Large Discrete Structures

The proposed project seeks to introduce novel methods to analyze and approximate large graphs and other discrete structures and to apply the developed methods to solve specific open problems. A need for such methods comes from computer science where the sizes of input structures are often enormous. Specifically, the project will advance the recently emerged theory of combinatorial limits by developing new insights in the structure of limit objects and by proposing a robust theory bridging the sparse and dense cases. The analytic methods from the theory of combinatorial limits will be used to analyze possible asymptotic behavior of large graphs and they will be applied in conjunction with structural arguments to provide solutions to specific problems in extremal combinatorics. The obtained insights will also be combined with methods from discrete optimization and logic to provide new algorithmic frameworks.

Project End Date: **30-NOV-20**

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:
677120	**INDEX**	**PE1** Mathematics

Principal Investigator: **Dr. PIOTR NOWAK**
Host Institution: Instytut Matematyczny Polskiej Akademii Nauk, PL

Rigidity of groups and higher index theory

The Atiyah-Singer index theorem was one of the most spectacular achievements of mathematics in the XXth century, connecting the analytic and topological properties of manifolds. The Baum-Connes conjecture is a hugely successful approach to generalizing the index theorem to a much broader setting. It has remarkable applications in topology and analysis. For instance, it implies the Novikov conjecture on the homotopy invariance of higher signatures of a closed manifold and the Kaplansky-Kadison conjecture on the existence of non-trivial idempotents in the reduced group C*-algebra of a torsion-free group. At present, the Baum-Connes conjecture is known to hold for a large class of groups, including groups admitting metrically proper isometric actions on Hilbert spaces and Gromov hyperbolic groups.

The Baum-Connes conjecture with certain coefficients is known to fail for a class of groups, whose Cayley graphs contain coarsely embedded expander graphs. Nevertheless, the conjecture in full generality remains open and there is a growing need for new examples of groups and group actions, that would be counterexamples to the Baum-Connes conjecture. The main objective of this project is to exhibit such examples.

Our approach relies on strengthening Kazhdan's property (T), a prominent cohomological rigidity property, from its original setting of Hilbert spaces to much larger classes of Banach spaces. Such properties are an emerging direction in the study of cohomological rigidity and are not yet well-understood. They lie at the intersection of geometric group theory, non-commutative geometry and index theory. In their study we will implement novel approaches, combining geometric and analytic techniques with variety of new cohomological constructions.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
678698	**3DWATERWAVES**	**PE1** Mathematics

Principal Investigator: **Dr. ERIK WAHLÉN**
Host Institution: Lunds Universitet, SE

Mathematical aspects of three-dimensional water waves with vorticity

The goal of this project is to develop a mathematical theory for steady three-dimensional water waves with vorticity. The mathematical model consists of the incompressible Euler equations with a free surface, and vorticity is important for modelling the interaction of surface waves with non-uniform currents. In the two-dimensional case, there has been a lot of progress on water waves with vorticity in the last decade. This progress has mainly been based on the stream function formulation, in which the problem is reformulated as a nonlinear elliptic free boundary problem. An analogue of this formulation is not available in three dimensions, and the theory has therefore so far been restricted to irrotational flow. In this project we seek to go beyond this restriction using two different approaches. In the first approach we will adapt methods which have been used to construct three-dimensional ideal flows with vorticity in domains with a fixed boundary to the free boundary context (for example Beltrami flows). In the second approach we will develop methods which are new even in the case of a fixed boundary, by performing a detailed study of the structure of the equations close to a given shear flow using ideas from infinite-dimensional bifurcation theory. This involves handling infinitely many resonances.

Project End Date: **28-FEB-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681207	**GrDyAp**	**PE1** Mathematics

Principal Investigator:	**Dr. ANDREAS THOM**
Host Institution:	Technische Universitaet Dresden, DE

Groups, Dynamics, and Approximation

Eversince, the study of symmetry in mathematics and mathematical physics has been fundamental to a thourough understanding of most of the fundamental notions. Group theory in all its forms is the theory of symmetry and thus an indispensible tool in many of the basic theoretical sciences. The study of infinite symmetry groups is especially challenging, since most of the tools from the sophisticated theory of finite groups break down and new global methods of study have to be found. In that respect, the interaction of group theory and the study of group rings with ring theory, probability, Riemannian geometry, functional analyis, and the theory of dynamical systems has been extremely fruitful in a variety of situations. In this proposal, I want to extend this line of approach and introduce novel approaches to longstanding and fundamental problems.
There are four main interacting themes that I want to pursue:

(i) Groups and their study using ergodic theory of group actions
(ii) Approximation theorems for totally disconnected groups
(iii) Kaplansky's Direct Finiteness Conjecture and p-adic analysis
(iv) Kervaire-Laudenbach Conjecture and topological methods in combinatorial group theory

Project End Date: **30-SEP-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695621	**HOLOGRAM**	**PE1** Mathematics

Principal Investigator: **Dr. DIERK SCHLEICHER**
Host Institution: Technische Universitat Berlin, DE

Holomorphic Dynamics connecting Geometry, Root-Finding, Algebra, and the Mandelbrot set

Dynamical systems play an important role all over science, from celestial mechanics, evolution biology and economics to mathematics. Specifically holomorphic dynamics has been credited as "straddling the traditional borders between pure and applied mathematics". Activities of numerous top-level mathematicians, including Fields medalists and Abel laureates, demonstrate the attractivity of holomorphic dynamics as an active and challenging research field. We propose to work on a research project based in holomorphic dynamics that actively connects to adjacent mathematical fields. We work on four closely connected Themes: A. we develop a classification of holomorphic dynamical systems and a Rigidity Principle, proposing the view that many of the additional challenges of non-polynomial rational maps are encoded in the simpler polynomial setting; B. we advance Thurston's fundamental characterization theorem of rational maps and his lamination theory to the world of transcendental maps, developing a novel way of understanding of spaces of iterated polynomials and transcendental maps; C. we develop an extremely efficient polynomial root finder based on Newton's method that turns the perceived problem of "chaotic dynamics" into an advantage, factorizing polynomials of degree several million in a matter of minutes rather than months – and providing a family of rational maps that are highly susceptible to combinatorial analysis, leading the way for an understanding of more general maps; D. and we connect this to geometric group theory via "Iterated Monodromy Groups", an innovative concept that helps solve dynamical questions in terms of their group structure, and that contributes to geometric group theory by providing natural classes of groups with properties that used to be thought of as "exotic".

Project End Date: **30-SEP-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725010	**BG-BB-AS**	**PE1** Mathematics

Principal Investigator: **Dr. EDWARD SEGAL**
Host Institution: University College London, UK

Birational Geometry, B-branes and Artin Stacks

Derived categories of coherent sheaves on a variety are a fundamental tool in algebraic geometry. They also arise in String Theory, as the category of B-branes in a quantum field theory whose target space is the variety. This connection to physics has been extraordinarily fruitful, providing deep insights and conjectures.

An Artin stack is a sophisticated generalization of a variety, they encode the idea of equivariant geometry. A simple example is a vector space carrying a linear action of a Lie group. In String Theory this data defines a Gauged Linear Sigma Model, which is a basic tool in the subject. A GLSM should also give rise to a category of B-branes, but surprisingly it is not yet understood what this should be. An overarching goal of this project is to develop an understanding of this category (more accurately, system of categories), and to extend this understanding to more general Artin stacks.

The basic importance of this question is that in certain limits a GLSM reduces to a sigma model, whose target is a quotient of the vector space by the group. This quotient must be taken using Geometric Invariant Theory. Thus this project is intimately connected with the question of how derived categories change under variation-of-GIT, and birational maps in general.

For GLSMs with abelian groups this approach has already produced spectacular results, in the non-abelian case we understand only a few remarkable examples. We will develop these examples into a wide-ranging general theory.

Our key objectives are to:

- Provide powerful new tools for controlling the behaviour of derived categories under birational maps.
- Understand the category of B-branes on a large class of Artin stacks.
- Prove and apply a striking new duality between GLSMs.
- Construct completely new symmetries of derived categories.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
740132	**iHEART**	**PE1** Mathematics

Principal Investigator: **Dr. ALFIO QUARTERONI**
Host Institution: Politecnico Di Milano, IT

An Integrated Heart Model for the simulation of the cardiac function

The goal of this project is to construct, mathematically analyze, numerically approximate, computationally solve, and validate on clinically relevant cases a mathematically-based integrated heart model (IHM) for the human cardiac function. The IHM comprises several core cardiac models – electrophysiology, solid and fluid mechanics, microscopic cellular force generation, and valve dynamics – which are then coupled and finally embedded into the systemic and pulmonary blood circulations. It is a multiscale system of Partial Differential Equations (PDEs) and Ordinary Differential Equations (ODEs) featuring multiphysics interactions among the core models.

The physical and mathematical properties of each core model and those of the even more complex integrated heart model (IHM) will be analyzed. The numerical approximation of IHM develops along several steps: introduce new high order methods for the core models, carry out their stability and convergence analysis, devise new paradigms for their numerical coupling, and construct optimal, scalable, and adaptive preconditioners for the efficient solution of the resulting large-scale discrete problems. To address data variability in clinically relevant cases, new reduced order models and efficient computational techniques will be developed also for forward and inverse uncertainty quantification problems. Two software libraries, LifeHEART and RedHEART, will be built and made available to the scientific community.

The project is original, very ambitious, mathematically inspired and rigorous, tremendously challenging, and groundbreaking. If successful, it will provide researchers from applied mathematics and life sciences, cardiologists, and cardiac surgeons with a powerful tool for both the qualitative and quantitative study of cardiac function and dysfunction. iHEART has the potential to drive improvements in diagnosis and treatment for cardiovascular pathologies that are responsible for more than 45% of deaths in Europe.

Project End Date: **30-NOV-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:
772479	**TRANSHOLOMORPHIC**	**PE1** Mathematics

Principal Investigator: **Dr. CHRIS WENDL**
Host Institution: Humboldt-Universitaet Zu Berlin, DE

New transversality techniques in holomorphic curve theories

In the study of symplectic and contact manifolds, a decisive role has been played by the theory of pseudoholomorphic curves, introduced by Gromov in 1985. One major drawback of this theory is the fundamental conflict between "genericity" and "symmetry", which for instance causes moduli spaces of holomorphic curves to be singular or have the wrong dimension whenever multiply covered curves are present. Most traditional solutions to this problem involve abstract perturbations of the Cauchy-Riemann equation, but recently there has been progress in tackling the transversality problem more directly, leading in particular to a proof of the "super-rigidity" conjecture on symplectic Calabi-Yau 6-manifolds. The overriding goal of the proposed project is to unravel the full implications of these new transversality techniques for problems in symplectic topology and neighboring fields. Examples of applications to be explored include: (1) Understanding the symplectic field theory of unit cotangent bundles for manifolds with negative or nonpositive curvature, with applications to the nearby Lagrangian conjecture and dynamical questions in Riemannian geometry; (2) Developing a comprehensive bifurcation theory for Reeb orbits and holomorphic curves in symplectic cobordisms, leading e.g. to a proof that planar contact structures are "quasiflexible"; (3) Completing the analytical foundations of Hutchings's embedded contact homology (ECH), a 3-dimensional holomorphic curve theory with important applications to dynamics and symplectic embedding problems; (4) Developing new refinements of the Gromov-Witten invariants based on super-rigidity and bifurcation theory; (5) Defining higher-dimensional analogues of ECH; (6) Proving integrality relations in the setting of 6-dimensional symplectic cobordisms, analogous to the Gopakumar-Vafa formula for Calabi-Yau 3-folds.

Project End Date: **31-AUG-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:
681818	**IMPACT**	**PE10** Earth System Science

Principal Investigator: **Dr. RAZVAN CARACAS**
Host Institution: Centre National De La Recherche Scientifique Cnrs, FR

The giant impact and the Earth and Moon formation

Very little is understood of the physics governing the Giant Impact and the subsequent formation of the Moon. According to this model an impactor hit the proto-Earth; the resulting energy was enough to melt and partially vaporize the two bodies generating a large protolunar disk, from which the Earth-Moon couple formed. Hydrodynamic simulations of the impact and the subsequent evolution of the protolunar disk are currently based on models of equations of state and phase diagrams that are unconstrained by experiments or calculations. Estimates of the positions of critical points, when available at all, vary by one order of magnitude in both temperature and density. Here we propose to compute the thermodynamics of the major rock-forming minerals and rock aggregates, and use it to study the formation and evolution of the protolunar disk. For this we employ a unique combination of atomistic state-of-the-art ab initio simulations. We use large-scale density-functional theory (DFT) molecular dynamics to study bulk fluids, coupled with Green functions (GW) and time-dependent DFT techniques to analyze atomic clusters and molecular species. We compute the vaporization curves, position the supercritical points, and characterize the sub-critical and supercritical regimes. We construct equations of state of the rocks at the conditions of the giant impact that are beyond current experimental capabilities. We employ a multiscale approach to bridge the gap between atomic, geological sample, and planetary scales via thermodynamics; we simulate the thermal profile through the disk, the ratio between liquid and vapor, and the speciation. From speciation we predict elemental and isotopic partitioning during condensation. Plausible impact scenarios, features of the impactor and of the proto-Earth will be constrained with a feedback loop, until convergence between predictions of final Earth-Moon compositions and observations is reached.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
692891	**DAMOCLES**	**PE10** Earth System Science

Principal Investigator:	**Dr. HANNA VEHKAMÄKI**
Host Institution:	Helsingin Yliopisto, FI

Simulating Non-Equilibrium Dynamics of Atmospheric Multicomponent Clusters

Atmospheric aerosol particles play a key role in regulating the climate, and particulate matter is responsible for most of the 7 million deaths per year attributed to air pollution. Lack of understanding of aerosol processes, especially the formation of ice crystals and secondary particles from condensable trace gases, hampers the development of air quality modelling, and remains one of the major uncertainties in predicting climate.

The purpose of this project is to achieve a comprehensive understanding of atmospheric nanocluster and ice crystal formation based on fundamental physico-chemical principles. We will use a wide palette of theoretical methods including quantum chemistry, reaction kinetics, continuum solvent models, molecular dynamics, Monte Carlo simulations, Markov chain Monte Carlo methods, computational fluid dynamics, cluster kinetic and thermodynamic models. We will study non-equilibrium effects and kinetic barriers in atmospheric clustering, and use these to build cluster distribution models with genuine predictive capacity.

Chemical ionization mass spectrometers can, unlike any other instruments, detect the elemental composition of many of the smallest clusters at ambient low concentrations. However, the charging process and the environment inside the instrument change the composition of the clusters in hitherto unquantifiable ways. We will solve this problem by building an accurate model for the fate of clusters inside mass spectrometers, which will vastly improve the amount and quality of information that can be extracted from mass spectrometric measurements in atmospheric science and elsewhere.

DAMOCLES will produce reliable and consistent models for secondary aerosol and ice particle formation and growth. This will lead to improved predictions of aerosol concentrations and size distributions, leading to improved air quality forecasting, more accurate estimates of aerosol indirect climate forcing and other aerosol-cloud-climate interactions.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694188	**GlobalMass**	**PE10** Earth System Science

Principal Investigator: **Dr. JONATHAN BAMBER**
Host Institution: University Of Bristol, UK

Global land ice, hydrology and ocean mass trends

Sea level rise will be one of the most serious and costly consequences of future climate change. Constraining the sources and sinks of sea level change is essential for understanding the drivers of past variations and for improving predictions of future behaviour. Matching estimates of sea level rise with the components that affect it is a long standing problem in geosciences spanning multiple disciplines: oceanography, glaciology, hydrology and solid Earth physics. Traditionally, each part of the problem has been tackled separately using different data, techniques and physical understanding. This is because of the challenge in determining just one component but also because of the different expertise and understanding within the various communities. The proposed research will, for the first time, tackle all components simultaneously. I will combine all the relevant observations (both from satellites and in situ) with physical principles of the coupled system to solve for all components of the sea level budget. First, I will produce a data-driven estimate for glacio-isostatic adjustment that is independent of any assumptions about Earth structure or ice loading history. Second, I will partition the sea level budget into its steric, hydrological, cryospheric and solid earth components for 1981-2020. Third, I will apply the methods and datasets to re-evaluate the 20th Century sea level record. These advances will also result in the determination of regional mass trends of land ice and hydrology over a ~30 year period. In the process of attaining these goals in geosciences, I will also develop state of the art techniques for statistical inference of Big Data. I have developed and tested the approach, using a subset of the data, for the Antarctic ice sheet. The approach is unique, global in scale and will address fundamental problems across four different disciplines in geosciences, as well as advancing techniques in statistical inference and computer science.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714062	**C2Phase**	**PE10** Earth System Science

Principal Investigator: **Dr. CORINNA HOOSE**
Host Institution: Karlsruher Institut Fuer Technologie, DE

Closure of the Cloud Phase

Whether and where clouds consist of liquid water, ice or both (i.e. their thermodynamic phase distribution), has major impacts on the clouds' dynamical development, their radiative properties, their efficiency to form precipitation, and their impacts on the atmospheric environment. Cloud ice formation in the temperature range between 0 and -37°C is initiated by aerosol particles acting as heterogeneous ice nuclei and propagates through the cloud via a multitude of microphysical processes. Enormous progress has been made in recent years concerning the understanding and model parameterization of primary ice formation. In addition, high-resolution atmospheric models with complex cloud microphysics schemes can now be employed for realistic case studies of clouds. Finally, new retrieval schemes for the cloud (top) phase have recently been developed for various satellites, including passive polar orbiting and geostationary sensors, which provide a good spatial and temporal coverage and a long data record.

We propose here to merge the bottom-up, forward modeling approach for the cloud phase distribution with the top-down view of satellites. C2Phase will conduct systematic closure studies for variables related to the cloud phase distribution such as the cloud ice area fraction, its distribution as function of temperature and its temporal evolution, with a focus on Europe. For this, we will (1) use clustering techniques to separate different cloud regimes in model and satellite data, (2) explore the parameters and processes which the simulated phase distribution is most sensitive to, (3) investigate whether closure is reached between state-of-the art cloud resolving models and satellite observations, and how this closure can be improved by consistent and physically justified changes in microphysical parameterizations, and (4) use our results to improve the representation of mixed-phase clouds in weather and climate models and to quantify the impacts of these improvements.

Project End Date: **31-MAR-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:
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:
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:
757526	**FODEX**	**PE10** Earth System Science

Principal Investigator:	**Dr. EDWARD MITCHARD**
Host Institution:	The University Of Edinburgh, UK

Tropical Forest Degradation Experiment

We know how to map tropical forest biomass using an array of satellite and aircraft sensors with reasonable accuracy (±15-40 %). However, we do not know how to map biomass change. Simply differencing existing biomass maps produces noisy and biased results, with confidence intervals unknowable using existing static field plots. Thus the potential for using plentiful free satellite data for biomass change mapping is being wasted.

To solve this I propose setting up the first experimental arrays of biomass change plots. In total 52 large plots will be located in logging concessions in Gabon and Peru, where biomass will be assessed before and after logging, and during recovery. In addition to traditional field inventory, terrestrial laser scanning (TLS) data will give the precise 3D shape of thousands of trees before and after disturbance, allowing biomass change to be estimated without bias. The project's unmanned aerial vehicle (UAV) will collect LiDAR data 4 times over each concession over 4 years, scaling up the field data to give thousands of hectares of biomass change data. In tandem, data from all potentially useful satellites (17+) flying over the field sites over the study period will be ordered and processed.

These data will enable the development of new methods for mapping carbon stock changes, with known uncertainty, which I will scale up across the Amazon basin and west/central Africa. For the first time we will have the methods to assess the balance of regrowth and anthropogenic disturbance across tropical forests, informing us about the status and resilience of the land surface carbon sink. As well as of scientific interest, these results are urgently needed for forest conservation: the Paris Agreement relies on paying countries to reduce losses and enhance gains in forest carbon stocks, but we do not currently have the tools to map forest carbon stock changes. Without accurate monitoring it is not possible to target resources nor assess success.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757695	**MEMETRE**	**PE10** Earth System Science

Principal Investigator: **Dr. MARI PIHLATIE**
Host Institution: Helsingin Yliopisto, FI

From processes to modelling of methane emissions from trees

Atmospheric concentration of the strong greenhouse gas methane (CH4) is rising with an increased annual growth rate. Biosphere has an important role in the global CH4 budget, but high uncertainties remain in the strength of its different sink and source components. Among the natural sources, the contribution of vegetation to the global CH4 budget is the least well understood. Role of trees to the CH4 budget of forest ecosystems has long been overlooked due to the perception that trees do not play a role in the CH4 dynamics. Methanogenic Archaea were long considered as the sole CH4 producing organisms, while new findings of aerobic CH4 production in terrestrial vegetation and in fungi show our incomplete understanding of the CH4 cycling processes. Enclosure measurements from trees reveal that trees can emit CH4 and may substantially contribute to the net CH4 exchange of forests.

The main aim of MEMETRE project is to raise the process-based understanding of CH4 exchange in boreal and temperate forests to the level where we can construct a sound process model for the soil-tree-atmosphere CH4 exchange. We will achieve this by novel laboratory and field experiment focusing on newly identified processes, quantifying CH4 fluxes, seasonal and daily variability and drivers of CH4 at leaf-level, tree and ecosystem level. We use novel CH4 flux measurement techniques to identify the roles of fungal and methanogenic production and transport mechanisms to the CH4 emission from trees, and we synthesize the experimental work to build a process model including CH4 exchange processes within trees and the soil, transport of CH4 between the soil and the trees, and transport of CH4 within the trees. The project will revolutionize our understanding of CH4 flux dynamics in forest ecosystems. It will significantly narrow down the high uncertainties in boreal and temperate forests for their contribution to the global CH4 budget.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758005	**MC2**	**PE10** Earth System Science

Principal Investigator: **Dr. TRUDE STORELVMO**
Host Institution: Universitetet I Oslo, NO

Mixed-phase clouds and climate (MC2) – from process-level understanding to large-scale impacts

The importance of mixed-phase clouds (i.e. clouds in which liquid and ice may co-exist) for weather and climate has become increasingly evident in recent years. We now know that a majority of the precipitation reaching Earth's surface originates from mixed-phase clouds, and the way cloud phase changes under global warming has emerged as a critically important climate feedback. Atmospheric aerosols may also have affected climate via mixed-phase clouds, but the magnitude and even sign of this effect is currently unknown. Satellite observations have recently revealed that cloud phase is misrepresented in global climate models (GCMs), suggesting systematic GCM biases in precipitation formation and cloud-climate feedbacks. Such biases give us reason to doubt GCM projections of the climate response to CO2 increases, or to changing atmospheric aerosol loadings. This proposal seeks to address the above issues, through a multi-angle and multi-tool approach: (i) By conducting field measurements of cloud phase at mid- and high latitudes, we seek to identify the small-scale structure of mixed-phase clouds. (ii) Large-eddy simulations will then be employed to identify the underlying physics responsible for the observed structures, and the field measurements will provide case studies for regional cloud-resolving modelling in order to test and revise state-of-the-art cloud microphysics parameterizations. (iii) GCMs, with revised microphysics parameterizations, will be confronted with cloud phase constraints available from space. (iv) Finally, the same GCMs will be used to re-evaluate the climate impact of mixed-phase clouds in terms of their contribution to climate forcings and feedbacks. Through this synergistic combination of tools for a multi-scale study of mixed-phase clouds, the proposed research has the potential to bring the field of climate science forward, from improved process-level understanding at small scales, to better climate change predictions on the global scale.

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:
771369	**Sea2Cloud**	**PE10** Earth System Science

Principal Investigator: **Dr. KARINE SELLEGRI**
Host Institution: Centre National De La Recherche Scientifique Cnrs, 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:
772852	**GlacialLegacy**	**PE10** Earth System Science

Principal Investigator: **Dr. ULRIKE HERZSCHUH**
Host Institution: Alfred-Wegener-Institut Helmholtz-Zentrum Fur Polar- Und Meeresforschung, DE

Glacial Legacy on the establishment of evergreen vs. summergreen boreal forests

Boreal forests provide critical ecosystem services to humanity, including timber supplies, cli-mate-regulation, and permafrost-stabilization. However, these forests differ markedly between Asia, which is dominated by summergreen larch forests, and North America, where boreal for-ests are exclusively evergreen. The basic mechanisms controlling the distributions of these bo-real biomes remain poorly understood.

My new hypothesis is that summergreen and evergreen needle-leaf forests represent alterna-tive quasi-stable states that occur today under similar climatic conditions, but were triggered by different environmental conditions and gene pools during the Last Glacial.

GlacialLegacy will use coherent empirical and modelling approaches to investigate this hypoth-esis across the entire Northern Hemisphere, also collecting new data from northern Asia, where both forests types occur today.

Work package (WP) A will explore the dependency of post-glacial forest establishment on the glacial climate and genetic characteristics of northern tree refugia. We will use ancient DNA analysis of sediments, complemented by results from pollen data synthesis. For a mechanistic understanding of the empirical evidence obtained, we will simulate post-glacial forest migra-tion using the LAVESI individual-based vegetation model, into which long-term genetic process-es will be incorporated.

WP-B will further refine the LAVESI model using results from vegetation and biophysical field surveys. This will enable us to quantify the vegetation–fire–permafrost–climate feedbacks that are likely to facilitate boreal forest bi-stability.

Such a model configuration is the only way that reliable predictions of the future of boreal for-ests can be made, which will be the objective of WP-C. These predictions will aim to anticipate potentially critical future ecosystem service changes on a continental scale, thus providing the knowledge base required for adaptation strategies to be prepared.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772923	**VORTEX**	**PE10** Earth System Science

Principal Investigator: **Dr. HELGE NIEMANN**
Host Institution: Stichting Nederlandse Wetenschappelijk Onderzoek Instituten, NL

Plastic in the Ocean: Microbial Transformation of an 'Unconventional' Carbon Substrate

Large quantities of plastics comprising a diverse set of hydrocarbon or hydrocarbon-like polymers are constantly released to the oceans. The impacts of plastics in marine environments are detrimental, as they are seemingly recalcitrant and harmful to marine life. The severity of this problem is gaining momentum because the untamed demand for plastics has led to an ever-increasing release of plastic to the sea. However, despite their seemingly persistent properties, they do not accumulate as expected, indicating a substantial sink for plastics in the ocean. Plastics are synthetic and thus rather new and 'unconventional' compounds in the marine realm, yet microbes can utilise plastics as carbon substrates. However, the potential for microbial degradation of plastics in the ocean as well as key factors controlling degradation kinetics are largely unknown and have been discussed controversially. Using innovative stable isotope assays, my preliminary research has shown that plastics can be degraded in marine sediments under aerobic as well as anaerobic conditions. Here I propose to further investigate the potential for marine plastic degradation by microbes in laboratory- and field-based experiments across a wide range of contrasting environmental boundary conditions. In the VORTEX project, we will use cutting-edge stable isotope labelling and stable isotope probing assays in combination with biogeochemical/microbiological and organic geochemical tools to trace isotopically labelled carbon from the plastic-substrate pools into microbial metabolites (e.g. CO2) and biomass (e.g. diagnostic lipid biomarkers, DNA/RNA). This will lead to a breakthrough in our understanding of microbial plastic degradation in the ocean because the proposed analytical approaches allow to quantify kinetics of microbial polymer breakdown, to identify and quantify the responsible microbes and degradation pathways, and to determine environmental conditions conducive for plastic degradation.

Project End Date: **31-MAY-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:
787263	**PALGLAC**	**PE10** Earth System Science

Principal Investigator: **Dr. CHRIS CLARK**
Host Institution: The University Of Sheffield, UK

Palaeoglaciological advances to understand Earth's ice sheets by landform analysis

Ice sheets regulate Earth's climate by reflecting sunlight away, enabling suitable temperatures for human habitation. Warming is reducing these ice masses and raising sea level. Glaciologists predict ice loss using computational ice sheet models which interact with climate and oceans, but with caveats that highlight processes are inadequately encapsulated. Weather forecasting made a leap in skill by comparing modelled forecasts with actual outcomes to improve physical realism of their models. This project sets out an ambitious programme to adopt this data-modelling approach in ice sheet modelling. Given their longer timescales (100-1000s years) we will use geological and geomorphological records of former ice sheets to provide the evidence; the rapidly growing field of palaeoglaciology.

Focussing on the most numerous and spatially-extensive records of palaeo ice sheet activity - glacial landforms - the project aims to revolutionise understanding of past, present and future ice sheets. Our mapping campaign (Work-Package 1), including by machine learning techniques (WP2), should vastly increase the evidence-base. Resolution of how subglacial landforms are generated and how hydrological networks develop (WP3) would be major breakthroughs leading to possible inversions to information on ice thickness or velocity, and with key implications for ice flow models and hydrological effects on ice dynamics. By pioneering techniques and coding for combining ice sheet models with landform data (WP4) we will improve knowledge of the role of palaeo-ice sheets in Earth system change. Trialling of numerical models in these data-rich environments will highlight deficiencies in process-formulations, leading to better models. Applying our coding to combine landforms and geochronology to optimise modelling (WP4) of the retreat of the Greenland and Antarctic ice sheets since the last glacial will provide 'spin up' glaciological conditions for models that forecast sea level rise.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787574	**PALAEO-RA**	**PE10** Earth System Science

Principal Investigator: **Dr. STEFAN BRÖNNIMANN**
Host Institution: Universitaet Bern, CH

A Palaeoreanalysis To Understand Decadal Climate Variability

Climatic variations at decadal scales, such as phases of accelerated warming, weak monsoons, or widespread subtropical drought, have profound effects on society and the economy. Understanding such variations requires insights from the past. However, no data sets of past climate are available to study decadal variability of large-scale climate with state-of-the-art diagnostic methods. Currently available data sets are limited to statistical reconstructions of local or regional surface climate. The PALAEO-RA project will produce the first ever comprehensive, 3-dimensional, physically consistent reconstruction of the global climate system at a monthly scale for the past six centuries. This palaeoreanalysis is based on combining information from early instrumental measurements, historical documents (e.g., capitalizing on large amounts of newly available data from China), and proxies (e.g., tree rings) with a large ensemble of climate model simulations. To achieve this novel combination, a completely new data assimilation system for palaeoclimatological data will be developed. The unique data sets produced in this project will become reference data sets for studying past climatic variations (i) for diagnostic studies of interannual-to-decadal variability, (ii) as a benchmark for model simulations and (iii) for climate impact studies. Using the data produced, the project will analyse episodes of slowed or accelerated global warming, decadal subtropical drought periods, episodes of expanding or contracting tropics, slowed or strengthened monsoons, changes in storm tracks, blocking and associated weather extremes, and links between Arctic and midlatitude climate. The analyses will provide new insights into the processes governing decadal variability of weather and climate.

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:
817919	**SPACE TIE**	**PE10** Earth System Science

Principal Investigator: **Dr. ADRIAN JÄGGI**
Host Institution: Universitaet Bern, CH

Unifying the three pillars of Geodesy using space ties

Terrestrial Reference Frames (TRFs) are the basis to which all positions on the Earth's surface and all satellite orbits in the near Earth space have to refer to. The changes in the Earth's shape, rotation, and gravity field, the so-called "three pillars" of geodesy, provide the conceptual and observational basis for the TRFs. For today's TRF realizations, four space geodetic techniques are combined and linked by co-location sites on the Earth's surface ("Earth's shape") and by common Earth orientation parameters ("Earth rotation"). The third pillar ("Earth's gravity field") is today only contributing to the TRF determination via its associated center-of-mass. In SPACE TIE we will pave the way to unify the "three pillars" of Geodesy in future TRF realizations. We propose to use two satellite geodetic techniques, namely Global Navigation Satellite Systems (GNSS) and Satellite Laser Ranging (SLR), to connect them by co-location sites in space. These so-called space ties shall be realized on satellites of the currently existing space infrastructure, as well as on satellites due for launch in the near future. This includes the Medium Earth Orbits (MEO) of the GNSS satellites and, in particular, all satellites in Low Earth Orbits (LEO) with GNSS and SLR co-located on-board. To maximize the sensitivity to the Earth's gravity field, the ultra-precise inter-satellite ranging between LEO satellites of dedicated gravity missions shall be added as a third satellite geodetic technique. One and the same state-of-the-art space geodetic software package will be used to ensure that standards, background models, and processing strategies are consistently applied across all co-location satellites and measurement techniques. The outcome of SPACE TIE will allow it to assess the geometric and gravimetric impact of mass transport in the atmosphere, oceans, and ice caps in a most consistent way to globally quantify the mass exchange between the different components of the system Earth.

Project End Date: **30-APR-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:
646597	**MaGRaTh**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. VITOR CARDOSO**
Host Institution: Instituto Superior Tecnico, PT

Matter and strong-field gravity: New frontiers in Einstein's theory

Gravity is the weakest but the most intriguing fundamental interaction in the Universe. In the last decades a formidable intellectual effort has shown that the full-fledged geometric nature of gravity offers much more than a beautiful description and understanding of all stellar and galactic. In the quest for the ultimate theory of gravity, new and spectacular connections between high-energy physics, astrophysics, cosmology and theoretical physics have emerged. Triggered by breakthroughs at the observational, experimental and conceptual levels, strong gravity physics is experiencing a Golden Age, making it one of the most active fields of research of the 21st century.

My group in Lisbon has been involved in groundbreaking research into the nature of strong-field effects in curved spacetime with applications in various fields, thus establishing international leadership in the field. This proposal aims at understanding,
via perturbative techniques and full-blown nonlinear evolutions, the strong-field regime of gravity, and includes challenging nonlinear evolutions describing gravitational collapse, compact binary inspirals and collisions in the presence of fundamental fields. The proposed programme will significantly advance our knowledge of Einstein's field equations and their role in fundamental questions (e.g. cosmic censorship, hoop conjecture, spacetime stability, no hair theorems), but also its interplay with high energy, astro and particle physics (testing the precise nature of the interaction between compact objects and matter --such as dark matter candidates or accretion disks-- and its imprint on gravitational wave emission, understanding gravitational-led turbulence,etc).

This is a cross-cutting and multidisciplinary program with an impact on our understanding of gravity at all scales, on our perception of black hole-powered phenomena and on gravitational-wave and particle physics.

Project End Date: **30-NOV-20**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
669288	**SM-GRAV**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. ELIAS KIRITSIS**
Host Institution: Centre National De La Recherche Scientifique Cnrs, FR

Gravity, Holography and The Standard Model

The main thrust of this proposal is to investigate implications of a recent correspondence (string theory (ST) vs. gauge theory) to the physics beyond the Standard Model (SM) and its coupling to gravity. Instead of relying on the string picture of the unification of all interactions with gravity, I propose to look at its dual version: 4d quantum field
theories (QFT). The different perspective is expected to provide 3 distinct results:
(a) A QFT view of the SM embedding in string theory
(b) Novel phenomena and properties that are hard to see in the string theory picture.
(c) A "dual" view that would be valid in non-stringy regimes.
The key idea is that gravity, as observed in nature, is emergent: it is the avatar of a (hidden) large-N (near)
CFT that is interacting with the SM at high energy (the Planck scale). Such an approach provides an appealing UV completion to the SM+gravity: a UV complete four-dimensional QFT. There are, however, many questions that need to be
addressed in order for this setup to be a viable physical theory:
1. Why is the gravitational force four-dimensional (instead of higher-dimensional as suggested by standard holography)?
2. Why does the coupling of the gravitational force to the SM satisfy the equivalence principle to such a high accuracy?
3. What are other universal interactions with the SM model implied in this picture? What are their phenomenological consequences?
4. How can one construct, precise and controllable models for this setup?
5. How is Cosmology emerging in this picture? How do the important problems associated with it get resolved?
SM-GRAV will address all of the above questions using the tools of QFT, of string theory and the AdS-CFT correspondence. The outcome of the proposed research is expected to be a concrete and quantitative model/scenario for the emergence and coupling of the "gravitational sector fields" to the SM model and the novel phenomenological implications for particle physics and cosmology.

Project End Date: **31-DEC-20**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677323	**MULTISCALE**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. WOUTER WAALEWIJN**
Host Institution: Universiteit Van Amsterdam, NL

Precision Multi-Scale Predictions for the LHC: Higgs, Jets and Supersymmetry

My project will boost the precision of theoretical predictions for collisions at the Large Hadron Collider. Precise predictions are crucial to further constrain the properties of the recently-discovered Higgs boson, and uncover a faint signal of Beyond-the-Standard Model physics. I will focus on the strong interactions, which dominate the theoretical uncertainty and play a role at multiple energy scales, including those related to the incoming protons, the hard scattering, the masses of (new) particles, the transverse momentum and size of jets.

The critical progress of this proposal lies in taking this intrinsically multi-scale nature into account, moving beyond the current trade-off between precision and realism in the three dominant calculational paradigms. Fixed-order calculations are systematically improvable but assume that there is no hierarchy between perturbative scales. Monte Carlo event generators provide a fully exclusive description of the final state, but are currently limited to leading-logarithmic order and lack theoretical uncertainties. Resummed calculations can reach a higher logarithmic accuracy, but have been restricted to single observables.

In a recent breakthrough, I constructed a new effective field theory that simultaneously achieves higher logarithmic accuracy in two independent observables, by factorizing the physics at the corresponding scales. Moving beyond this prototypical study, I will develop the general effective field theory framework that accounts for the relevant scales in realistic measurements, which overcomes the limitations of all three paradigms. This research will be carried out in the context of several important LHC applications: precision Higgs measurements, jet substructure techniques for identifying boosted heavy particles and supersymmetry searches. My new field-theoretic insights and more precise predictions will be critical as the LHC starts Run 2, searching for new physics at even higher energies.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682399	**TeX-MEx**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. STUART MANGLES**
Host Institution: Imperial College Of Science, Technology And Medicine, UK

Time resolved X-ray probing of Matter under Extreme conditions

The unique properties of a new type of X-ray source produced by a compact laser-plasma accelerator will be used to probe the ultra-fast dynamics of the electronic structure of matter under extreme conditions.

The TeX-MEx project will study: 1) hot dense matter, such as that found at the centre of the Sun; 2) warm dense matter such as that found at the centre of Jupiter and 3) photo-ionized plasmas far from equilibrium such as is found in the exotic environment of an accretion disk surrounding a black hole. These extreme conditions will be created in the laboratory using 1) direct laser heating, 2) proton heating and laser driven shock heating and 3) intense X-ray pumping using the betatron source itself and the extraordinary X-ray fluxes available with a free electron laser.

Using the unique combination of a few-femtosecond duration and broad spectral coverage that the X-rays produced by a laser wakefield accelerator possess, the TeX-MEx project will explore new physics in each of these regimes. For example we will be able to directly measure the rates of ionization of hot dense matter for the first time; we will observe the onset of ion motion in warm dense matter and how this affects the electron energy levels; we will make the first observations of non-collisional photo-ionized plasmas. These will allow us to accurately test and develop models used to describe matter under extreme conditions in the laboratory and in astrophysics.

This integrated program of innovative experiments and new approaches to modeling will open up a new field of femtosecond time-resolved absorption spectroscopy of matter under extreme conditions and will drastically improve our understanding of how matter behaves throughout our Universe. It will, for the first time, bring to our laboratories on Earth the ability to probe some of Nature's most violent processes, to date only hinted at in data from a new generation of astronomical instruments.

Project End Date: **30-JUN-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
683107	**TempoQ**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. OTFRIED GUEHNE**
Host Institution: Universitaet Siegen, DE

Temporal Quantum Correlations

Correlations are central for our modern view on the foundations of quantum theory and applications like quantum information processing. So far, research concentrated on correlations between two or more particles. Indeed, for this situation it is well established that spatial quantum correlations are a useful resource for tasks like quantum cryptography and quantum metrology. There are, however, other types of correlations in quantum mechanics, which arise if a sequence of measurements on a single quantum system is made. These temporal quantum correlations have recently attracted attention, because they are central for the understanding of some differences between the quantum and the classical world. Moreover, due to experimental progress their observation has become feasible with trapped ions, polarized photons, or other quantum optical systems.

This project aims at a full understanding and characterization of temporal quantum correlations. For that, we will derive criteria and measures for temporal quantum correlations and investigate their connection to information theory. Then, we will elucidate to which extent temporal correlations can be used to prove that a system is quantum and not classical. Finally, we
consider implementations of temporal quantum correlations using continuous variable systems like nanomechanical oscillators and applications in quantum information processing.

Project End Date: **30-APR-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694340	**srEDM**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. HANS STROEHER**
Host Institution: Forschungszentrum Julich Gmbh, DE

Search for electric dipole moments using storage rings

One of the great mysteries in the natural sciences is the dominance of matter over antimatter in the universe. According to our present understanding, the early universe contained the same amount of matter and antimatter. If the universe had behaved symmetrically as it developed, every particle would have been annihilated by one of its antiparticles. We therefore
owe our very existence to mechanisms that have led to a world where something that we call matter remains. We propose to study such mechanisms by searching for electric dipole moments (EDMs) of charged hadrons in a new class of precision storage rings. Our project will lay the foundations for a new European flagship research infrastructure. The breaking of the combined charge conjugation and parity symmetries (CP-violation) in the Standard Model is not strong enough to explain the observed excess of matter and further sources of CP-violation must be sought. These sources could manifest themselves in Electric Dipole Moments of elementary particles, which occur when the centroids of positive and negative charges are mutually and permanently displaced. The observation of an electric dipole moment will elucidate the mechanisms which led to the matter that dominates the universe. Although the measurement principle, the time development of the polarization vector subject to a perpendicular electric field, is simple, the smallness of the effect makes this an enormously challenging project. This can only be mastered through the common effort of an international team of accelerator and particle physicists, working closely with engineers. The proponents of this design study and the research environment at the Forschungszentrum Jülich (Germany), including the conventional storage ring COSY, provide the optimal basis for one of the most spectacular possibilities in modern science: finding an EDM as a signal for new physics beyond the Standard Model and perhaps explaining the puzzle of our existence.

Project End Date: **30-SEP-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695088	**InPairs**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. LUIS SILVA**
Host Institution: Instituto Superior Tecnico, PT

In Silico Pair Plasmas: from ultra intense lasers to relativistic astrophysics in the laboratory

How do extreme electromagnetic fields modify the dynamics of matter? Will quantum electrodynamics effects be important at the focus of an ultra intense laser? How are the magnetospheres of compact stellar remnants formed, and can we capture the physics of these environments in the laboratory? These are all longstanding questions with an overarching connection to extreme plasma physics.

Electron-positron pair plasmas are pervasive in all these scenarios. Highly nonlinear phenomena such as QED processes, magnetogenesis, radiation, field dynamics in complex geometries, and particle acceleration, are all linked with the collective dynamics of pair plasmas through mechanisms that remain poorly understood.

Building on our state-of-the-art models, on the availability of enormous computational power, and on our recent transformative discoveries on ab initio modelling of plasmas under extreme conditions, the time is ripe to answer these questions in silico. InPairs aims to understand the multidimensional dynamics of electron-positron plasmas under extreme laboratory and astrophysical fields, to determine the signatures of the radiative processes on pair plasmas, and to identify the physics of the magnetospheres of compact stellar remnants, focusing on the electrodynamics of pulsars, that can be mimicked in laboratory experiments using ultra high intensity lasers and charged particle beams.

This proposal relies on massively parallel simulations to bridge the gap, for the first time, between the pair plasma creation mechanisms, the collective multidimensional microphysics, and their global dynamics in complex geometries associated with laboratory and astrophysical systems. Emphasis will be given to detectable signatures e.g. radiation and accelerated particles, with the ultimate goal of solving some of the central questions in extreme plasma physics, thus opening new connections between computational studies, laboratory experiments, and relativistic plasma astrophysics.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
		PE2 Fundamental Constituents of Matter
695405	**Dark-OsT**	

Principal Investigator: **Dr. DMITRY BUDKER**
Host Institution: Johannes Gutenberg-Universitat Mainz, DE

Experimental Searches for Oscillating and Transient effects from the Dark Sector

The objective of the proposed project is to pioneer a magnetometry-based experimental framework for the detection of time-varying signatures of the 'dark sector'. This novel approach will enable systematic searches for particles contributing to the dark matter and for dark-energy components.

The nature of dark matter and that of dark energy are among the central open problems in modern physics. There are only few experimental bounds and so far no conclusive observations of dark-sector particles or fields. Experiments enabling a direct coupling to the dark sector and thus a systematic search for and study of the contributing particles and fields would open up new vistas for areas ranging from particle physics to astrophysics and cosmology, and would in particular provide insights into the physics beyond the Standard Model.

Here, we propose a framework for such experimental searches based on high-precision magnetometers, and networks thereof. Our approach is distinct from existing efforts in two ways. First, it will enable searches for so-far unexplored couplings to ultra-light bosonic particles present in the Universe that could be components of dark matter and/or dark energy, in particular axions and axion-like particles (ALPs). Second, we will develop and use devices and methods tailored to search for oscillating and transient, rather than time-independent, effects. Specifically, we will use nuclear magnetic resonance (NMR) techniques for detecting spin precession caused by background axion and ALP dark matter, and geographically separated magnetometers for identify transient effects, such as crossing domain walls of ALP fields, which have been proposed as a possible dark-energy component.

The devices and methods developed in the framework of this project will provide the essential components for unique searches for a broad class of dark-matter and dark-energy candidates and might enable the key experiments to understanding the dark sector.

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

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:
714626	**BinGraSp**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. SEBASTIANO BERNUZZI**
Host Institution: Friedrich-Schiller-Universitat Jena, DE

Modeling the Gravitational Spectrum of Neutron Star Binaries

The most energetic electromagnetic phenomena in the Universe are believed to be powered by the collision of two neutron stars, the smallest and densest stars on which surface gravity is about 2 billion times stronger than gravity on Earth. However, a definitive identification of neutron star mergers as central engines for short-gamma-ray bursts and kilonovae transients is possible only by direct gravitational-wave observations. The latter provide us with unique information on neutron stars' masses, radii, and spins, including the possibility to set the strongest observational constraints on the unknown equation-of-state of matter at supranuclear densities.

Neutron stars binary mergers are among the main targets for ground-based gravitational-wave interferometers like Advanced LIGO and Virgo, which start operations this year. The astrophysical data analysis of the signals emitted by these sources requires the availability of accurate waveform models, which are missing to date. Hence, the theoretical understanding of the gravitational spectrum is a necessary and urgent step for the development of a gravitational-based astrophysics in the next years.

This project aims at developing, for the first time, a precise theoretical model for the complete gravitational spectrum of neutron star binaries, including the merger and postmerger stages of the coalescence process. Building on the PI's unique expertise and track record, the proposed research exploits synergy between analytical and numerical methods in General Relativity. Results from state of the art nonlinear 3D numerical relativity simulations will be combined with the most advanced analytical framework for the relativistic two-body problem. The model developed here will be used in the first gravitational-wave observations and will dramatically impact multimessenger astrophysics.

Project End Date: **30-SEP-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:
716651	**NEDM**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. GUILLAUME PIGNOL**
Host Institution: Universite Grenoble Alpes, FR

The Neutron Electric Dipole Moment: pushing the precision to understand the matter-antimatter asymmetry

The existence of a permanent electric dipole moment (EDM) of the neutron, or any subatomic particle, would have far reaching implications connecting particle physics with cosmology. Time reversal invariance and CP symmetry would be violated. A new fundamental interaction producing the EDM, that is, deforming the charge distribution inside the neutron, could also have generated the matter-antimatter asymmetry in the early Universe. After 60 years of evolution, techniques to measure the neutron EDM are now so evolved that experiments are sensitive to microphysics associated with an energy scale beyond that accessible at the LHC. This situation offers a high likelihood of discovery for the next generation of experiments. In the same time, any improvement in precision is technically challenging. The control of the magnetic field must surpass that of the state of the art of atomic magnetometers. The n2EDM project aims at improving the precision by an order of magnitude or more. Systematic effects need to be controlled at an unprecedented level. In particular, the use of a mercury co-magnetometer based on the precession of 199Hg spins induces a set of subtle false effects due to the relativistic motional field.

I propose to initiate a comprehensive program to master these systematic effects beyond the current research program. In particular, the proposed project includes a precise determination of the 199Hg magnetic moment with a precision of 0.1 ppm. To this end, I will attempt a novel approach: combining mercury and 4He magnetometry in the same cell. As a by-product, this will also produce an improved determination of the neutron magnetic moment, a quantity of interest for metrology. The cross-check I propose will prove that all disturbances on the neutron or mercury spins are mastered at the sub-ppm level, a decisive step in the quest for the neutron EDM.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716950	**XSTREAM**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. TENIO POPMINTCHEV**
Host Institution: Technische Universitaet Wien, AT

X-ray-waveforms at the Space-Time Resolution Extreme for Atomic-scale Movies

Nonlinear optics revolutionized the ability to create directed, coherent beams particularly in spectral regions where lasers based on conventional population inversion are not practical. New breakthroughs in extreme nonlinear optics promise a similar revolution in the X-ray regime. In a dramatic and unanticipated breakthrough, an international team lead by the PI demonstrated that the high harmonic generation process (HHG) driven by mid-IR lasers can be used to generate keV photons, implementing a >5000 order nonlinear process, while still maintaining the full phase matching that is necessary for good conversion efficiency. This work represents the most extreme, fully coherent upconversion for electromagnetic waves in the 50 year history of nonlinear optics. Moreover, the limits of HHG are still not understood, either theoretically or experimentally. It may be possible to generate coherent hard X-rays using a tabletop-scale apparatus.

In another surprising breakthrough, the PI showed that UV-driven HHG in multiply ionized plasma can be also highly efficient, representing a 2nd route towards the X-ray region. Remarkably, this regime provides X-rays with contrasting spectral and temporal properties. Furthermore, by shaping the polarization of a bi-color mid-IR driving laser the PI, the JILA team in collaboration with Technion, demonstrated robust phase matching of circularly polarized soft X-rays.

In the proposed work, the fundamental atomic, phase matching plus group velocity matching limits of HHG in the multi-keV X-ray regime will be explored using the 3 most promising, complimentary approaches: 1) mid-IR driven HHG, 2) UV driven HHG, and 3) all-optical quasi phase matching. The knowledge gained as a result of this effort will identify the best path forward for generating bright coherent X-ray beams on a tabletop, at photon energies of 1-10 keV and greater with unprecedented attosecond-to-zeptosecond pulse durations, and arbitrary polarization state.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724208	**STRUGGLE**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. ALEKSANDRA WALCZAK**
Host Institution: Centre National De La Recherche Scientifique Cnrs, FR

Statistical physics of immune-viral co-evolution

The immune system within each individual host destroys viruses, which manage to escape immunity on the global scale. Recent experiments show population-level responses of both immune repertoires and viruses, and a history dependence of their functional phenotypes. This constrained long-term co-evolution of immune receptor and viral populations is a stochastic many-body problem occurring at many scales, in which the response emerges based on the past states of both the repertoire and viral populations. STRUGGLE infers the details of viral-immune receptor interactions from functional datasets to obtain a predictive statistical model of co-evolution between immune repertoires and viruses.

STRUGGLE covers the many scales of immune-virus interactions: from the molecular level, analyzing high-throughput mutational screens of libraries of antibodies binding a given antigen, through the population-level response of immune repertoires, analyzing next-generation sequencing of vaccine-stimulated whole repertoires, to the population level, modeling the long term co-evolution of both repertoires and viruses.

STRUGGLE combines a statistical data analysis approach with cross-scale many-body physics to:
- build a molecular model for antigen-receptor binding;
- learn statistical models for repertoire-level response to viral antigen stimulation;
- validate dynamical models of interactions between antigen and immune receptors;
- theoretically evaluate the predictive power of the immune system and viruses;
- and predict virus strains and immune responses based on past infections.

The outcomes of STRUGGLE include the quantitative characterization of the human T-cell response to flu vaccines, with implications for vaccination strategies, and the trout B-cell response to life-threatening rhabdoviruses, which aids vaccine design for fish, with wide use in agriculture. The statistical properties of the co-evolutionary process are needed for informed development of immunotherapies.

Project End Date: **31-OCT-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:
725366	**QuPoPCoRN**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. CHRISTINE SILBERHORN**
Host Institution: Universitaet Paderborn, DE

Quantum Particles on Programmable Complex Reconfigurable Networks

Understanding the complex interactions and dynamics of multiple quantum particles within large networks is an extremely challenging task, but doing so reveals the underlying structure of an enormously diverse range of phenomena. Therefore, a reliable platform to investigate complex quantum network dynamics, which incorporates the rich interplay between noise, coherence and nonclassical correlations, will be an extremely powerful tool.

Classical optical networks have been widely used to simulate a broad range of propagation phenomena across many disparate areas of physics, chemistry and biology, based on coherent interference of waves. At the quantum level, the quantized nature of light – the existence of photons – gives rise to bosonic interference effects that are completely counter-intuitive. Yet, to date, quantum network experiments remain very limited in terms of the number of photons, reconfigurability and, most importantly, network size.

Here, we propose time-multiplexed optical networks, in combination with tailored multi-photon states as a new platform for large-scale quantum networks. Our approach allows us to emulate multi-particle dynamics on complex structures, specifically the role of bosonic interference, correlations and entanglement.

To achieve large networks sizes, we will develop novel decoherence mitigation strategies: programmable noise, topologically protected quantum states and perpetual entanglement distillation. This approach will blend ideas from solid state physics, random media and quantum information and communication in order to pursue the following three objectives:
1. Demonstrate noise-assisted entanglement distribution
2. Demonstrate nonclassical states on topological structures
3. Demonstrate perpetual distillation of entanglement within a network

These objectives target the overall goal to understand the role of multi-particle quantum physics in complex, large-scale structures harnessing time-multiplexed photonic networks.

Project End Date: **30-JUN-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: Npl Management Limited, UK

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:
758027	**PrecisionNuclei**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. ANDREAS EKSTRÖM**
Host Institution: Chalmers Tekniska Hoegskola Ab, SE

Strong interactions for precision nuclear physics

Nuclear physics is a cornerstone in our scientific endeavour to understand the universe. Indeed, atomic nuclei bring us closer to study both the stellar explosions in the macrocosmos, where the elements are formed, and the fundamental symmetries of the microcosmos. Having access to a precise description of the interactions between protons and neutrons would provide a key to new knowledge across 20 orders of magnitude; from neutrinos to neutron stars. Despite a century of the finest efforts, a systematic description of strongly interacting matter at low energies is still lacking. Successful theoretical approaches, such as mean-field and shell models, rely on uncontrolled approximations that severely limit their predictive power in regions where the model has not been adjusted. In this project I will develop a novel methodology to use experimental information from heavy atomic nuclei in the construction of nuclear interactions from chiral effective field theory. I expect this approach to enable me and my team to make precise ab initio predictions of various nuclear observables in a wide mass-range from hydrogen to lead as well as infinite nuclear matter. I will apply Bayesian regression and methods from machine learning to quantify the statistical and systematic uncertainties of the theoretical predictions. The novelty and challenge in this project lies in synthesising (i) the design of nuclear interactions, (ii) ab initio calculations of nuclei, and (iii) statistical inference in the confrontation between theory and experimental data. This alignment of methods, harboured within the same project, will create a clear scientific advantage and allow me to tackle the following big research questions: How can atomic nuclei be described in chiral effective field theories of quantum chromo dynamics? What is the probability for neutrinoless double-beta decay in atomic nuclei? What are the nuclear uncertainties in muonic atoms relevant for the proton radius puzzle?

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758329	**AGEnTh**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. MARCELLO DALMONTE**
Host Institution: Scuola Internazionale Superiore Di Studi Avanzati Di Trieste, IT

Atomic Gauge and Entanglement Theories

AGEnTh is an interdisciplinary proposal which aims at theoretically investigating atomic many-body systems (cold atoms and trapped ions) in close connection to concepts from quantum information, condensed matter, and high energy physics. The main goals of this programme are to:

I) find to scalable schemes for the measurements of entanglement properties, and in particular entanglement spectra, by proposing a shifting paradigm to access entanglement focused on entanglement Hamiltonians and field theories instead of probing density matrices;

II) show how atomic gauge theories (including dynamical gauge fields) are ideal candidates for the realization of long-sought, highly-entangled states of matter, in particular topological superconductors supporting parafermion edge modes, and novel classes of quantum spin liquids emerging from clustering;

III) develop new implementation strategies for the realization of gauge symmetries of paramount importance, such as discrete and SU(N)xSU(2)xU(1) groups, and establish a theoretical framework for the understanding of atomic physics experiments within the light-from-chaos scenario pioneered in particle physics.

These objectives are at the cutting-edge of fundamental science, and represent a coherent effort aimed at underpinning unprecedented regimes of strongly interacting quantum matter by addressing the basic aspects of probing, many-body physics, and implementations. The results are expected to (i) build up and establish qualitatively new synergies between the aforementioned communities, and (ii) stimulate an intense theoretical and experimental activity focused on both entanglement and atomic gauge theories.

In order to achieve those, AGEnTh builds: (1) on my background working at the interface between atomic physics and quantum optics from one side, and many-body theory on the other, and (2) on exploratory studies which I carried out to mitigate the conceptual risks associated with its high-risk/high-gain goals.

Project End Date: **30-APR-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: Universitat 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:
758794	**Q-ROOT**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. PIERRE VERLOT**
Host Institution: The University Of Nottingham, UK

Quantum optomechanics at ROOm Temperature

5 years ago, the field of optomechanics has entered the quantum regime. By doing so, this domain which investigates the reciprocal interactions between light and mechanical motion has overcome the long-standing paradox of Quantum Mechanical effects at the macroscopic scale. Such outstanding achievement relies on the so-called “cavity nano-optomechanical” technology, which combines strongly reduced dimensions with ultra-high optical confinement, enabling very large optomechanical coupling rates at the nanoscale.

In a more fundamental perspective, decreasing the size of optomechanical systems has enabled minimizing the detrimental effects of decoherence, resulting in a quasi-instantaneous collapse of quantum coherence at a macroscopic scale. At present, optomechanical systems seem to have reached their limits at cryogenic temperatures and remain overly sensitive to decoherence at room temperature to display any quantum behaviour.

The project Q-ROOT proposes a novel cavity optomechanical approach showing such unprecedentedly large coupling rates that it will operate in the quantum regime at room temperature for the first time. Our concept relies on tethering a low-loss nano-optical scatterer at the edge of the lightest possible mechanical device that is a carbon nanotube resonator. This system is expected to outperform the state-of-the-art (including atom–based systems) by orders of magnitude, even at room temperature. Amongst objectives, Q-ROOT notably plans to demonstrate ground-state cooling, strong ponderomotive squeezing, the standard quantum limit, quantum non-demolition of mechanical Fock states, and optomechanical photon blockade at room temperature. Besides very fundamental impact, the unique sensing abilities of the system developed in Q-ROOT will be further utilized in order to perform quantum limited sensing applications at room temperature, paving a generalized use of optomechanics for quantum sensing and information technology at room temperature.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772369	**mPP**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. MAURIZIO PIERINI**
Host Institution: European Organization For Nuclear Research, CH

machine learning for Particle Physics

This project proposes to use modern Machine Learning (ML), particularly Deep Learning (DL), as a breakthrough solution to address the scientific, technological, and financial challenges that High Energy Physics (HEP) will face in the decade ahead. The quest for new physics is increasing the complexity of the experiments and, consequently, the human and financial costs to operate these detectors, with experiments facing at best flat budgets. ML offers a way out of this impasse. With the development of DL, ML has successfully addressed tasks such as image reCoGnition and text understanding, which eventually opened the way to automatizing complex tasks. These progresses have the potential to revolutionize HEP experimental techniques. We propose to apply cutting-edge ML technologies to HEP problems, paving the way to self-operating detectors, capable of visually inspecting events and identifying the physics process generating them, while monitoring the goodness of the data, the correct functioning of the detector components and, if any, the occurrence of anomalous events caused by unspecified new physics processes. We structure the work in a set of working packages, representing intermediate steps towards this final goal. We propose to apply ML to data taking, event identification, data-taking monitoring, and event reconstruction as intermediate steps toward using these techniques for unsupervised physics searches. The project resources will by used to create a team of computer scientists, who will carry on a systematic R&D program to apply cutting-edge ML technology to HEP: reinforced learning, generative models, event indexing, data mining, anomaly and outliers detection, etc. Being hosted at CERN, the project will benefit from existing computing infrastructures, large datasets availability, the presence of local experts of each aspect of HEP, and established collaborations with private companies on hardware and software R&D.

Project End Date: **31-MAR-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:
786851	**FLEET**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. NIKOLAY ZHELUDEV**
Host Institution: University Of Southampton, UK

Flying Electromagnetic Toroids

In this project I will study the generation, detection, and interaction with matter of Flying Toroids, a new type of light pulses never experimentally studied before. This represents an exciting opportunity to advance optics and electromagnetism in a radically new direction since Hertz, Marconi, Popov and Tesla developed technology for generating, detecting, and communicating with transverse electromagnetic waves.

Conventional transverse electromagnetic waves propagate in free-space with the electric and magnetic field vectors perpendicular to the wave propagation direction, forming the famous triad. Theoretical analysis of recent years has shown that another, very different type of waves exists, which propagate at the speed of light, but only occur as short bursts of electromagnetic energy in the form of Flying Toroids. Flying Toroids are inseparable solutions of Maxwell equations with a unique, doughnut-like configuration of the electric and magnetic fields. Flying Toroids interact with matter in unique ways, drastically different from that of conventional electromagnetic pulses.

In a broader context, the electrodynamics of Flying Toroids is an exciting emerging field of optical science linked to intriguing recent developments in physics such as toroidal dipoles and anapoles, and, due to their topology, to Majorana fermions and skyrmions.

Building on my recent proof-of-principle demonstration of Flying Toroid generation through conversion of few-cycle conventional transverse light pulses in artificial photonic nanostructures, my goal for this project is to experimentally study and understand the fundamental properties of Flying Toroids and their interaction with matter at optical frequencies, and to assess their potential for developing new technologies. In my vision this project can lead to spectacular new opportunities for spectroscopic and light-enabled applications, and will impact on other branches of science, from astronomy to solid-state physics.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787539	**GENESIS**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. JULIEN FUCHS**
Host Institution: Centre National De La Recherche Scientifique Cnrs, FR

GEnerating extreme NEutrons for achieving controlled r-process nucleosyntheSIS

The project aim is to perform the first direct measurements of neutron capture and beta-decay rates related to the “r-process” of nucleosynthesis. This process, based on squeezing at once multiple neutrons in a nucleus, is presently thought to be the main mechanism that forms the heaviest elements in our Solar System and in stars.

At present, there are large discrepancies between the observed element abundances in stars and those found from simulations. It is speculated that this problem stems from the uncertainties in nuclear parameters, particularly in the plasma environment. These nuclear parameters have not been experimentally verified due to the too-low flux of current neutron facilities and the lack of means to create on-site hot and dense plasmas.

Lasers are not the first thing that comes to mind as a neutron source, but with the upcoming ultra high-power laser facilities (Apollon in 2018 and ELI-NP in 2019), high-density and high-energy protons can be generated. Through spallation, these can then produce neutrons with the needed flux, a flux comparable to that found in Supernovae. To further emulate the astrophysical scenario, auxiliary lasers can be used to turn the target material into a plasma.

In practice, this project will aim to measure neutron capture and beta-decay rates, as well as yields and abundances of the products of nucleosynthesis obtained by exposing heavy-ion targets to laser-produced extreme neutron fluxes. These targets will be either in a plasma or a solid state. In plasmas, we will investigate the effect of excited nuclear states, created by the plasma photons and electrons, on neutron capture. In solid targets, we will take advantage of the unique possibility of generating on-site unstable nuclei, and then re-expose them to the neutron beam in order to measure double neutron capture.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
789339	**Topo Ins Laser**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. MORDECHAI SEGEV**
Host Institution: Technion - Israel Institute Of Technology, IL

Topological Insulator Laser

Triggered by condensed matter, a new frontier recently emerged: Photonic Topological Insulators (PTIs). These are photonic structures where the transport of light is topologically protected: light propagates in a unidirectional manner without reflection, even in the presence of corners, defects, or disorder. The first step toward PTIs was the electromagnetic analogue of the quantum Hall effect, employing magnetic fields in gyrooptic media. Bringing the concepts of topological insulators into photonics required fundamentally different effects, eluding researchers until in 2013 we demonstrated the first PTI. That, along with experiments in silicon photonics and pioneering theory work, launched the field of Topological Photonics.

This proposal aims to explore the possibility of the “next big thing”, a fundamentally new concept, never suggested before in any context, with high potential impact on fundamentals and on lasers technology: we will explore the idea of the Topological Insulator Laser.

Topological Insulator Lasers are lasers where the lasing mode is topologically protected: light propagates around the cavity unaffected by disorder and defects. Based on our preliminary studies, we envision that by lasing in a topological mode, the interplay between the topology and gain will lead to a highly efficient laser, robust to defects and disorder, that lases in a single mode even at high gain values.

The road to achieve this goes against current knowledge: topological insulators are linear Hermitian closed systems, whereas the topological insulator laser is a non-Hermitian, highly nonlinear, open system.

Our study will be theoretical and experimental, starting at the fundamentals of topological transport in systems with gain, and we will take it all the way to experimentally demonstrate the concepts in several different platforms.

The idea of the Topological Insulator Laser is unique: success will mark a new milestone in optics and topological physics.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802701	**ANYON**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. CHRISTOF WEITENBERG**
Host Institution: Universitaet Hamburg, DE

Engineering and exploring anyonic quantum gases

This project enters the experimental investigation of anyonic quantum gases. We will study anyons – conjectured particles with a statistical exchange phase anywhere between 0 and π – in different many-body systems. This progress will be enabled by a unique approach of bringing together artificial gauge fields and quantum gas microscopes for ultracold atoms.

Specifically, we will implement the 1D anyon Hubbard model via a lattice shaking protocol that imprints density-dependent Peierls phases. By engineering the statistical exchange phase, we can continuously tune between bosons and fermions and explore a statistically-induced quantum phase transition. We will monitor the continuous fermionization via the build-up of Friedel oscillations. Using state-of-the-art cold atom technology, we will thus open the physics of anyons to experimental research and address open questions related to their fractional exclusion statistics.

Secondly, we will create fractional quantum Hall systems in rapidly rotating microtraps. Using the quantum gas microscope, we will i) control the optical potentials at a level which allows approaching the centrifugal limit and ii) use small atom numbers equal to the inserted angular momentum quantum number. The strongly-correlated ground states such as the Laughlin state can be identified via their characteristic density correlations. Of particular interest are the quasihole excitations, whose predicted anyonic exchange statistics have not been directly observed to date. We will probe and test their statistics via the characteristic counting sequence in the excitation spectrum. Furthermore, we will test ideas to transfer anyonic properties of the excitations to a second tracer species. This approach will enable us to both probe the fractional exclusion statistics of the excitations and to create a 2D anyonic quantum gas.

In the long run, these techniques open a path to also study non-Abelian anyons with ultracold atoms.

Project End Date: **31-DEC-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:
802836	**AxScale**	**PE2** Fundamental Constituents of Matter

Principal Investigator: **Dr. BABETTE DOBRICH**
Host Institution: European Organization For Nuclear Research, CH

Axions and relatives across different mass scales

Pseudoscalar QCD axions and axion-like Particles (ALPs) are an excellent candidate for Dark Matter or can act as a mediator particle for Dark Matter. Since the discovery of the Higgs boson, we know that fundamental scalars exist and it is timely to explore the Axion/ALP parameter space more intensively. A look at the allowed axion/ALP parameter space makes it clear that these might exist at low mass (below few eV), as (part of) Dark Matter. Alternatively they might exist at higher mass, above roughly the MeV scale, potentially as a Dark Matter mediator particle. AxScale explores parts of these different mass regions, with complementary techniques but with one research team.

Firstly, with RADES, it develops a novel concept for a filter-like cavity for the search of QCD axion Dark matter at a few tens of a micro-eV. Dark Matter Axions can be discovered by their resonant conversion in that cavity embedded in a strong magnetic field. The `classical axion window' has recently received much interest from cosmological model-building and I will implement a novel cavity concept that will allow to explore this Dark Matter parameter region.

Secondly, AxScale searches for axions and ALPs using the NA62 detector at CERN's SPS. Especially the mass region above a few MeV can be efficiently searched by the use of a proton fixed-target facility. During nominal data taking NA62 investigates a Kaon beam. NA62 can also run in a mode in which its primary proton beam is fully dumped. With the resulting high interaction rate, the existence of weakly coupled particles can be efficiently probed. Thus, searches for ALPs from Kaon decays as well as from production in dumped protons with NA62 are foreseen in AxScale. More generally, NA62 can look for a plethora of `Dark Sector' particles with recorded and future data. With the AxScale program I aim at maximizing the reach of NA62 for these new physics models.

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:
832848	**FunI**	**PE2** Fundamental Constituents of Matter

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

Revealing Fundamental Interactions and their Symmetries at the highest Precision and the lowest Energies

The four fundamental interactions and their symmetries, the fundamental constants as well as the properties of elementary particles like masses and moments, determine the basic structure of the universe and are the basis for our so well tested Standard Model (SM) of physics. Performing stringent tests on these interactions and symmetries in extreme conditions at lowest energies and with highest precision by comparing e.g. the properties of particles and their counterpart, the antiparticles, will allow us to search for physics beyond the SM. Any improvement of these tests beyond their present limits will require novel experimental techniques. To this end, we propose ambitious Penning-trap based single-ion experiments and measurements of magnetic moments and atomic masses to substantially improve the to-date best limits on some of the key SM predictions. While the measurement technique in determining the eigenfrequencies of the stored particles with unprecedented precision will be identical to the technique used in the past ERC grant by the PI (MEFUCO - MEasurements of FUndamental COnstants), the novel ion preparation and cooling techniques to be developed as well as the physics questions to be addressed are completely different. The new findings will enable us to perform stringent tests of fundamental symmetries like charge-parity-time reversal symmetry (CPT theorem) with (anti)protons or of the energy-mass equivalence principle as well as tests of interactions like quantum electrodynamics in strong fields by using highly charged ions. This will enable us to set new limits on SM predictions or even to reveal their failures. To meet these challenges, advanced charge breeding and cooling techniques will make it possible for us to achieve among other advances a ten-fold improved test of E = mc2, and thus of Einstein's special theory of relativity and the most stringent CPT test in the baryonic sector by comparing the magnetic moments of the proton and the antiproton.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677488	**INCEPT**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. DANIELE FAUSTI**
Host Institution: Universita Degli Studi Di Trieste, IT

INhomogenieties and fluctuations in quantum CohErent matter Phases by ultrafast optical Tomography

Standard time domain experiments measure the time evolution of the reflected/transmitted mean number of photons in the probe pulses. The evolution of the response of a material is typically averaged over the illuminated area as well as over many pump and probe measurements repeated stroboscopically. The aim of this project is to extend time domain optical spectroscopy beyond mean photon number measurements by performing a full Time Resolved Quantum State Reconstruction (TRQSR) of the probe pulses as a function of the pump and probe delay. The nature of the light matter interaction and the transient light-induced states of matter will be imprinted into the probe quantum state after the interaction with the material and can be uncovered with unprecedented detail with this new approach to time domain studies.

TRQSR will be implemented by combining pump and probe experiments resolving single light pulses with balanced homodyne detection quantum tomography in the pulsed regime. We will apply and exploit the unique capabilities of TRQSR to address two different unresolved problems in condensed matter. Firstly, we will investigate the coherent and squeezed nature of low energy photo-induced vibrational states. We will use TRQSR with probe pulses shorter than the phonon timescale to interrogate the time evolution of the vibrational state induced by the pump pulse. Secondly, we will address inhomogeneities in photo-induced phase transformations. With TRQSR we can perform time domain measurements with a very small photon number per pulse which will give information on the interaction between the material (as prepared by the pump pulse) and individual photons. In this limit, TRQSR will allow us to retrieve rich statistics. While the average will deliver the information of a standard pump and probe experiment, higher order moments will give information on the time evolution of spatial inhomogenieties in the transient state.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677532	**MicMactin**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. MARTIN LENZ**
Host Institution: Centre National De La Recherche Scientifique Cnrs, FR

Dissecting active matter: Microscopic origins of macroscopic actomyosin activity

Biological motion and forces originate from mechanically active proteins operating at the nanometer scale. These individual active elements interact through the surrounding cellular medium, collectively generating structures spanning tens of micrometers whose mechanical properties are perfectly tuned to their fundamentally out-of-equilibrium biological function. While both individual proteins and the resulting cellular behaviors are well characterized, understanding the relationship between these two scales remains a major challenge in both physics and cell biology.

We will bridge this gap through multiscale models of the emergence of active material properties in the experimentally well-characterized actin cytoskeleton. We will thus investigate unexplored, strongly interacting nonequilibrium regimes. We will develop a complete framework for cytoskeletal activity by separately studying all three fundamental processes driving it out of equilibrium: actin filament assembly and disassembly, force exertion by branched actin networks, and the action of molecular motors. We will then recombine these approaches into a unified understanding of complex cell motility processes.

To tackle the cytoskeleton's disordered geometry and many-body interactions, we will design new nonequilibrium self consistent methods in statistical mechanics and elasticity theory. Our findings will be validated through simulations and close experimental collaborations.

Our work will break new ground in both biology and physics. In the context of biology, it will establish a new framework to understand how the cell controls its achitecture and mechanics through biochemical regulation. On the physics side, it will set up new paradigms for the emergence of original out-of-equilibrium collective behaviors in an experimentally well-characterized system, addressing the foundations of existing macroscopic "active matter" approaches.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679722	**QUANTMATT**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. JENS H BARDARSON**
Host Institution: Kungliga Tekniska Hoegskolan, SE

Dynamics and transport of quantum matter --- exploring the interplay of topology, interactions and localization

Quantum matter is condensed matter which properties are dominated by the quantum nature of its constituents. The two most fundamental properties of quantum mechanics are interference and entanglement. How do these properties, and their derivatives, show up in an experiment? And how does one control them? These are the fundamental questions addressed in this proposal.

The study is divided into three main parts: many-body localization, topological insulator nanowires, and topological semimetals. Many-body localization is concerned with the interplay of interference and entanglement and is central to questions about quantum thermalization. I aim to understand experimental signatures of many-body localization as well as devising simulation schemes that allow us to conduct numerical experiments on many-body localization for larger system sizes than has been so far possible. The interplay of interference, topology and geometry is the central theme of the topic of topological insulator nanowires. I have in the past theoretically demonstrated the signatures of fundamental quantum phenomena in these systems, including perfectly transmitted mode and Majorana fermions. The major goal of this part of the project is to collaborate closely with experimental groups seeking to verify my past theories, by providing new and more detailed predictions for these systems. This requires to further understand experimental details, develop certain theoretical devices and simulation techniques based on them. The final part on topological semimetals is particularly timely in view of recent experimental realizations of Dirac semimetals and the impending realization of Weyl semimetals, which both can be roughly thought of as 3D analogs of graphene. I seek to understand their unique transport signatures and the interplay of disorder with 3D Dirac fermions. The three parts feed into and from each other both through unified concepts and common methodology.

Project End Date: **31-DEC-20**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681405	**Dynasore**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. SAMIR LOUNIS**
Host Institution: Forschungszentrum Julich Gmbh, DE

Dynamical magnetic excitations with spin-orbit interaction in realistic nanostructures

Nano-spin-orbitronics is an emerging and fast growing field that aims at combining three degrees of freedom − spin, charge and spin-orbit interaction − to explore new nanotechnologies stemming from fundamental physics. New magnetic phases of matter are investigated using, in particular, atomic design to tailor beneficial physical properties down to the atomic level. Storage, transport and manipulation of magnetic information within a small set of atoms does not only require a fundamental understanding of their ground-state properties from the perspective of quantum mechanics, but crucially also their dynamical excited states. We propose to go beyond the state of the art by investigating from first-principles the dynamical properties of chiral spin textures in nanostructures from 2-dimensions to 0-dimension with these nanostructures being deposited on different substrates where spin-orbit interaction plays a major role. Understanding their response to external dynamical fields (electric/magnetic) or currents will impact on the burgeoning field of nano-spin-orbitronics. Indeed, to achieve efficient manipulation of nano-sized functional spin textures, it is imperative to exploit and understand their resonant motion, analogous to the role of ferromagnetic resonance in spintronics. A magnetic skyrmion is an example of a spin-swirling texture characterized by a topological number that will be explored. This spin state has huge potential in nanotechnologies thanks to the low spin currents needed to manipulate it. Based on time-dependent density functional theory and many-body perturbation theory, our innovative scheme will deliver a paradigm shift with respect to existing theoretical methodologies and will provide a fundamental understanding of: (i) the occurrence of chiral spin textures in reduced dimensions, (ii) their dynamical spin-excitation spectra and the coupling of the different excitation degrees of freedom and (iii) their impact on the electronic structure.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682237	**EvoStruc**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. ROSALIND ALLEN**
Host Institution: The University Of Edinburgh, UK

The physics of antibiotic resistance evolution in spatially-structured multicellular assemblies

The rise in bacterial infections that are resistant to antibiotic treatment poses a major global health challenge. Addressing this challenge is not just a clinical issue: understanding bacterial resistance evolution calls for an interdisciplinary approach, in which the development of new physics, in coordination with biology, chemistry and engineering, has a central role to play. In particular, statistical physics, to predict the stochastic emergence of drug-resistant mutants, must be integrated with soft matter and chemical physics, to understand the spatial organization of the bacterial populations within which this happens.

Bacterial infections are very often spatially heterogeneous. This is known to influence the outcome of antibiotic treatment – for example bacterial biofilms, which form on the surfaces of medical implants, are notoriously hard to remove. However, much less attention has been paid to the role of spatial structure in the evolution of drug resistance, i.e. the emergence and spread of genetically drug-resistant bacterial strains.

I will lead a research programme which will for the first time uncover the two-way link between the emergence of spatial structure in bacterial multicellular assemblies and the evolution of drug resistance. The programme builds on my current theoretical, simulation and experimental work. I will first determine the basic principles of evolution in drug gradients using theoretical models, combined with experiments in a controlled, 1D geometry. I will then explore how these principles translate to the more realistic scenario of bacterial biofilms, where spatial structure and drug gradients are emergent properties, using advanced computer simulation methods and both confocal microscopy and evolution experiments. In the final part of the programme, I will use these insights to reveal optimization principles for the design of evolution-resistant surface coatings for applications in medical devices.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682782	**SOFTBREAK**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. JASPER VAN DER GUCHT**
Host Institution: Wageningen Universiteit, NL

From bond breaking to material failure in soft polymer networks

The microscopic mechanisms that lead to mechanical failure of soft polymer materials are still poorly understood. The main reason for this is a lack of experimental tools to prepare well-controlled model systems and to observe the failure process in real time at the microscopic scale. Here, I propose to fill this gap by taking a multidisciplinary approach that combines innovative chemical tools with state-of-the art physical experiments and modelling. Previous work in my group has led to the development of polymer networks with extremely well-controlled architecture and bond strength, and of various tools to study their structure and mechanics. Here, I will take advantage of this expertise to systematically unravel the microscopic physics of failure of polymer networks.

To visualize how the failure process proceeds, we will make use of recently developed mechanosensors, molecules that change colour in response to a force or that emit light when they break. These chemical tools will allow us to map in real time the spatial distribution of both strains and bond rupture events. Together with computer simulations carried out in parallel, this will give us unprecedented insight in the microscopic processes that occur during failure of the material, from the very first bonds that rupture, to the gradual accumulation of damage, all the way to macroscopic failure. We will use this to address the following unresolved questions about failure of polymer networks:

1. What is the microscopic mechanism that leads to delayed failure of polymer networks at subcritical loads?
2. How does the initiation of failure depend on the material's heterogeneity?
3. How does failure occur in a network with transient (viscoelastic) bonds?

The project will not only provide detailed insight in the physics of failure of polymer networks, but it will also shed light on fracture physics in general. Finally, it will help material scientists to design new materials with superior properties.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
692670	**FIRSTORM**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. MICHELE FABRIZIO**
Host Institution: Scuola Internazionale Superiore Di Studi Avanzati Di Trieste, IT

Modeling first-order Mott transitions

Mott insulators are “unsuccessful metals”, where conduction is impeded by strong Coulomb repulsion. Their use in microelectronics started to be seriously considered in the 1990s, when first reports of field-effect switches appeared. These attempts were motivated by the expectation that the dielectric breakdown in Mott insulators could suddenly release all formerly localized carriers, a significant potential for nanometer scaling. Over the very last years striking experimental data on narrow-gap Mott insulators have finally materialized that expectation disclosing an unprecedented scenario where the metal phase actually stabilized was only metastable at equilibrium, which foreshadows exciting potential applications. These new data call for an urgent theoretical understanding so far missing. In fact, the conventional portrait of Mott insulators has overlooked that Mott transitions are mostly 1st order, implying an extended insulator-metal coexistence. As a result, bias or light may nucleate long-lived metastable metal droplets within the stable insulator, as indeed seen in experiments. The unexpected 1st order nature of dielectric breakdown in Mott insulators and its poorly explored but important conceptual and practical consequences are the scope of my theoretical project. I will model known Mott insulators identifying the variety of mechanisms (Coulomb, lattice distortions) that support and boost the 1st order character of the Mott transition. I will model and study insulator-metal coexistence and associated novel phenomena such as those related to nucleation and wetting at the interface, including possible unexplored role of quantum fluctuations. I will then simulate in model calculations the spatially inhomogeneous dynamics and non-equilibrium pathways across the 1st order Mott transition, relating the results to ongoing experiments in top groups. The outcome of this project is expected to yield immediate conceptual as well as later technological consequences.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694709	**SuperMagnonics**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. BURKARD HILLEBRANDS**
Host Institution: Technische Universitaet Kaiserslautern, DE

Supercurrents of Magnon Condensates for Advanced Magnonics

I propose the opening of the new research field of room-temperature supercurrents formed in condensates of magnons. These supercurrents represent a novel type of macroscopic quantum phenomenon analogous to the low-temperature effects of superconductivity and superfluidity. They constitute the transport of angular momentum, which is driven by a phase gradient in the magnon-condensate wavefunction. The results I envision possess the potential to completely revolutionize information processing with minimum dissipation and in ambient conditions.

Magnons are the quanta of spin waves, the dynamic eigen-excitations of a magnetically ordered body. Condensates of magnons relate to Bose-Einstein condensates, and they spontaneously form a spatially extended coherent ground state, which can be established independently of the magnon excitation mechanism and, most importantly, can be realized at room temperature.

Magnon condensates and supercurrents will offer unprecedented opportunities to address novel, emergent, fundamental perspectives for the investigation of macroscopic quantum phenomena and their potential applications. SUPERMAGNONICS will pioneer the generation, processing and detection of magnonic supercurrents. I will specifically address the realization of magnonic Josephson junctions and the magnon version of the Aharonov-Casher effect where the phase of a magnon condensate and, thus, a persistent supercurrent, is controlled by an electric field. This approach will allow for fundamentally new means of magnon control.

Experiments will be carried out using the unique technique of space-, phase- and time-resolved Brillouin Light Scattering spectroscopy for the imaging of the wavefunction of the condensates allowing for direct access to the supercurrent phenomena. In order to show the high potential for applications, I will demonstrate the functionality of a logic gate based on supercurrent wavefunction manipulation.

Project End Date: **30-SEP-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714577	**PHONOMETA**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. JOHAN CHRISTENSEN**
Host Institution: Universidad Carlos Iii De Madrid, ES

Frontiers in Phononics: Parity-Time Symmetric Phononic Metamaterials

The boost experienced by acoustic and elastic (phononic) metamaterial research during the past years has been driven by the ability to sculpture the flow of sound waves at will. Thanks to recent developments at the frontiers of phononic metamaterials it can be identified that active phononic control is at the cutting edge of the current research on phononic metamaterials. Introducing piezoelectric semiconductors as a material platform to discover new avenues in wave physics will have the potential to open horizons of opportunities in science of acoustic wave control. Electrically biased piezoelectric semiconductors are non-reciprocal by nature, produce mechanical gain and are highly tunable.

The aim is to explore novel properties of sound and the ability to design Parity-Time (PT) symmetric systems that define a consistent unitary extension of quantum mechanics. Through cunningly contrived piezoelectric media sculpturing balanced loss and gain units, these structures have neither parity symmetry nor time-reversal symmetry, but are nevertheless symmetric in the product of both. PHONOMETA is inspired and driven by these common notions of quantum mechanics that I wish to translate into classical acoustics with unprecedented knowledge for the case of sound.

I expect that the successful realization of PHONOMETA has the potential to revolutionize acoustics in our daily life. Environmental and ambient noise stem from multiple scattering and reflections of sound in our surrounding. The extraordinary properties of PT acoustic metamaterials have the groundbreaking potential to push forward physical acoustics with new paradigms to design tunable diode-like behaviour with zero reflections, which is applicable for noise pollution mitigation. Also I anticipate to impact the progress on invisibility cloaks by introducing PT symmetry based acoustic stealth coatings for hiding submarines.

Project End Date: **30-NOV-21**

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:
715939	**NanoPhennec**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. NORBERTO DANIEL LANZILLOTTI KIMURA**
Host Institution: Centre National De La Recherche Scientifique Cnrs, 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:
724489	**CellStructure**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. JONAS RIES**
Host Institution: European Molecular Biology Laboratory, DE

Structural cell biology in situ using superresolution microscopy

Supra-molecular protein machineries control diverse cellular processes. Knowing their structural organization is crucial for understanding their function. As classical structural biology techniques are limited in studying such assemblies in their natural cellular environment, there is a critical methodological gap inhibiting a direct link between structure and function. Consequently, the structural intermediates underlying a full activity cycle of a large multi-protein complex have been impossible to visualize. Recent advances in fluorescence microscopy, in particular the development of groundbreaking superresolution microscopy (SRM) methods, can now help bridge this gap. With this interdisciplinary proposal, my group will develop unique and innovative optical, biological and computational imaging technologies to determine the structural organization of multi-protein assemblies in their functional cellular context.

We will reach this goal by developing a method to robustly measure the precise 3D arrangements of proteins in supra-molecular assemblies in situ with nanometer isotropic resolution based on supercritical-angle detection and by measuring their absolute stoichiometries with engineered counting standards. We will also develop new data analysis tools to statistically analyze such data, taking into account the functional cellular context measured with correlative superresolution and electron microscopy, multi-color SRM and molecular biology tools. We will apply these new methods to address key questions on endocytosis, a fundamental membrane trafficking process. Our aim is to determine a time-resolved 3D superresolution localization map of the yeast endocytic proteins during the major functional transitions and to integrate these data into a mechanistic model of endocytosis. Importantly, the methods we develop here can be applied to many other large protein-based machines, and thus have the potential to have high impact in other key areas of cell biology.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725920	**2DQP**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. BRIAN GERARDOT**
Host Institution: Heriot-Watt University, UK

Two-dimensional quantum photonics

Quantum optics, the study of how discrete packets of light (photons) and matter interact, has led to the development of remarkable new technologies which exploit the bizarre properties of quantum mechanics. These quantum technologies are primed to revolutionize the fields of communication, information processing, and metrology in the coming years. Similar to contemporary technologies, the future quantum machinery will likely consist of a semiconductor platform to create and process the quantum information. However, to date the demanding requirements on a quantum photonic platform have yet to be satisfied with conventional bulk (three-dimensional) semiconductors.

To surmount these well-known obstacles, a new paradigm in quantum photonics is required. Initiated by the recent discovery of single photon emitters in atomically flat (two-dimensional) semiconducting materials, 2DQP aims to be at the nucleus of a new approach by realizing quantum optics with ultra-stable (coherent) quantum states integrated into devices with electronic and photonic functionality. We will characterize, identify, engineer, and coherently manipulate localized quantum states in this two-dimensional quantum photonic platform. A vital component of 2DQP's vision is to go beyond the fundamental science and achieve the ideal solid-state single photon device yielding perfect extraction - 100% efficiency - of on-demand indistinguishable single photons. Finally, we will exploit this ideal device to implement the critical building block for a photonic quantum computer.

Project End Date: **31-DEC-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:
757725	**ETOPEX**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. JELENA KLINOVAJA**
Host Institution: Universitat Basel, CH

Engineering Topological Phases and Excitations in Nanostructures with Interactions

The main goal of this theory project is to propose engineered topological phases emerging only in strongly interacting systems and to identify the most feasible systems for experimental implementation. First, we will focus on setups hosting topological states localized at domain walls in one-dimensional channels such as parafermions, which are a new class of non-Abelian anyons and most promising candidates for topological quantum computing schemes. Second, in the framework of weakly coupled wires and planes, we will develop schemes for novel fractional topological phases in two- and three-dimensional interacting systems. To achieve these two goals, my team will identify necessary ingredients such as strong electron-electron interactions, helical magnetic order, or crossed Andreev proximity-induced superconductivity and address each of them separately. Later, we combine them to lead us to the desired topological phases and states. On our way to the main goal, as test cases, we will also study non-interacting analogies of the proposed effects such as Majorana fermions and integer topological insulators and pay close attention to the rapid experimental progress to come up with the most feasible proposals. We will study transport properties, scanning tunneling and atomic force microscopy. Especially for systems driven out of equilibrium, we will develop a Floquet-Luttinger liquid technique. We will explore the stability of engineered topological phases, error rates of topological qubits based on them, and computation schemes allowing for a set of universal qubit gates. We will strive to find a reasonable balance between topological stability and experimental
feasibility of setups. Our main theoretical tools are Luttinger liquid techniques (bosonization and renormalization group), Green functions, Floquet formalism, and numerical simulations in non-interacting test models.

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:
758461	**SeeSuper**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. SIMON WALL**
Host Institution: Fundacio Institut De Ciencies Fotoniques, ES

Probing nanoscale and femtosecond fluctuations in high temperature superconductors

One of the major outstanding challenges in condensed matter physics is the origin of high temperature superconductivity. Low temperature BCS superconductivity is mediated by the electron-phonon interaction, but this interaction is believed to be too weak to explain high temperature superconductivity. Instead electron interactions are considered responsible, but experimental proof has been difficult to obtain. Despite over thirty years of research, the mechanism responsible for generating the superconducting state still remains unknown.

SeeSuper aims to break this deadlock by applying new experimental techniques to study the superconducting state. Our strategy is to probe high temperature superconductors through their nanoscale and femtosecond fluctuations. We will focus on three key parameters in superconductors: phonons, spins and nanoscale phase separation, with the aim of revealing the coupling mechanism.

Our approach combines transient optical spectroscopy and time-resolved diffuse X-ray scattering to measure the lattice response to large amplitude coherent vibrations, time-resolved non-linear optical spectroscopy to directly probe spin dynamics, and resonant soft X-ray holography to image dynamics on the nanoscale.

We will use these cutting edge techniques to prove our hypothesis, that lattice anharmonicity is the key missing ingredient to explain the origins of high temperature superconductivity. If demonstrated, the impact of such a result will lead to a step-change in our understanding of how superconductivity at high temperature occurs, help guide the search for materials with higher transition temperatures, and influence how we view and understand a much broader class of materials. Furthermore, the experimental techniques that we will develop can be applied to understand a range of materials and will, therefore, have an impact also on the broader field of condensed matter physics.

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

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:
773091	**InCell**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. GEORG FANTNER**
Host Institution: Ecole Polytechnique Federale De Lausanne, CH

High speed AFM imaging of molecular processes inside living cells

Imaging the inside of living cells with single nanometre resolution has been a long-standing dream in bio-microscopy. Direct observation of changes to molecular networks inside of living cells would revolutionize the way we study structural cell biology. Unfortunately, no such tool exists. Atomic force microscopy (AFM) is the closest we have, to nanoscale functional imaging of cells in their native, fluid environment. However, it is limited to imaging the outside of the cell.

With InCell, I will remedy this by developing an AFM capable of imaging the inside of living cells. The approach is based on a microfabricated high speed AFM cantilever encased in a double barrel patch-clamp shell. The patch clamp shell seals onto the plasma membrane of the cell, so that the tip of the AFM cantilever can enter the cell without causing the cytosol to leak out. Parasitic interactions of the AFM tip with the cytosol will be subtracted from the cantilever deflection signal, using high speed photo-thermal off-resonance tapping (PT-ORT), a novel AFM mode we have recently developed in my lab. This allows the extraction of the true tip-sample interaction, even in viscous fluids. A dedicated InCell HS-AFM combined with confocal optical microscopy will be used to guide the InCell cantilever inside the cell to the area of interest.

Using this minimally invasive technique we will study the formation of clathrin coated pits, a crucial part of endocytosis. By imaging for the first time the nanoscale dynamics of this process in living cells, we aim to answer fundamental questions about the clathrin coat assembly. We will characterize the kinetics, stability and force generation by the clathrin lattice. This will be the first example of how enabling nanoscale imaging inside living cells will be a game changer in cell biology. It will open up a myriad of possibilities for the study of vesicular transport, viral and bacterial infection, nuclear pore transport, cell signalling and many more.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787356	**EvoTrap**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. DIETER BRAUN**
Host Institution: Ludwig-Maximilians-Universitaet Muenchen, DE

Mechanisms to emerge and replicate the first sequence information of life in geothermal microfluidics of early Earth

Can we reconstruct in the lab the onset of molecular evolution? To trigger the autonomous emergence of the first oligonucleotide sequences, we will explore non-equilibrium boundary conditions and selective mechanisms to host the fast progressing prebiotic replication chemistry of oligonucleotides. We will explore novel water-fog microfluidic settings to boost the replication and selection of the first RNA sequences. The findings aims to enable the creation of primitive life forms in the lab, starting from simple molecules in heated rock pores of early Earth.

Autonomous replication and metabolism. We will expand our thermal gradient expertise to host three replication chemistries. Using 3D printed microfluidics, we will mimick conditions in pores on early Earth. Thermophoresis will select long over short strands, accumulate small food molecules and strands will be separated by thermal convection and novel mechanisms in water-air systems. With respective collaboration partners, we will drive the replication from RNA ribozymes (Joyce), base-by-base RNA replication (Szostak) and EDC activated DNA ligation (Richert) and monitor the results with Illumina sequencing and TOF LC/MS. The ligation will be also explored with Taq ligase since we expect a cooperative replication dynamics with hypercycle-like characteristics. Thermal gradients will drive early metabolism to boost RNA polymerization and select ATP over ADP to drive modern biochemistry.

Sequence selection in low pressure water-air systems. Oligonucleotides bind to water-air interfaces. and can be accumulated 800-fold by heat-driven capillary flows. Based on this, we expect interesting selection effects under microfluidic boiling, fog formation and recondensation dynamics. The settings are tested for sequence selective hydro-gelation of RNA/DNA and enhanced replication chemistry. The temperature of boiling water will be limited below 60°C by using air pressures <200mbar, mimicking very early Earth conditions.

Project End Date: **30-SEP-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:
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-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:
818751	**MesoPhone**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. EDWARD LAIRD**
Host Institution: University Of Lancaster Royal Charter, 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:
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:
834402	**ULTRADISS**	**PE3** Condensed Matter Physics

Principal Investigator: **Dr. ERNST MEYER**
Host Institution: Universitat Basel, CH

Ultra-sensitive mechanical dissipation in classical, quantum and non-equilibrium nanocontacts

Dissipation spectroscopy: Nanomechanical dissipation, experienced by oscillating tip-based Force Microscopy (AFM) instruments, provides an innovative probe of the physics of classical and quantum materials, solids, surfaces. My group made, in the last decade, well-reCoGnized experimental and conceptual advances by exploiting and adapting advanced AFM techniques, especially the ultra-sensitive pendulum-AFM, (p-AFM, dissipation sensitivity ~0.1 aW, force sensitivity ~ 10-12N) detecting collective phenomena and phase transitions including structural, electronic, magnetic. This dissipation spectroscopy was applied so far mostly at the equilibrium physics of 3D classical solids.
The challenge: I propose to extend nanomechanical dissipation spectroscopy to pick up much weaker effects caused by non-equilibrium perturbations, by nanomanipulations, and by quantum effects in carefully picked case studies. Such as measuring the imperceptible wind force exerted on a noncontact tip by a thermal or electrical current in the surface below, or the minute mechanical cost of creating and dismantling a single spin Kondo state, or a topological surface state.
Risks, benefits, relevance: None of this was done before, so despite our experience and good feasibility estimates there is some risk. The benefits however will be substantial. Thermal and electrical migration of defects and impurities is important in materials, and electrical contacts. The dragging, peeling, sensing of 2D systems like graphene nanoribbons and twisted bilayers is hot. And quantum dissipation is pertinent to the limiting factor of quantum information processes. To do all this by nanomechanics will be unique.
The opportunity: My group is ready to put its expertise in these exciting new problems, once I can through an Advanced Grant secure the instrumental and experimental human resources, as well as the theoretical support of additional beneficiary SISSA, indispensable in such a frontier context.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677511	**ComplexSwimmers**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. GIOVANNI VOLPE**
Host Institution: Goeteborgs Universitet, SE

Biocompatible and Interactive Artificial Micro- and Nanoswimmers and Their Applications

Microswimmers, i.e., biological and artificial microscopic objects capable of self-propulsion, have been attracting a growing interest from the biological and physical communities. From the fundamental side, their study can shed light on the far-from-equilibrium physics underlying the adaptive and collective behavior of biological entities such as chemotactic bacteria and eukaryotic cells. From the more applied side, they provide tantalizing options to perform tasks not easily achievable with other available techniques, such as the targeted localization, pick-up and delivery of microscopic and nanoscopic cargoes, e.g., in drug delivery, bioremediation and chemical sensing.
However, there are still several open challenges that need to be tackled in order to achieve the full scientific and technological potential of microswimmers in real-life settings. The main challenges are: (1) to identify a biocompatible propulstion mechanism and energy supply capable of lasting for the whole particle life-cycle; (2) to understand their behavior in complex and crowded environments; (3) to learn how to engineer emergent behaviors; and (4) to scale down their dimensions towards the nanoscale.
This project aims at tackling these challenges by developing biocompatible microswimmers capable of elaborate behaviors, by engineering their performance when interacting with other particles and with a complex environment, and by developing working nanoswimmers.
To achieve these goals, we have laid out a roadmap that will lead us to push the frontiers of the current understanding of active matter both at the mesoscopic and at the nanoscopic scale, and will permit us to develop some technologically disruptive techniques, namely, targeted delivery of cargoes within complex environments, which is of interest for drug delivery and bioremediation, and efficient sorting of chiral nanoparticles, which is of interest for biomedical and pharmaceutical applications.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679033	**EVODIS**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. WIM DE MALSCHE**
Host Institution: Vrije Universiteit Brussel, BE

Exploiting vortices to suppress dispersion and reach new separation power boundaries

The 21st century is expected to develop towards a society depending ever and ever more on (bio-)chemical measurements of fluids and matrices that are so complex they are well beyond the current analytical capabilities. Incremental improvements can no longer satisfy the current needs of e.g. the proteomics field, requiring the separation of tens of thousands of components. The pace of progress in these fields is therefore predominantly determined by that of analytical tools, whereby liquid chromatography is the most prominent technique to separate small molecules as well as macromolecules, based on differential interaction of each analyte with support structures giving it a unique migration velocity. To improve its performance, a faster transport between these structures needs to be generated. Unfortunately the commonly pursued strategy, relying on diffusion and reducing the structure size, has come to its limits due to practical limitations related to packing and fabrication of sub-micron support structures, pressure tolerance and viscous heating.

A ground-breaking step to advance chromatographic performance to another level would be to accelerate mass transport in the lateral direction, beyond the rate of diffusion only. To meet this requirement, an array of microstructures and local electrodes can be defined to create lateral electroosmotic vortices in a pressure-driven column, aiming to accelerate the local mass transfer in an anisotropic fashion. The achievement of ordered arrays of vortices is intimately linked to this requirement, which is also of broader importance for mixing, anti-fouling of membrane and reactor surfaces, enhanced mass transfer in reactor channels, emulsification, etc. Understanding and implementing anisotropic vortex flows will therefore not only revolutionize analytical and preparative separation procedures, but will also be highly relevant in all flow systems that benefit from enhanced mass transfer.

Project End Date: **28-FEB-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679841	**ORDERin1D**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. SOFIE CAMBRÉ**
Host Institution: Universiteit Antwerpen, BE

Order in one dimension: Functional hybrids of chirality-sorted carbon nanotubes

The hollow structure of carbon nanotubes (CNTs), with a wide range of diameters, forms an ideal one-dimensional (1D) host system to study restricted diameter-dependent molecular transport and to achieve unique polar molecular order. I have shown that the vibrational and optical transitions of CNTs show characteristic shifts upon encapsulation of different molecules. For the ORDERin1D project, I will capitalise on my recent breakthroughs in the processing, filling, chiral sorting and high-resolution spectroscopic characterisation of empty and filled CNTs, and unite this expertise with an innovative experimental design for real-time spectrally-resolved fluorescence imaging. By selective imaging of the empty and filled CNT emission after in situ opening of one CNT end, this project aims for the first real-time visualisation of the filling dynamics into the 1D CNT channels. The chirality-sorting method that I recently co-developed is indispensable for this objective, as it allows for an atomically-precise control over the pore diameter and thus also a diameter-dependent characterisation of the filling dynamics. The in-depth characterisation of the filling mechanisms and dynamics will pave the way for the rational design of ultraselective filtermembranes, sensors, nanofluidic devices and nanohybrids with unseen control over the structural order at the molecular scale. In particular, I recently found that dipolar molecules naturally align head-to-tail into a 1D polar array inside the CNTs, after which their molecular directional properties such as their dipole moment and second-order nonlinear optical response add up coherently. I will build on this new concept and apply it to the principle of symmetry breaking observed in bistable molecules. As such, I expect to create a 1D array of ferroelectrically-coupled molecules, resulting in the first organic ferroelectric materials with a purely electronic origin, groundbreaking for the development of nanophotonics applications.

Project End Date: **30-APR-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681285	**TAME-Plasmons**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. STEFANO CORNI**
Host Institution: Universita Degli Studi Di Padova, IT

a Theoretical chemistry Approach to tiME-resolved molecular Plasmonics

Ultrafast spectroscopy is a powerful tool able to disclose the atomistic real-time motion picture of the basic chemical events behind technology and Life, such as catalytic reactions or photosynthetic light harvesting. Nowadays, by cleverly harnessing the interaction of the studied molecules with plasmons (collective electron excitations supported, e.g., by metal nanoparticles) it is becoming possible to focus these investigations on specific nanoscopic regions, such as a portion of a catalytic surface or of a photosynthetic membrane. This coupling can also produce new quantum effects such as molecule-plasmon hybrid excitations. On the other hand, it makes the real-time molecular evolution and its perturbation by light more complex, and thus calls for new theoretical treatments. The available ones are unable to tackle this complexity, because they consist of phenomenological models focused on field enhancements or on generic features of the various plasmon-molecule coupling regimes. The goal of TAME-Plasmons is to develop a theoretical chemistry approach to directly simulate the real time evolution of molecules interacting with plasmons and light. Our approach lifts the current theoretical limitations by coupling a real-time quantum chemical description of the molecules with a time-dependent electromagnetic description of plasmons, rooted in our previous work on steady-state molecular plasmonics. We will implement this approach in an open-source software, accessible also to non-specialists. We will address current open issues such as the controversial nature of plasmon-aided frequency up-conversion by noble gases and the interpretation of sub-molecularly resolved photoemission induced by scanning tunneling microscopy. We will also anticipate questions that may arise along with progress in the field, for example how to engineer energy transfer paths in photosynthetic light harvesting proteins by exploiting the coupling to plasmons.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682275	**IsoMS**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. JANA ROITHOVA**
Host Institution: Stichting Katholieke Universiteit, NL

Mass Spectrometry of Isomeric Ions

Mass spectrometry (MS) in combination with electrospray ionization (ESI) is one of the principal tools currently used to gain insight into newly developed catalytic reactions. It is used to identify key reaction intermediates and to study their structure and reactivity. This proposal is based on the combination of modern MS approaches with novel experiments in a unique cryo-trapping instrument. This combination allows the study of short-lived ionic species that cannot be studied by other known methods. Our distinguishing feature is the in situ helium-tagging of ions, which allows us to record their infrared spectra via a pre-dissociation technique. Here, we will go beyond this state-of-the-art approach in two directions:

(1) The unparalleled advantage of ESI-MS is its high sensitivity to low-abundant and reactive species. The pertinent question at the heart of all reaction mechanism investigations via MS is how the ions found in the gas-phase relate to the condensed-phase reaction. We will address this question using "Delayed Reactant Labelling", which will directly link condensed phase kinetics to the abundance of isolated gaseous ions.

(2) We will take advantage of long storage times in our cryogenic linear quadrupole trap and expand the portfolio of the methods available to address mixtures of ions with the same mass. Isobaric mixtures are resolved in MS by differences in ion mobilities, i.e. the ions are separated by their mass-to-charge ratios and by their shapes. We will perform ion mobility separation directly in the trap by excitation of the ion secular motion using a resonant dipolar electric field. Further, we will combine cryo-trapping experiments with the probing or modifying of the stored ions by reactive collisions with neutral molecules. The mobility experiments and the reactivity probing will be routinely combined with spectroscopic experiments.

Project End Date: **30-JUN-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694965	**COCONIS**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. FRANK STIENKEMEIER**
Host Institution: Albert-Ludwigs-Universitaet Freiburg, DE

Coherent multidimensional spectroscopy of controlled isolated systems

Fundamental quantum mechanical processes determine the properties of matter and their functionality. In order to understand complex processes such as light harvesting in photosynthesis and photovoltaics, a detailed knowledge of coherent effects in excitation and charge transfer processes and related dynamics is required. To a large extent, the complexity of the systems induces too many interactions and perturbations of the processes to isolate and understand individual mechanisms. Advanced experimental methods, capable of detecting quantum coherences, so far are not applicable to quantum state controlled molecular complexes isolated from the perturbing environment, due to the low density of such targets. In this project we will for the first time employ coherent femtosecond multidimensional spectroscopy to dilute isolated molecular complexes. For a specific heterogeneous synthesis we will use aggregation in superfluid helium at millikelvin temperatures. In order to reach the needed sensitivity we will setup a novel phase modulation technique including lock-in demodulation in combination with mass-resolved ionization and photoelectron detection. Advanced mathematical methods will furthermore be developed and applied, boosting efficient collection of multidimensional datasets. We will be able to (a) identify processes and coherent dynamics of excitation and charge transfer in fundamental heterogeneous complexes, in particular van der Waals bound donor acceptor complexes (b) elucidate coherence and dissipation effects in contact with tailored external baths, (c) investigate microsolvation, i.e. measure the evolution of dynamic properties as a function of attached solvent molecules, (d) determine collective effects like autoionization in dilute atomic gases or exciton annihilation in semiconductor systems, (e) implement compressed sensing in multidimensional data acquisition, (f) implement largely parallelized phase-cycling into real-time data acquisition.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695197	**DYNAMOX**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. MAJED CHERGUI**
Host Institution: Ecole Polytechnique Federale De Lausanne, CH

Charge carrier dynamics in metal oxides

Transition metal (TM) oxides (TiO2, ZnO, NiO) are large gap insulators that have emerged as highly attractive materials over the past two decades for applications in photocatalysis, solar energy conversion, etc., all of which rely on the generation of charge carriers, their evolution and their eventual trapping at defects or a self-trapped excitons. Despite the huge interest for such materials, the very nature of the elementary electronic excitations (Frenkel, Wannier or charge transfer exciton) is still not established, nor is the way these excitations evolve after being created: excitonic polaron or charged polaron. Finally, the electron and hole recombine is also not clearly established because of issue of defects and trapping.

In order to tackle these issues, here we implement novel experimental tools that would provide us with hitherto inaccessible information about the charge carrier dynamics in TM oxides. Of importance is the ability to detect both the electrons and the holes. Some of these tools have been developed in the PI's group: i) Ultrafast X-ray absorption spectroscopy (XAS) will provide information about the final metal d-orbitals and about the structural changes around it; ii) Ultrafast X-ray emission (XES) will provide information about hole states. While these two approaches are ideal element-selective ones, the localization of the electron at metal atoms represents a small proportion of the electron population. Therefore, ultrafast Angle-resolved photoemission spectroscopy (ARPES) will be used to map out the band structure changes in the system and the evolution of the conduction band electrons. Ultrafast 2-dimensional (2D) UV (<400nm) transient absorption spectroscopy allows the mapping of the time evolution of both the valence and the conduction bands by its ability to pump and probe above the band gap. Last, Fourier Transform visible 2D spectroscopy will allow the probing of gap state dynamics at high time resolution.

Project End Date: **30-SEP-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714519	**HP4all**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. SAMI JANNIN**
Host Institution: Universite Lyon 1 Claude Bernard, FR

Persistent and Transportable Hyperpolarization for Magnetic Resonance

Magnetic resonance imaging (MRI) and nuclear magnetic resonance (NMR) and are two well-established powerful and versatile tools that are extensively used in many fields of research, in clinics and in industry.

Despite considerable efforts involving highly sophisticated instrumentation, these techniques suffer from low sensitivity, which keeps many of today's most interesting problems in modern analytical sciences below the limits of MR detection.

Hyperpolarization (HP) in principle provides a solution to this limitation. We have recently pioneered breakthrough approaches using dissolution dynamic nuclear polarization (d-DNP) for preparing nuclear spins in highly aligned states, and therefore boosting sensitivity in several proof-of-concept reports on model systems. The proposed project aims to leverage these new advances through a series of new concepts i) to generate the highest possible hyperpolarization that can be transported in a persistent state, and ii) to demonstrate their use in magnetic resonance experiments with > 10'000 fold sensitivity enhancements, with the potential of revolutionizing the fields of MRI and NMR.

By physically separating the source of polarization from the substrate at a microscopic level, we will achieve polarized samples with lifetimes of days that can be stored and transported over long distances to MRI centers, hospitals and NMR laboratories. Notable applications in the fields of drug discovery, metabolomics and real-time metabolic imaging in living animals will be demonstrated.

These goals require a leap forward with respect to today's protocols, and we propose to achieve this through a combination of innovative sample formulations, new NMR methodology and advanced instrumentation.

This project will yield to a broadly applicable method revolutionizing analytical chemistry, drug discovery and medical diagnostics, and thereby will provide a powerful tool to solve challenges at the forefront of molecular and chemical sciences today.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715354	**p-TYPE**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. ELIZABETH GIBSON**
Host Institution: University Of Newcastle Upon Tyne, UK

Transparent p-type semiconductors for efficient solar energy capture, conversion and storage.

This proposal will develop new transparent p-type semiconductors that will make dye-sensitized solar cells (DSC) a vastly more efficient and a realistic prospect for carbon-free energy generation worldwide. Two key challenges will be addressed: (1) a means of converting NIR radiation to increase the amount of sunlight utilised from 35% to over 70%; (2) a means of storing the energy. Almost all the research in the field is based on dye or "perovskite" sensitized TiO2 (n-type) solar cells, which are limited by their poor spectral response in the red-NIR. pTYPE approaches the problem differently: tandem DSCs will be developed which combine a n-type and a p-type DSC in a single p/n device. This increases the theoretical efficiency from 33% to 43% by extending the spectral response without sacrificing the voltage. The device will be modified with catalysts to convert H2O or CO2 and sunlight into fuel without using sacrificial reagents that limit the efficiency of current systems. An efficient tandem DSC has not yet been developed because p-type DSCs are much less efficient than n-type cells. As an independent Royal Society Dorothy Hodgkin fellow I increased the photocurrent by developing new dyes. This project will exploit this breakthrough by increasing the voltage, which is currently limited by the NiO semiconductor conventionally used. I will rapidly synthesise libraries of alternative p-type semiconductors; select promising candidates based on key criteria which can be measured on a single sample within minutes: transparency and dye adsorption (for high light harvesting efficiency by the dye), conductivity (for high charge collection efficiency) and valence band potential (for high voltage); assemble the new materials in tandem DSCs. As one of the few researchers experienced in preparing, characterising and optimising each aspect of this photoelectrochemical system, I aim to match the efficiency from TiO2 with p-type DSCs to obtain tandem efficiencies above 20%.

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

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, 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:
716641	**AQUARAMAN**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. ALEIX GARCIA GUELL**
Host Institution: Ecole Polytechnique, FR

Pipet Based Scanning Probe Microscopy Tip-Enhanced Raman Spectroscopy: A Novel Approach for TERS in Liquids

Tip-enhanced Raman spectroscopy (TERS) is often described as the most powerful tool for optical characterization of surfaces and their proximities. It combines the intrinsic spatial resolution of scanning probe techniques (AFM or STM) with the chemical information content of vibrational Raman spectroscopy. Capable to reveal surface heterogeneity at the nanoscale, TERS is currently playing a fundamental role in the understanding of interfacial physicochemical processes in key areas of science and technology such as chemistry, biology and material science.

Unfortunately, the undeniable potential of TERS as a label-free tool for nanoscale chemical and structural characterization is, nowadays, limited to air and vacuum environments, with it failing to operate in a reliable and systematic manner in liquid. The reasons are more technical than fundamental, as what is hindering the application of TERS in water is, among other issues, the low stability of the probes and their consistency. Fields of science and technology where the presence of water/electrolyte is unavoidable, such as biology and electrochemistry, remain unexplored with this powerful technique.

We propose a revolutionary approach for TERS in liquids founded on the employment of pipet-based scanning probe microscopy techniques (pb-SPM) as an alternative to AFM and STM. The use of recent but well established pb-SPM brings the opportunity to develop unprecedented pipet-based TERS probes (beyond the classic and limited metallized solid probes from AFM and STM), together with the implementation of ingenious and innovative measures to enhance tip stability, sensitivity and reliability, unattainable with the current techniques.

We will be in possession of a unique nano-spectroscopy platform capable of experiments in liquids, to follow dynamic processes in-situ, addressing fundamental questions and bringing insight into interfacial phenomena spanning from materials science, physics, chemistry and biology.

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

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:
724394	**HIGH-GEAR**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. MARTIN HÖGBOM**
Host Institution: Stockholms Universitet, SE

High-valent protein-coordinated catalytic metal sites: Geometric and Electronic ARchitecture

It is estimated that almost half of all enzymes utilize metal cofactors for their function, for example the respiratory complexes and the oxygen-evolving photosystem II, the most fundamental requirements for aerobic life as we know it. If we could mimic nature's use of metals for harvesting sunlight, energy conversion and chemical synthesis it would eliminate the need for fossil fuels and greatly increase the possibilities of chemical industry while reducing the environmental impact. Achieving this type of chemistry is an outstanding testament to evolution and understanding it is a glaring challenge to mankind.

These types of reactions are based on very challenging redox chemistry (involving one or several electrons). The key catalytic species are generally high-valent metal clusters with a varying ligand environment, provided by the protein and other bound molecules, that directly controls the reactivity of the inorganic core. To be able to understand and mimic this chemistry it is of central importance to know the geometric and electronic structures of the metal core as well as the entire ligand environment for these usually short-lived and very reactive intermediates. It has, for a number of reasons, proven extremely challenging to obtain these for protein-coordinated catalysts.

The central goal of this project is to determine true and accurate geometric and electronic structures of high-valent di-nuclear Fe/Fe and Mn/Fe metal sites coordinated in protein matrices known to direct these for varied and important chemistry. By combining new X-ray diffraction based techniques with advanced spectroscopy we aim to define how the protein controls the entatic state as well as reactivity and mechanism for some of the most potent catalysts in nature. The results will serve as a basis for design of oxygen-activating catalysts with novel properties.

Project End Date: **31-MAY-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:
741431	**2DNanoSpec**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. RENATO ZENOBI**
Host Institution: Eidgenoessische Technische Hochschule Zurich, CH

Nanoscale Vibrational Spectroscopy of Sensitive 2D Molecular Materials

I propose to investigate the nanometer scale organization of delicate 2-dimensional molecular materials using nanoscale vibrational spectroscopy. 2D structures are of great scientific and technological importance, for example as novel materials (graphene, MoS2, WS2, etc.), and in the form of biological membranes and synthetic 2D-polymers. Powerful methods for their analysis and imaging with molecular selectivity and sufficient spatial resolution, however, are lacking. Tip-enhanced Raman spectroscopy (TERS) allows label-free spectroscopic identification of molecular species, with ≈10 nm spatial resolution, and with single molecule sensitivity for strong Raman scatterers. So far, however, TERS is not being carried out in liquids, which is the natural environment for membranes, and its application to poor Raman scatterers such as components of 2D polymers, lipids, or other membrane compounds (proteins, sugars) is difficult. TERS has the potential to overcome the restrictions of other optical/spectroscopic methods to study 2D materials, namely (i) insufficient spatial resolution of diffraction-limited optical methods; (ii) the need for labelling for all methods relying on fluorescence; and (iii) the inability of some methods to work in liquids. I propose to address a number of scientific questions associated with the spatial organization, and the occurrence of defects in sensitive 2D molecular materials. The success of these studies will also rely critically on technical innovations of TERS that notably address the problem of energy dissipation. This will for the first time allow its application to study of complex, delicate 2D molecular systems without photochemical damage.

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:
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:
755744	**TUCAS**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. CHRISTOPH RAMESHAN**
Host Institution: Technische Universitaet Wien, AT

Tuneable Catalyst Surfaces for Heterogeneous Catalysis – Electrochemical Switching of Selectivity and Activity

In heterogeneous catalysis surfaces decorated with uniformly dispersed, catalytically highly active particles are a key requirement for excellent performance. One of the main tasks in catalysis research is the continuous improvement or development of catalytically active materials.

An emerging concept in catalyst design, and the aim of this project, is to selectively and reversibly tune and modify the surface chemistry by electrochemical polarisation. Perovskite-type catalysts raise the opportunity to incorporate guest elements as dopants. Upon electrochemical polarisation these dopants emerge from the oxide lattice to form catalytically active clusters or nanoparticles on the surface (by exsolution). In consequence this leads to a strong modification or enhancement of catalytic selectivity and activity. Electrochemical polarisation offers the possibility to adjust the surface chemistry in response to an external signal (here the applied voltage).

Studies in a realistic catalytic reaction environment (in-situ) will enable a direct correlation of surface structure with catalytic activity, selectivity and the electrochemical stimulation. The unique combination of surface science, heterogeneous catalysis and electrochemistry will take this research to a new ground-breaking level. No research group has yet tried to tackle this topic on a fundamental mechanistic level by this multidisciplinary approach.

The proposed project opens unprecedented possibilities for catalyst design and in-situ control due to the versatility of perovskite-type catalyst materials and dopant elements. Nanoparticle exsolution is a highly time- and cost-efficient way of catalyst preparation and it will offer solutions to major problems in heterogeneous catalysis, such as ageing (sintering) or catalyst deactivation (coking). Tuneable catalyst surfaces will facilitate tackling a major concern of the 21st century, the utilisation of CO2 and its conversion to renewable fuel.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757733	**STRONG**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. KARL BÖRJESSON**
Host Institution: Goeteborgs Universitet, SE

Strong Coupling Between Molecules and Vacuum Fields: New Molecular Properties

Chemistry has had profound impact on society during the last two centuries. From mass production of drugs and pigments, to the invention of plastics, and more recently with the introduction of molecular electronics. However, some basic physical laws govern possible utilizations. It is therefore of great importance to examine how to bend these laws, how to bypass them and by so doing open up new opportunities for novel applications.

A central physical property of the molecule is its ability to interact with light. Plant leaves are green because they absorb light. However, less known is that this light-matter interaction can be enhanced to the point where it is so strong so that the photon and molecule cannot be regarded as separate entities, but as a system with unique properties. So called strong coupling occurs when exchange of energy between light and matter is stronger than any dissipation process and it leads to the formation of hybrid states with new physical and chemical properties.

STRONG will use a chemical viewpoint to develop unique molecules optimized for strong light-matter interactions, and with these examine excited state processes of strongly coupled systems. My aim is to demonstrate that strong light-matter coupling enables selective manipulation of energy levels. By so doing I will allow for a singlet ground and first excited state, thus challenge Hund's rule and change how the basic rules of electronic state energetics are envisioned. This enables channelling of all excitation energy, irrespectively of origin, through a singlet pathway, which is of great technological importance in organic electronics. Furthermore, I will use reversible oriented molecules to enhance the coupling and for the first time examine the relationship between orientation of molecules and strong light-matter coupling. Also the ability of light-matter interactions to increase order of an ensemble of molecules, which has profound technological applications, will be explored.

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

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:
758224	**NanoVirus**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. DAVID ALSTEENS**
Host Institution: Universite Catholique De Louvain, BE

Deciphering virus-host interactions using correlated confocal-atomic force microscopy

Viruses are a major class of pathogens that infect a variety of organisms. Infection is a multistep process that involves the concerted action of both virus and host cell machineries. The first steps of virus infection include cell binding, cell entry and release of the viral genetic material. Entry pathways are largely defined by the preliminary interactions between viruses and their receptors at the cell surface. Those interactions determine the mechanisms of virus attachment, uptake, and, ultimately, penetration into the cytosol. Elucidating the complex interplay between viruses and their receptors at the cell surface is an essential step towards establishing a full picture of the infection process.

Currently, a crucial challenge in virology is to develop a quantitative method to decipher the entry pathways of a virus, thus allowing the probing of the kinetics and energetic parameters of the interactions established between the virus and the cell surface. While current methods successfully describe the entry pathways, they fail in identifying in a quantitative manner the key steps such as energy intensive and high-affinity steps. To overcome this limitation, the ambition of this ERC proposal is to combine the latest generations of atomic force microscopes (AFM) with confocal laser scanning microscopes (CLSM). This will allow us to investigate and quantitatively characterize the early steps of single virus entry directly on living cells. At the frontiers of nanotechnology, biophysics and biology, this project aims at pushing the limits of AFM to enable us to better understand the molecular mechanisms of virus entry.

This project will have strong scientific and medical impacts. In virology, it will significantly improve the understanding of the mechanisms of virus infection. In medicine, the new method will help us and other researchers to screen new compounds that are targeting viral infection.

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

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, 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:
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: Universitat 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:
788982	**COLMIN**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. NICO SOMMERDIJK**
Host Institution: Technische Universiteit Eindhoven, NL

A Google Earth Approach to Understanding Collagen Mineralization

Collagen mineralization in bone is one of the most crucial processes in our body as it supplies the skeleton on which we depend for support and protection. Bone's impressive mechanical properties arise from the hierarchical organization of the organic collagen matrix that is mineralized with ultrathin, aligned inorganic crystals of carbonated hydroxyapatite.

Despite its importance to the human body, relatively little is understood about collagen mineralization and how the proteins govern mineral growth with such precision. This is because the matrix development is a complex process with different stages that occur over multiple length scales and depends on many different components.

I propose to obtain the first comprehensive picture of the collagen mineralization mechanism by unraveling its dynamics and structural details. It is not only of great fundamental importance, it also opens the way to the development of better biomaterials, as well as to strategies for the treatment of mineralization-related diseases.

I will achieve this ambitious goal by designing a dedicated tissue engineering platform that models real bone as closely as possible, and will allow application of multiple advanced analysis techniques. These I will employ in a "Google Earth" approach, studying the process from the micrometer to the nanometer scale, combining live cell imaging and "beyond state-of-the-art" electron microscopy with chemical and biochemical analysis to reveal the details of collagen mineralization with the highest spatial, temporal and molecular resolution thus far. Exploiting my extensive expertise in the field of biomineralization and advanced electron microscopy, COLMIN will provide a major step in understanding collagen formation and mineralization, and provide insights that will help to fight bone-related diseases. The advanced multidisciplinary methodology developed here will set a new standard for the advanced analysis of bone formation and other biological processes.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
801936	**HYPROTIN**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. DENNIS KURZBACH**
Host Institution: Universitat Wien, AT

Hyperpolarized Nuclear Magnetic Resonance Spectroscopy for Time-Resolved Monitoring of Interactions of Intrinsically Disordered Breast-Cancer Proteins

HYPROTIN proposes a pioneering research platform for hyperpolarized magnetic resonance of breast-cancer related proteins that will revolutionize our view on tumorigenesis at the atomic level, through bottom-up reconstitution of medicinal relevant interaction pathways involving the breast cancer susceptibility protein 1 (BRCA1).

The risk to develop a hereditary breast or ovarian cancer (HBOC) increases to 55-65 % upon mutation of the BRCA1 gene. Yet, little is known about the biochemistry of tumorigenesis, so that drugs directed towards molecular targets are not satisfactory. To date, mastectomy remains the only preventive treatment. This dramatic lack of knowledge is a consequence of BRCA1 being an intrinsically disordered protein (IDP). ReCoGnizing the importance of IDPs has revolutionized structural biology in the last decade, but this also represents a huge experimental challenge. To date, nuclear magnetic resonance (NMR) is the only technique available to study IDPs at high resolution. However, several limits of the technique must be overcome. Its low sensitivity impedes investigations under biologically meaningful conditions, so that new approaches are required.

The HYPROTIN project aims to achieve two methodological goals: 1) Residue-resolved studies of the BRCA1 IDP under physiological conditions; and 2) real-time monitoring of BRCA1-ligand binding, thereby adding a time-resolved dimension to the NMR characterization of IDPs. This systematic approach will provide unprecedented insight into the BRCA1 interactome, provide medically relevant data and residue-resolved protein interaction kinetics. This will open a new knowledge base for rational drug design.

The project will employ cutting-edge equipment that is unique worldwide, and will represent the first facility in Europe suited for these ground-breaking experiments. The PI has unique interdisciplinary experience enabling the demanding hyperpolarization approach to IDPs.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802123	**HDEM**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. TIMOTHY PENNYCOOK**
Host Institution: Universiteit Antwerpen, BE

High Definition Electron Microscopy: Greater clarity via multidimensionality

Atomic resolution microscopy relies on beams of energetic electrons. These beams quickly destroy fragile materials, making imaging them a major challenge. I have recently developed a new approach that provides the greatest possible resolving power per electron. The method provides both double resolution and excellent noise rejection, via multidimensional data acquisition and analysis. Here I propose to couple the new method with breakthroughs in high speed cameras to achieve unprecedented clarity at low doses, almost guaranteeing major advances for imaging beam sensitive materials. Proof of principle will be achieved for biochemical imaging using the easy to handle, commercially available GroEL chaperone molecule. We will combine our enhanced imaging capabilities with the averaging methods recently reCoGnized by the Nobel prize in chemistry for imaging biomolecules at ultra low doses. After proving our low dose capabilities we will apply them to imaging proteins of current interest at greater resolution. Similar techniques will be used for fragile materials science samples, for instance metal organic framework, Li ion battery, 2D, catalyst and perovskite solar cell materials. Furthermore the same reconstruction algorithms can be applied to simultaneously acquired spectroscopic images, allowing us to not only locate all the atoms, but identify them. The properties of all materials are determined by the arrangement and identity of their atoms, and therefore our work will impact all major areas of science, from biology to chemistry and physics.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803024	**MIDNP**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. MICHAL LESKES**
Host Institution: Weizmann Institute Of Science, IL

Metal Ions Dynamic Nuclear Polarization: Novel Route for Probing Functional Materials with Sensitivity and Selectivity

Materials with specific electrical, optical or chemical properties often derive their special functions from small perturbations in their composition or structure. Thus, rational design of new functional materials demands sensitive and versatile determination of structural and compositional properties, a very difficult goal not presently available. The overarching goal of this ERC project is to develop a novel route for Magic-Angle Spinning Dynamic Nuclear Polarization (MAS-DNP) as an enabling methodology in materials science, introducing new opportunities for investigating and designing functional materials.

Solid State Nuclear Magnetic Resonance (ssNMR) spectroscopy is an excellent probe for local order/disorder, but unfortunately its sensitivity is limited. DNP, a process whereby the large electron spin polarization is transferred to the nuclear spins, had greatly expanded the range of materials systems and questions that can be probed by ssNMR. However, it commonly relies on the use of exogenous nitroxide radicals, thereby limiting its utilization in materials science to nonreactive surfaces.

We propose to develop Metal Ions DNP (MIDNP) utilizing paramagnetic dopants as endogenous polarization agents in the bulk. To effectively harness the electron spin polarization of the dopants for higher sensitivity, we will (a) address challenges such as the effect of bonding, spin interactions and relaxation on DNP via a mechanistic study of carefully selected dopants in energy materials; (b) Develop new techniques for NMR spectral assignment and explore alternative DNP mechanisms for paramagnetic solids; (c) Expand the approach for sensitizing the detection of surfaces and interfaces and elucidate the critical role of surface chemistry in the efficacy of energy storage materials.

MIDNP will provide a novel, sensitive alternative for probing the structure and composition of new materials and will transform the utilization of ssNMR in the study of functional materials.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804144	**A-LIFE**	**PE4** Physical and Analytical Chemical Sciences

Principal Investigator: **Dr. CORNELIA MEINERT**
Host Institution: Centre National De La Recherche Scientifique Cnrs, FR

The asymmetry of life: towards a unified view of the emergence of biological homochirality

What is responsible for the emergence of homochirality, the almost exclusive use of one enantiomer over its mirror image? And what led to the evolution of life's homochiral biopolymers, DNA/RNA, proteins and lipids, where all the constituent monomers exhibit the same handedness?

Based on in-situ observations and laboratory studies, we propose that this handedness occurs when chiral biomolecules are synthesized asymmetrically through interaction with circularly polarized photons in interstellar space. The ultimate goal of this project will be to demonstrate how the diverse set of heterogeneous enantioenriched molecules, available from meteoritic impact, assembles into homochiral pre-biopolymers, by simulating the evolutionary stages on early Earth. My recent research has shown that the central chiral unit of RNA, ribose, forms readily under simulated comet conditions and this has provided valuable new insights into the accessibility of precursors of genetic material in interstellar environments. The significance of this project arises due to the current lack of experimental demonstration that amino acids, sugars and lipids can simultaneously and asymmetrically be synthesized by a universal physical selection process.

A synergistic methodology will be developed to build a unified theory for the origin of all chiral biological building blocks and their assembly into homochiral supramolecular entities. For the first time, advanced analyses of astrophysical-relevant samples, asymmetric photochemistry triggered by circularly polarized synchrotron and laser sources, and chiral amplification due to polymerization processes will be combined. Intermediates and autocatalytic reaction kinetics will be monitored and supported by quantum calculations to understand the underlying processes. A unified theory on the asymmetric formation and self-assembly of life's biopolymers is groundbreaking and will impact the whole conceptual foundation of the origin of life.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
804523	**SPECs**	**PE4** Physical and Analytical Chemical Sciences

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

Sustainable plasmon-enhanced catalysis

Industries creating inorganic, organic, and agricultural chemicals use a staggering 4.2% of the worldwide delivered energy, mainly from unsustainable fossil fuels. Meanwhile, the sun provides energy that could be utilized to power photochemical reactions sustainably and cleanly. Recent advances revealing how localized surface plasmon resonances (LSPRs), light-driven electron oscillations in metal nanoparticles, can concentrate light at the molecular scale made the dream of efficient photochemistry one step closer. However, plasmonic materials are almost exclusively constructed from the rare and unsustainable metals Ag and Au. In addition to being incompatible with current industrial practices relying on catalytic surfaces to lower energy barriers and guide reactions, Ag and Au cause prohibitive cost challenges for real-world applications. But there is hope: several of the few metals predicted to sustain LSPRs and become potential alternatives to Ag and Au are amongst the most abundant, i.e. sustainable, elements on Earth (Al, Mg, Na, K).

The way forward, and key objective of my proposal, is thus to design, synthesize, and understand multimetallic nanostructures where a cheap, Earth-abundant plasmonic material traps and concentrates (sun)light directly at a catalytic surface to efficiently and intelligently power and choreograph chemical reactions. To achieve this ambitious goal, I devised a project concurrently advancing important aspects of sustainable plasmon-enhanced catalysis, from the development of two synthetic approaches for Earth-abundant plasmonic-catalysts, to the fundamental studies of light-trapping in these new materials with state-of-the-art numerical and experimental approaches and the unravelling of the relative contribution of plasmon-generated hot electrons, enhanced field, and heat using key model chemical reactions. These results will help develop a more sustainable future by lowering our reliance on both fossil fuels and rare metals.

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

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:
637394	**SILION**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. SHIGEYOSHI INOUE**
Host Institution: Technische Universitaet Muenchen, DE

Design, Synthesis, Characterization and Catalytic Application of Silyliumylidene Ions

This ERC-StG 2014 proposal, SILION, outlines a strategy for the one-pot synthesis, characterization, and reactivity investigation of a positively charged, electron-deficient, highly Lewis acidic, cationic silicon(II) species, denoted “silyliumylidene ions”. Silyliumylidene ion has only four valence electrons, consisting of a lone pair of electrons and two vacant orbitals on the central silicon atom. It will be expected to bear the best combined character of both silylenes as silicon analogue of carbene and silylium ions as silicon analogue of carbenium ions. The program described herein is also aimed at the development of silyliumylidene ion as novel catalysts based on main group elements.

The proposed silyliumylidene ions should fulfil the following criteria:

a) compounds can be synthesized by a facile one-pot reaction of the corresponding dichlorosilane with two equivalents of N-heterocyclic carbenes,

b) silyliumylidene ions will potentially possess three reactive sites including (i) a lone pair at the silicon center, (ii) p-orbital at the silicon center, and (iii) N-heterocyclic carbenes,

c) thanks to their strong sigma-donor as well as pi-acceptor ability, the highly reactive silyliumylidene ions are expected to serve as innovative reagents for activation of organic small molecules, excellent catalysts, and strikingly versatile coordination ligands toward transition metals.

The target of this proposal is the introduction of facile accessible silyliumylidene ions, which are combined the best properties of silylene and silylium ions, and development of its reactivity and catalytic activity. The synthesis of silyliumylidene ions is straightforward and should allow the investigation of electronic and steric properties of the substituents and N-heterocyclic carbenes. It is anticipated that novel silyliumylidene ions can be used for a promising new building block for low-valent organosilicon compounds and high-performance catalysts.

Project End Date: **30-NOV-20**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
670986	**NoNaCat**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. MATTHIAS BELLER**
Host Institution: Leibniz - Institut Fur Katalyse Ev An Der Universitat Rostock, DE

Development of Molecular-defined Non-noble Metal Complexes and Nano-structured Materials for Sustainable Redox Reactions

Development of Molecular-defined Non-noble Metal Complexes and Nano-structured

The major objective of this proposal is the development of new active and selective catalysts based on earth abundant metals (e.g. Fe, Mn, Co, Cu). These catalysts will be used for improved synthetic transformations which are of interest for organic chemistry in general and which are also of significant practical value for the chemical and life science industries. Traditional catalysts based on non-noble metals are not efficient for hydrogenation and dehydrogenation processes under mild conditions. However, by creating a suitable microenvironment with M-N interactions they are becoming active and selective. According to our concept the suitable surrounding will be created either by using nitrogen-containing pincer ligands or nitrogen-doped graphenes. Consequently, a variety of both molecular-defined homogeneous catalysts as well as nano-structured heterogeneous materials will be prepared, characterized and tested in various catalytic applications. More specifically, the following redox transformations will be investigated: Hydrogenation and transfer hydrogenation of carboxylic acids, esters, and nitriles; hydrogenation of amides and peptides; hydrogenation of carbon dioxide and selective oxidative coupling of alcohols to esters, amides, and nitriles. Furthermore, “waste-free” carbon-carbon bond forming reactions such as alkylations with alcohols and domino-synthesis of heterocycles from alcohols will be exploited. Finally, homogeneous and heterogeneous catalysts from earth abundant metals will be used in industrially relevant oxidative carbonylation reactions. With respect to methodology this proposal combines homogeneous with heterogeneous catalysis, which will result in new ideas for both fields.

Project End Date: **30-NOV-20**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
676832	**TagIt**	**PE5** Synthetic Chemistry and Materials

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

A Minimal-Tag Bioorthogonal Labelling Approach to Protein Uptake, Traffic and Delivery

The ability to probe dynamic cellular events involv disease-associated proteins is limited, to a large degree, by the development of a strategy that uses small-sized coupling partners that react in a chemoselective fashion with very rapid kinetics and without interfering with biological function(s) and localisation. In this application. I describe a conceptually novel bioorthogonal approach by combining the introduction of small alkene-tags with chemoselective reactions that display rapid kinetics to label proteins in live cells. The small size of the handles S-allyl cysteine and its nitrogen analogue, which will be genetically encoded, should not interfere with the protein's innate function(s) and localisation. Site-selective bioorthogonal labelling will be achieved through the use of a novel photo-triggered [2+2] cycloaddition with an alkene-fluorophore and the known inverse-electron-demand Diels-Alder reaction with a fluorogenic tetrazine. While the former offers potentially improved spatial and temporal resolution, the latter allows for turn-on fluorescence. The proposed methodology will be applied in the context of interleukin 7 (IL7), a key actor in T-cell acute lymphoblastic leukaemia (T-ALL) progression as well as in other cancers. The ability to label IL7 with minimal perturbation of its structure, function and localisation will enable time-lapsed monitoring of its internalisation and trafficking pathways in Il7 receptor positive cells. In doing so, new biological insight into IL7 biology will be generated that will assist the construction of safer, more selective and more efficient IL7-drug conjugates for T-ALL treatment. The concept here proposed has been designed to be generally applicable to label and study disease-associated proteins that are difficult to access using conventional protein labelling methods constituting the first integrated, interdisciplinary approach for the development of protein-drug conjugates.

Project End Date: **30-SEP-21**

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: Universidade 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-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
678462	**BEGMAT**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. MICHAEL BOJDYS**
Host Institution: Humboldt-Universitaet Zu Berlin, DE

Layered functional materials - beyond 'graphene'

There is an apparent lack of non-metallic 2D-matrials for the construction of electronic devices, as only five materials of the "graphene family" are known: graphene, hBN, BCN, fluorographene, and graphene oxide – none of them with a narrow bandgap close to commercially used silicon. This ERC-StG proposal, BEGMAT, outlines a strategy for design, synthesis, and application of layered, functional materials that will go beyond this exclusive club. These materials "beyond graphene" (BEG) will have to meet – like graphene – the following criteria:
(1) The BEG-materials will feature a transfer of crystalline order from the molecular (pm-range) to the macroscopic level (cm-range),
(2) individual, free-standing layers of BEG-materials can be addressed by mechanical or chemical exfoliation, and
(3) assemblies of different BEG-materials will be stacked as van der Waals heterostructures with unique properties.
In contrast to the existing "graphene family",
(4) BEG-materials will be constructed in a controlled way by covalent organic chemistry in a bottom-up approach from abundant precursors free of metals and critical raw materials (CRMs).
Moreover – and unlike – many covalent organic frameworks (COFs),
(5) BEG-materials will be fully aromatic, donor-acceptor systems to ensure that electronic properties can be addressed on macroscopic scale.
The potential to make 2D materials "beyond graphene" is a great challenge to chemical bond formation and material design. In 2014 the applicant has demonstrated the feasibility of the concept to expand the "graphene family" with triazine-based graphitic carbon, a compound highlighted as an "emerging competitor for the miracle material" graphene. Now, the PI has the opportunity to build a full-scale research program on layered functional materials that offers unique insights into controlled, covalent linking-chemistry, and that addresses practicalities in device manufacture, and structure-properties relationships.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
678565	**STEM**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. JUAN JOSÉ VILATELA**
Host Institution: Fundacion Imdea Materiales, ES

Structural energy harvesting composite materials

The purpose of this project is the development of new multifunctional structural composite materials that combine high-performance mechanical properties and the possibility to harvest energy. The multifunctional composites are based on a continuous macroscopic fibre made up of highly aligned carbon nanotubes that has bulk mechanical, electrical and thermal properties already superior to carbon fibre and the mesoporosity and chemical resistance of an activated carbon; which will be combined with nanostructured semiconductors that can transfer charge/energy when subjected to external stimuli (piezoelectric, photovoltaic) and integrated in a polymer matrix to form composite ply structures. Such composites will be fabricated from bottom to top, resulting in a 3-component hierarchical structure. Load, charge and energy transfer processes at the nanocarbon/inorganic interface, for example, will be carefully controlled through tailoring the structure and optoelectronic properties of the two components during their synthesis, and by exploiting the role of the fibre surface to template the growth of inorganic semiconductors and form an electronic junction. The project comprises a detailed multiscale study of materials synthesis and properties, including in-situ spectroscopy, electron microscopy and synchrotron XRD during mechanical testing, junction characterisation (emission/absorption spectroscopy, impedance) and photocurrent measurements. The uniqueness of the proposal lies in exploiting advanced optoelectronic processes in macroscopic strong composites on a composite ply length-scale, in the quest for a new generation of light-weight multifunctional structural materials.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679124	**NANOCOMP**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. MARIA DEL CARMEN GIMENEZ LOPEZ**
Host Institution: Universidade De Santiago De Compostela, ES

Complex Dynamics of Clusters in High-Aspect Ratio Hollow Nanostructures: A Nanoscale Platform for High-Performance Computing

Practical aspects and understanding of frontier-computing concepts such as memcomputing (a brain-inspired computational paradigm), quantum computing and spintronics are hindered because of the lack of suitable nanostructured materials. The NANOCOMP project aims to develop a technology for the integration of redox and magnetic nano-switches within the confined space of high-aspect ratio hollow carbon nanostructures, yielding a totally new class of hybrid metal-carbon nanomaterials with different dimensionality as model systems enabling the realisation of these computing schemes. This research will also pave the way for developing new energy-storage concepts. The main objectives are: 1) To develop protocols for successful transport and encapsulation of intact nano-switches within tubular carbon nanostructures (TCN); 2) To understand and control the effects of the confined nano-switches on the carbon nanocontainer (and vice versa); 3) To unravel and develop new methodologies for exploiting the functional properties of the confined nano-switches; 4) To fabricate nanodevices, novel 2D ordered arrays and highly-porous 3D networks for a variety of applications ranging from quantum processors to flexible spintronic devices and supercapacitors. For the first time, the interiors of TCN will be exploited for a) memory capacitors that can store energy in addition to information, b) tackling the problem of scalability of single-molecule magnets (qubits) into electronic circuits and c) exploiting the synergy between electron transport and nanomagnetism (solving spin injection in spintronics). This project will open up a new broad horizon for nanomaterials science and its applications, as the proposed approach can be extended not only to different types of carbon nanostructures (fibers & tubes) and nano-switches (with optical properties), but also to other hollow inorganic tubular nanostructures with different chemical composition and properties (TiO2, BN and WS2, among others).

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681491	**Autocat**	**PE5** Synthetic Chemistry and Materials

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

Autocatalysis: A bottom-up approach to understanding the origins of life

The origin of life is not well understood, and is one of the great remaining questions in science. Autocatalytic chemical reactions have been extensively studied with the aim of providing insight into the principles underlying living systems. In biology, organisms can be thought of as imperfect self-replicators, which produce closely related species, allowing for selection and evolution. Autocatalysis is also an important part of many other biological processes.

This project aims to develop new autocatalytic reactions where two simple chemical building blocks come together to give a more complex product, and then the product aggregates to give primitive cell-like structures of "protocells" such as micelles or vesicles. The protocells allow the starting material to mix more efficiently, speeding up the reaction in time and giving rise to complex behaviour of the protocells. These reactions will serve as models that I hope will contribute to understanding how cell-like systems can emerge from simpler chemicals and be relevant to how life started on Earth.

I have explicitly chosen complex areas in which to work where the potential for discovering new phenomena is high. This is a difficult and demanding project, most of the reactions are extremely challenging, but this is risk balanced by working on model reactions. A variety of related projects and contingency plans are proposed, all aimed at demonstrating previously unrealized, but fundamental, behaviour. Finally this project will give the opportunity to study chemical systems that may be able to evolve in time, allow development of useful chemical models of important biological processes, and provide 'bottom-up' approaches to synthetic biology. This research will potentially allow the study of evolution in new ways, develop technology useful to a number of scientific fields, and potentially shed light on the processes that allowed chemistry to become biology on the primitive Earth.

Project End Date: **30-APR-21**

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:
683083	**RAMSES**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. GUIDO CLEVER**
Host Institution: Technische Universitaet Dortmund, DE

Reactivity and Assembly of Multifunctional, Stimuli-responsive Encapsulation Structures

In biochemical systems, combinations of specialized molecular entities are precisely arranged to give highly complex architectures. Sophisticated functionality, such as the selective chemical transformation of substrates in enzymes, emerges from the interplay of the individual components that are often grouped around a nanoscopic cavity. Control mechanisms based on the cooperative binding of signal substances regulate the enzyme's action, and complicated feedback loops may apply.

Since the advent of supramolecular chemistry, scientists construct artificial systems with ever increasing complexity and functionality that promise to serve as the basis for future developments in bottom-up nanotechnology with applications in medicine (drug delivery), diagnostics, catalysis, material science and molecular photonics/electronics.

Self-assembly of functional entities with pre-programmed connectivities has produced an impressive line-up of nanoscopic architectures such as coordination cages that reCoGnize and transform molecular substrates. Most of these systems are based on one sort of ligand, joined by one kind of metal ion. My group has reported a number of cages, each equipped with a unique, single function such as chirality, redox-activity, light-switching, allosteric regulation or endohedral binding sites.

While all these mono-functionalized cages contribute to the progress of supramolecular architecture, nature demonstrates that the key to the most sophisticated systems lies in multi-functionalized structures.

As breakthrough strategies for achieving this level of complexity with artificial systems we propose:

1) Heteroleptic coordination of ligands by a [Pd2Ligand4]-platform-specific way of steric fine-tuning

2) Biopolymer-inspired folding of a modular chain of covalently joined building blocks

Combined with our recent achievements in host-guest switching, we aim at adjustable receptors, controllable molecular reaction chambers and multifunctional photo/redox systems

Project End Date: **30-NOV-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694159	**MONACAT**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. BRUNO CHAUDRET**
Host Institution: Centre National De La Recherche Scientifique Cnrs, FR

Magnetism and Optics for Nanoparticle Catalysis

MONACAT proposes a novel approach to address the challenge of intermittent energy storage. Specifically, the purpose is to conceive and synthesize novel complex nano-objects displaying both physical and chemical properties that enable catalytic transformations with a fast and optimum energy conversion. It follows over 20 years of research on “organometallic nanoparticles”, an approach of nanoparticles (NPs) synthesis where the first goal is to control the surface of the particles as in molecular organometallic species. Two families of NPs will be studied: 1) magnetic NPs that can be heated by excitation with an alternating magnetic field and 2) plasmonic NPs that absorb visible light and transform it into heat. In all cases, deposition of additional materials as islands or thin layers will improve the NPs catalytic activity. Iron carbides NPs have recently been shown to heat efficiently upon magnetic excitation and to catalyse CO hydrogenation into hydrocarbons. In order to transform this observation into a viable process, MONACAT will address the following challenges: determination and control of surface temperature using fluorophores or quantum dots, optimization of heating capacity (size, anisotropy of the material, crystallinity, phases: FeCo, FeNi, chemical order), optimization of catalytic properties (islands vs core-shell structures; Ru, Ni for methane, Cu/Zn for methanol), stability and optimization of energy efficiency. A similar approach will be used for direct light conversion using as first proofs of concept Au or Ag NPs coated with Ru. Catalytic tests will be performed on two heterogeneous reactions after deposition of the NPs onto a support: CO2 hydrogenation into methane and methanol synthesis. In addition, the potential of catalysis making use of self-heated and magnetically recoverable NPs will be studied in solution (reduction of arenes or oxygenated functions, hydrogenation and hydrogenolysis of biomass platform molecules, Fischer-Tropsch).

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694610	**SUPRABIOTICS**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. ANDREAS HERRMANN**
Host Institution: Dwi Leibniz-Institut Fur Interaktive Materialien Ev, DE

Supramolecular Protective Groups Enabling Antibiotics and Bioimaging

The pharmaceutical sector has a huge demand for new active compounds including natural products to fill the drug pipelines and to stop the global decline in novel approved active pharmaceutical ingredients. Therefore, developing new tools to fabricate complex molecular structures in a fast and reliable way is paramount. This holds especially true for the field of antibiotics. Multidrug resistant (MDR) pathogens evolve at a terrifying rate and confer resistance to all presently available antibacterial treatments and therefore WHO has identified MDR bacteria as major threat to human health.

In this ERC Advanced Grant, I propose a radically new approach to fabricate very complex molecules with minimal synthetic effort. The technology is based on nucleic acid binders (aptamers), which are evolved in a selection protocol and block several functional groups within a target molecule while allowing other functionalities not in contact with the aptamer to be selectively modified in a single reaction step. Here, we aim to establish this groundbreaking aptameric protective group (APG) method as a novel tool that gives access to compounds that would otherwise be too difficult to obtain by multistep synthesis. Toward this end, the specific objectives are:

- To develop reagents and reactions that are compatible with aptamer-mediated reactions
- To control the site of chemical modification within complex molecules by APGs
- To establish APGs as a general paradigm in natural product derivatization to modify several kinds of substrates
- To achieve site selective modification of proteins by aptamers
- To synthesize novel antibiotics that kill MDR bacteria
- To fabricate “image-and-activate” antibiotics by the APG technology
- To employ the aptamer-target complexes for live-cell imaging of RNA

The outcomes will enable future advances in drug discovery and drug design, bioimaging technologies, and the site-specific modification of therapeutic proteins.

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

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:
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:
716139	**INSPIRAL**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. MICHAL JURICEK**
Host Institution: Universitaet Zuerich, CH

Spin-Delocalization with a Twist: Chiral Open-Shell Helices

Spin-delocalization in molecules containing unpaired electrons gives rise to an unusual intermolecular interaction, named as pancake bond. This bonding interaction couples unpaired electrons between multiple pairs of atoms from each face-to-face oriented spin units, such as phenalenyl radical, and abets formation of assemblies that display large antiferromagnetic interaction in the solid state. This phenomenon governs the potential use of such spin systems as molecular conductors, magneto-optical bistable materials, or molecular spin batteries. Formation of such assemblies during crystallization is spontaneous. It is therefore difficult to control and tune the antiferromagnetic interaction, which dictates the electronic properties of the solid material. Inspired by this challenge, the goal of this project is to develop systems, where the spin-interaction can be tuned within a single molecule to understand principles that govern an intermolecular assembly in the solid state and the bulk properties.

To achieve this goal, I propose to synthesize and study chiral open-shell helices, in which the intramolecular spin-interaction can be tuned by varying (1) the coupling mode, ferromagnetic versus antiferromagnetic, and (2) its strength. The helical character of these systems enables tuning of the coupling strength by control of the degree of overlap and distance between the spin units, which is difficult to achieve by a spontaneous assembly. Additionally, it provides access to both racemic and enantiopure solid-state architectures that can further impact the properties. Two model systems will be investigated: one in which spins communicate simultaneously through backbone and space, and one where spins communicate only through space. Understanding the principles of spin-interactions in these helical systems is of fundamental interest for designing molecules with tailor-made properties, as well as features that arise unexpectedly from the interplay of the spins in a spiral.

Project End Date: **31-MAR-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:
716472	**VAPORE**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. ROB AMELOOT**
Host Institution: Katholieke Universiteit Leuven, BE

Vapor deposition of crystalline porous solids

Metal-organic frameworks (MOFs) are crystalline solids with highly regular pores in the nanometer range. The possibility to create a tailored nano-environment inside the MOF pores makes these materials high-potential candidates for integration with microelectronics, e.g. as sensor coatings, solid electrolytes, etc. However, current solvent-based methods for MOF film deposition, a key enabling step in device integration, are incompatible with microelectronics fabrication because of contamination and corrosion issues.

VAPORE will open up the path to integrate MOFs in microelectronics by developing a solvent-free chemical vapor deposition (CVD) route for MOF films. MOF-CVD will be the first example of vapor-phase deposition of any type of microporous crystalline network solid and marks an important milestone in processing such materials. Development of the MOF-CVD technology platform will start from a proof-of-concept case and will be supported by the following pillars: (1) Insight in the process, (2) expansion of the materials scope and (3) fine-tuning process control. The potential of MOF-CVD coatings will be illustrated in proof-of-concept sensors.

In summary, by growing porous crystalline films from the vapor phase for the first time, VAPORE implements molecular self-assembly as a scalable tool to fabricate highly controlled nanopores. In doing so, the project will enable cross-fertilization between the worlds of nanoscale chemistry and microelectronics, two previously incompatible fields.

Project End Date: **30-NOV-21**

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:
725184	**MULTIPROSMM**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. FABRICE POINTILLART**
Host Institution: Centre National De La Recherche Scientifique Cnrs, FR

MULtiple PROperties Single Molecule Magnets

The goal of the MULTIPROSMM project is to design systems able to present magnetic bistabilities under different stimuli (temperature, magnetic field or light) on an unprecedented large temperature range, i.e. very low temperature with Single Molecule Magnet (SMM) behaviour, intermediate temperature with Light Induced Excited State Trapping (LIESST) and high temperature with SpinCrossOver (SCO). On one hand, as a photography of the energy-splitting of the spectroscopic states, the lanthanide luminescence will be used as a key tool for the understanding of the magnetic properties of lanthanide ions. On the other hand, Circularly Polarized Luminescence (CPL) combines the sensitivity of the luminescence with crucial information on the chiral environment. A step by step synthetic strategy will be used to elaborate molecular systems in which the coexistence of i) SMM and SCO; ii) SMM and CPL and iii) SMM, SCO and CPL are operating. The enhancement of the magnetic properties is needed to step forward towards applications. To reach such optimizations, the quantum regime of the SMM and the internal magnetic field must be vanished playing with the hyperfine coupling and magnetic dilutions. Both isotopic enrichment and shaping (i.e. decoration of both mesoporous silica and nanoparticle surfaces) of the designed systems could allow high magnetic performance in multiple properties SMM. The final result could be a system suitable for very high density data storage on a wide temperature range (from cryogenic to room temperature).

Project End Date: **31-JUL-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 Universitaet 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:
756277	**ATMEN**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. TOMA SUSI**
Host Institution: Universitat 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:
757913	**NovAnI**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. ANNA KATHARINA HERTA HIRSCH**
Host Institution: Helmholtz-Zentrum Fuer Infektionsforschung Gmbh, DE

Indentification and optimisation of novel anti-infective agents using multiple hit-identification strategies

Given the rapid emergence of anti-infective resistance, drugs with a novel mode of action are urgently needed. Because of an exhaustion of existing strategies, a low return on investment and the fact that anti-infectives are difficult to develop (e.g., crossing the peculiar cell wall of Mycobacterium tuberculosis), promising un(der)explored targets and unconventional hit-identification strategies are needed.

I have selected three anti-infective targets based on their biochemical context for which few or no small-molecule inhibitors are known:

1) The antimalarial and antituberculotic drug target DXS is part of a unique biosynthetic pathway for pathogens that is absent in humans, thereby circumventing selectivity issues. Both diseases are a serious health threat with around 1.9 million deaths per year.
2) Energy-coupling factor transporters are essential vitamin importers for pathogens such as Staphylococcus aureus, the causative agent of methicillin-resistant Staphylococcus aureus (MRSA) infections.
3) The DNA polymerase sliding clamp DnaN has polymerase and DNA repair activities and is an excellent drug target for the development of antibacterial agents against Gram-negative and –positive bacteria given the low incidence of resistance development.

I will address these targets, employing a unique combination of potentially synergistic hit-identification strategies that take into account protein flexibility, provide access to novel scaffolds and give me a cutting edge for the development of novel anti-infectives.

This ERC proposal builds on my experience with the first two targets and provides an excellent platform for the new target DnaN. My expertise in synthetic organic and medicinal chemistry and established hit-identification strategies together with my collaborations with protein crystallographers, biochemists and pharmacologists place me in an excellent position for not only achieving the goals of this interdisciplinary proposal but also going beyond it.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758345	**DISCOVER**	**PE5** Synthetic Chemistry and Materials

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

Design of Mixed Anion Inorganic Semiconductors for Energy Conversion

Multi-component systems offer the chemical and structural flexibility necessary to meet the needs of next-generation energy conversion. The vast majority of work in the field has focused on mixed-metal compounds. DISCOVER will computationally explore mixed-anion compounds. These are complex systems that provide significant technical challenges for atomistic and electronic structure modelling. Currently, structure-property relationships are poorly developed and there is a distinct lack of understanding of order-disorder transitions. Crucially, no systematic approach has been established for designing new combinations which can be tailored to match the criteria for technological applications.

This project aims to utilize advanced computational techniques to: (i) understand trends in existing mixed anion systems, and (ii) to employ state of the art crystal structure prediction codes to investigate novel ternary and quaternary mixed-anion compositions. The structure-property information emanating from this analysis will allow us to develop design principles for mixed anion semiconductors, which we will use to predict prototype systems for energy conversion. Promising candidates will be experimentally tested through a collaborative network of experts in the field. This ambitious project will push the boundaries of computational materials design, through the use of both classical and electronic structure simulation techniques for bulk, surface and excited states calculations.

The principle outcome will be a novel understanding of how to controllably design mixed anion semiconductors for technological applications, which will drive this material class to the forefront of materials science, while establishing my group at the frontier of computational materials science.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
758913	**GlycoEdit**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. THOMAS BOLTJE**
Host Institution: Stichting Katholieke Universiteit, NL

New Chemical Tools for Precision Glycotherapy

Glycosylation, the expression of carbohydrate structures on proteins and lipids, is found in all the domains of life. The collection of all glycans found on a cell is called the “glycome” which is information rich and a key player in a plethora of physiological and pathological processes. The information that the glycome holds can be written, read and erased by glycosyltransferases, lectins and glycosidases, respectively. The immense structural complexity and the fact that glycan biosynthesis is not under direct genetic control makes it very difficult to study the glycome.

The glycosylation pattern of cancer cells is very different from that of healthy cells. It is still unclear whether aberrant glycosylation of cancer cells is a cause or consequence of tumorigenesis but it is associated with aggressive and invasive forms of cancer and hence poor prognosis. Malignant glycans are directly involved in a number of mechanisms that suppress the immune response, increase migration and extravasation (metastasis), block apoptosis and increase resistance to chemotherapy.

The aim of this proposal is develop new glycomimetics that can be used to edit the glycome of cancer cells to target such evasive mechanisms. Using combinations of new glycan based inhibitors, a coordinated attack on the cancer glycome can be carried out which is expected to severely cripple the cancers ability to grow and metastasize. This will make the tumor more susceptible to immune mediated killing which may be further enhanced in combination with other anti-cancer strategies.
To minimize systemic side effects, new methods for the local delivery/activation of glycan inhibitors will be developed. The developed methods are expected to have a much broader than just cancer alone since the studied mechanisms are also associated with autoimmune and neurodegenerative disease.

Project End Date: **31-OCT-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:
769599	**ECO-ZEN**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. MICHAEL INGLESON**
Host Institution: The University Of Manchester, UK

Enabling Catalytic Cross Couplings with only Zinc Electrophiles, Nucleophiles and Boranes

This high-impact, challenging CoG Proposal integrates multiple novel ideas in boron and zinc chemistry into an overarching project to open up new horizons across synthesis and catalysis. The Applicant's successful ERC StG has opened up new avenues of pioneering research in main group element mediated transformations that were not conceivable before the work was done. Components of this proposal extend out from the StG into new, exciting research areas that are completely different. Developing low toxicity earth abundant catalysts for important transformations is vital to the EU with the focus herein being on; (i) the Suzuki-Miyaura (S-M) cross coupling reaction which is ubiquitous in industry and academia, and (ii) the formation of organoboranes that are essential synthetic intermediates. Both of these are currently dominated by toxic, expensive and low abundance precious metal catalysts (e.g. Pd, Ir). This project will deliver innovation through utilising combinations of main group Lewis acids and nucleophilic anions that do not react with each other, i.e. are frustrated pairs. This "frustration" enables the two species to concertedly transform substrates to achieve:

(i) precious metal-free S-M cross coupling reactions of sp3C electrophiles catalysed by zinc and boron compounds, including stereospecific couplings and one pot two step cross electrophile couplings

(ii) trans-elementoboration of alkynes, including the unprecedented fluoroboration of alkynes

Other new approaches will be developed to access novel (hetero)arylboronic acid derivatives using only simple boranes and without requiring noble metal catalysts, specifically: (i) boron directed C-H borylation and (ii) directed ortho borylation to enable subsequent meta selective SEAr C-H functionalisation.

This CoG will afford the freedom and impetus via consolidated funding to undertake fundamental research to deliver high impact results, including developing a new area of cross coupling catalysis research.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771443	**DYNAFLUORS**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. MARC VENDRELL ESCOBAR**
Host Institution: The University Of Edinburgh, UK

Dynamic Activatable Fluorophores

In DYNAFLUORS I will develop the first chemical toolbox for imaging in real time the activity of immune cells in tumours.
Although the management of cancer has improved over the years, the cure rates for patients with metastasis and advanced tumours remain low due to lack of appropriate therapies. Recent studies suggest that drugs empowering host immune cells (i.e. immunotherapies) are promising approaches for intractable tumours. However, there are no tools to visualise and understand how host immune cells stop cancer progression in vivo. This important unmet challenge drives the ambitious targets of this proposal.

Over the past 10 years, I have pioneered the development of chemical fluorophores that allow unparalleled analysis of biological systems. In this project, I will implement an innovative approach to unify cutting-edge methodologies in chemistry and biology and develop Dynamic Activatable Fluorophores (DYNAFLUORS) as a chemical toolbox with enhanced imaging capabilities over current technologies.

The cross-disciplinary and ambitious nature of this project will open multiple avenues for broad impact in many areas of chemistry as well as in basic biology, imaging and medicine. DYNAFLUORS will allow us to image, from the molecular level to human tissue, the activity of immune cells in tumours and the response to therapy in real time. This ground-breaking chemical platform will represent a step forward in the forefront of chemical imaging and will create new opportunities in the personalised management of cancer.

In the long term, DYNAFLUORS will become a transformative toolbox for monitoring disease in humans. The integration of functional fluorophores into imaging technologies to perform 'optical biopsies' in vivo and to create patient-specific drug-response assays has the potential to revolutionise the diagnosis, stratification and personalised treatment of disease.

Project End Date: **31-MAY-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:
786734	**Herifuel**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. RICHARD WINPENNY**
Host Institution: The University Of Manchester, UK

Heterometallic Rings for Future Electronics

The proposal is to use our great synthetic control to examine the use of heterometallic cyclic coordination compounds (heterometallic rings, HRs) in two distinct application areas. One is of immediate impact: the use of the HRs as resist materials for lithography. This work has already been patented and is being developed as a means to fabricate devices that will be needed at the 7 nm node and smaller. The synthetic control also means we can make resists for extreme UV lithography (13 nm wavelength) which meet the tight specifications needed for industrial application. The second application is more long term, which is the proposal that such rings could be used as qubits in quantum information processing. Here we will build on recent work that has established a diamagnetic matrix in which complex polymetallic assembly could be incorporated. This gives us the opportunity of performing algorithms during the project and hence laying the ground-work for future developments.

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:
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:
788231	**ProgrES**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. SABINE FLITSCH**
Host Institution: The University Of Manchester, UK

Programmable Enzymatic Synthesis of Bioactive Compounds

Enzymes are now established as highly selective biocatalysts in organic synthesis with the range of catalysts and reactions rapidly increasing through access to large protein databases and high-throughput molecular biology tools for biocatalyst engineering. The diversity of biocatalytic reactions is now at a stage where they can be linked in (chemo)-enzymatic reaction cascades, where two or more chemical and/or enzymatic reactions can be catalysed simultaneously generating de novo biosynthetic pathways for chemical synthesis not found in Nature. These reaction cascades have demonstrated important prior art, however they have been mostly limited to few steps and lack the complexity provided by the natural pharmacopeia. ProgrES aims to achieve a step-change by introducing unprecedented structural complexity into de novo pathways and by moving away from manual to automated, high-throughput cascade design and implementation. The proposal is to use a transdisciplinary approach that addresses three important bottlenecks: i. Identification of enzymatic reactions that allow early functionalisation and late stage diversification of the cascade toolkit to increase structural complexity, building on C-H activation mediated by monooxygenases, which are well established in our research group. ii. As diversity of targets increases, high resolution structural analysis of pathway intermediates and products becomes a bottleneck, which is addressed by high-throughput label free mass spectrometry based analytical tools that will match the demands on timescale and numbers. iii. In parallel, we will establish bioinformatics tools adapted from both chemical synthesis and biosynthesis, to allow programmable enzymatic synthesis for cascade design. As proof-of-concept and test bed for the ProgrES platform we aim to generate a library of diverse synthetic imino sugars. This proposal will lead to a major breakthrough in creating a diverse range of scaffolds of therapeutic interest.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802940	**inCITe**	**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:
803092	**EMAGIN2D**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. EFRÉN NAVARRO-MORATALLA**
Host Institution: Universitat De Valencia, ES

Electrical control of magnetism in multiferroic 2D materials

The avenue of magnetism in the field of 2D materials has marked the ultimate milestone in the discovery of one-atom-thick classes of materials. Bulk ferromagnets and antiferomagnets now have their 2D counterparts and are at one's provision for the realization of imagination-limited artificial layered structures. At the same time, this awaited breakthrough has brought in new conundrums that demand investigation. This project is driven by the exploration of the limits of van der Waals 2D magnets from both a fundamental physics and a materials science and devices point of view. Firstly, it addresses fundamental key questions regarding spin order at the true 2D limit, which remain a mystery to the date. Here, the great variety of magnetic anisotropies exhibited by the transition metal halides will shed new light to the subtle equilibrium of interactions in few-layer magnets. Secondly, the project will invoke the control of the magnetic ground states and spin textures in true 2D magnets via electrical manipulation. Electric fields will assist in tuning the magnetic coupling and critical behaviour and the spatial manipulation of spin topologies. Anticipated breakthroughs will be the enhancement of the critical temperature in semiconducting single layer magnets towards room temperature 2D magnetism and the realization of single-layer multiferroic 2D materials. Thirdly, the field effect electrical control of magnetism in designer van der Waals and lateral heterostructures will allow for an enhanced magneto-electric coupling, yielding functional devices for effective charge-to-spin transduction that hold promise in spintronics. The proposal will achieve success by an integral approach to research, through the combination of the study of solid-state growth techniques together with the implementation of state-of-the-art deterministic manipulation of 2D materials in inert conditions and the use high resolution magnetism probes to test hybrid magnetic-optoelectronic devices.

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

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:
804665	**3D-PXM**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. HUGH SIMONS**
Host Institution: Danmarks Tekniske Universitet, DK

3D Piezoresponse X-ray Microscopy

Polar materials, such as piezoelectrics and ferroelectrics are essential to our modern life, yet they are mostly developed by trial-and-error. Their properties overwhelmingly depend on the defects within them, the majority of which are hidden in the bulk. The road to better materials is via mapping these defects, but our best tool for it – piezoresponse force microscopy (PFM) – is limited to surfaces. 3D-PXM aims to revolutionize our understanding by measuring the local structure-property correlations around individual defects buried deep in the bulk.

This is a completely new kind of microscopy enabling 3D maps of local strain and polarization (i.e. piezoresponse) with 10 nm resolution in mm-sized samples. It is novel, multi-scale and fast enough to capture defect dynamics in real time. Uniquely, it is a full-field method that uses a synthetic-aperture approach to improve both resolution and recover the image phase. This phase is then quantitatively correlated to local polarization and strain via a forward model. 3D-PXM combines advances in X-Ray optics, phase recovery and data analysis to create something transformative. In principle, it can achieve spatial resolution comparable to the best coherent X-Ray microscopy methods while being faster, used on larger samples, and without risk of radiation damage.

For the first time, this opens the door to solving how defects influence bulk properties under real-life conditions. 3D-PXM focuses on three types of defects prevalent in polar materials: grain boundaries, dislocations and polar nanoregions. Individually they address major gaps in the state-of-the-art, while together making great strides towards fully understanding defects. This understanding is expected to inform a new generation of multi-scale models that can account for a material's full heterogeneity. These models are the first step towards abandoning our tradition of trial-and-error, and with this comes the potential for a new era of polar materials.

Project End Date: **31-DEC-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:
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:
819698	**T2DCP**	**PE5** Synthetic Chemistry and Materials

Principal Investigator: **Dr. XINLIANG FENG**
Host Institution: Technische Universitaet Dresden, DE

Development of Thiophene Based Conjugated Polymers in Two Dimensions

The proceeding inexorable digitalisation of modern economics and society creates a steadily increasing demand on smart devices in the context of the industrial internet and the internet of things. To meet future requirements, organic electronics is a disruptive technology featuring low-cost, robust, lightweight, flexible and affordable devices based on organic small molecules and polymers. In contrast to the boosting development of linear conjugated polymers and their applications in organic electronics, the successive increase of dimensionality by connecting multiple strands towards two-dimensional (2D) conjugated polymers remains largely unexplored. In this project, we will develop unprecedented thiophene-based double- and triple-strand conjugated polymers to 2D conjugated polymers (T2DCPs) for organic electronics with tailorable electronic band gap at the molecular level for superior performance in terms of charge carrier mobility, and defect tolerance enabled by the increased dimensionality. In this respect, we aim to establish versatile but also reliable solution-based synthesis strategies (one-pot solvothermal, two-step metal-templating reaction and interfacial soft-templating route) employing thiophene monomers rendering T2DCPs with entirely C=C/Ar-Ar backbone. We will further establish ground-breaking one-pot synthesis of donor-acceptor type T2DCPs featuring lower band gap and unique charge transport behavior. By employing designed thiophene-based monomers and linkage topologies, we will accomplish optical and energy gap engineering, control of the molecular weight (or crystalline domain size), and conjugation channel densities. The consequence is that we will explore the key functions of this intriguing class of semiconducting polymers. As the key achievements, we expect to establish a novel solution-based chemistry, delineation of reliable structure-property relationships and superior device performance of T2DCPs for organic field effect transistors.

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-Universitat 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:
647544	**PAW**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. ANDERS MØLLER**
Host Institution: Aarhus Universitet, DK

Automated Program Analysis for Advanced Web Applications

Web applications that execute in the user's web browser constitute a substantial part of modern software. JavaScript is the main programming language of the web, although alternatives are emerging, in particular, TypeScript and Dart. Despite the advances in design of languages and libraries, it is difficult to prevent errors when programming such web applications.
Although the basic principles of software verification have been known for decades and researchers have developed an abundance of techniques for formal reasoning about programs, modern software has lots of errors, as everyday users can testify.

The PAW project will create novel automated program analysis algorithms for preventing errors and improving performance of advanced web applications. The project hypothesis is that a scientific breakthrough is within reach, due to recent results by the PI and others in static and dynamic program analysis for JavaScript. The central idea is to combine static and dynamic analysis in new ways and approach the main challenges from two sides:

1) Web applications, especially libraries and frameworks, contain complex uses of dynamic language features that obstruct existing static analysis techniques. The PAW project will address this by integrating concrete execution into static analysis.

2) Web applications are driven by events, which makes it difficult to test all relevant scenarios. The PAW project will enhance the coverage for automated testing by incorporating abstract domains into test scripts and using symbolic execution.

In addition, the project will demonstrate to the research community that it is possible, in contrast to the current dominant practice, to make program analysis algorithms and infrastructure available in a form that embraces reusability.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
670077	**AMPLify**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. TOBY WALSH**
Host Institution: Technische Universitat Berlin, DE

Allocation Made PracticaL

Allocation Made PracticaL

The AMPLify project will lay the foundations of a new field, computational behavioural game theory that brings a computational perspective, computational implementation, and behavioural insights to game theory. These foundations will be laid by tackling a pressing problem facing society today: the efficient and fair allocation of resources and costs. Research in allocation has previously considered simple, abstract models like cake cutting. We propose to develop richer models that capture important new features like asynchronicity which occur in many markets being developed in our highly connected and online world. The mechanisms currently used to allocate resources and costs are limited to these simple, abstract models and also do not take into account how people actually behave in practice. We will therefore design new mechanisms for these richer allocation problems that exploit insights gained from behavioural game theory like loss aversion. We will also tackle the complexity of these rich models and mechanisms with computational tools. Finally, we will use computation to increase both the efficiency and fairness of allocations. As a result, we will be able to do more with fewer resources and greater fairness. Our initial case studies in resource and cost allocation demonstrate that we can improve efficiency greatly, offering one company alone savings of up to 10% (which is worth tens of millions of dollars every year). We predict even greater impact with the more sophisticated mechanisms to be developed during the course of this project.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679127	**ProFoundNet**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. ALEXANDRA SILVA**
Host Institution: University College London, UK

Probabilistic Foundations for Networks

In an ever-connected world, increasingly complex network systems play a crucial role in many daily tasks. This results in an acute need for methods/tools that can enable easy control of the network and, at the same time, provide rigorous guarantees about its behavior, performance, and security. Recent years saw the growth of a new software ecosystem -Software-defined networking (SDN)- which advocates a clean and open interface between networking devices and the software that controls them. Yet, existing SDN languages do not support reasoning about crucial quantitative aspects, such as: ``How much congestion is there?'' or ``Is the network resilient under failure?''. Enabling compositional quantitative reasoning is the major breakthrough needed to fully realize the vision of SDN.

The central objective of this project is to develop new abstractions for programming of networks, with high-level modular constructs. We will provide rigorous semantic probabilistic foundations, enabling quantitative reasoning. This will serve as a solid platform for program analysis tools where compositional reasoning about complex interactions will be a reality. Our goal will be achieved through an interdisciplinary research effort: using techniques from concurrency and formal methods, areas where akin challenges can be found in the quest to design correct software systems. We will leverage the wealth of recent advances in those areas (some of which from the PI's own research) to networks, and bring awareness and new challenges arising from applications in networking to the other two communities.

The project will significantly advance the foundations of network programming/verification in new and previously unexplored directions. This line of research will not only result in fundamental theoretical contributions and insights in their own right but will also impact the practice of network programming and lead to new and more powerful techniques for the use of engineers and programmers.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681872	**DEMIURGE**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. MAURO BIRATTARI**
Host Institution: Universite Libre De Bruxelles, BE

Automatic Design of Robot Swarms

The scope of this project is the automatic design of robot swarms. Swarm robotics is an appealing approach to the coordination of large groups of robots. Up to now, robot swarms have been designed via some labor-intensive process.

My goal is to advance the state of the art in swarm robotics by developing the DEMIURGE: an intelligent system that is able to design and realize robot swarms in a totally integrated and automatic way

The DEMIURGE is a novel concept. Starting from requirements expressed in a specification language that I will define, the DEMIURGE will design all aspects of a robot swarm - hardware and control software.

The DEMIURGE will cast a design problem into an optimization problem and will tackle it in a computation-intensive way. In this project, I will study different control software structures, optimization algorithms, ways to specify requirements, validation protocols, on-line adaptation mechanisms and techniques for re-design at run time.

Project End Date: **30-SEP-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681988	**CSP-Infinity**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. MANUEL BODIRSKY**
Host Institution: Technische Universitaet Dresden, DE

Homogeneous Structures, Constraint Satisfaction Problems, and Topological Clones

The complexity of constraint satisfaction problems (CSPs) is a field in rapid development, and involves central questions in graph homomorphisms, finite model theory, reasoning in artificial intelligence, and, last but not least, universal algebra. In previous work, it was shown that a substantial part of the results and tools for the study of the computational complexity of CSPs can be generalised to infinite domains when the constraints are definable over a homogeneous structure. There are many computational problems, in particular in temporal and spatial reasoning, that can be modelled in this way, but not over finite domains. Also in finite model theory and descriptive complexity, CSPs over infinite domains arise systematically as problems in monotone fragments of existential second-order logic.

In this project, we will advance in three directions:
(a) Further develop the universal-algebraic approach for CSPs over homogeneous structures. E.g., provide evidence for a universal-algebraic tractability conjecture for such CSPs.
(b) Apply the universal-algebraic approach. In particular, classify the complexity of all problems in guarded monotone SNP, a logic discovered independently in finite model theory and ontology-based data-access.
(c) Investigate the complexity of CSPs over those infinite domains that are most relevant in computer science, namely the integers, the rationals, and the reals. Can we adapt the universal-algebraic approach to this setting?

Project End Date: **30-SEP-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-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682588	**FADAMS**	**PE6** Computer Science and Informatics

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

Foundations of Factorized Data Management Systems

The objective of this project is to investigate scalability questions arising with a new wave of smart relational data management systems that integrate analytics and query processing. These questions will be addressed by a fundamental shift from centralized processing on tabular data representation, as supported by traditional systems and analytics software packages, to distributed and approximate processing on factorized data representation.

Factorized representations exploit algebraic properties of relational algebra and the structure of queries and analytics to achieve radically better data compression than generic compression schemes, while at the same time allowing processing in the compressed domain. They can effectively boost the performance of relational processing by avoiding redundant computation in the one-server setting, yet they can also be naturally exploited for approximate and distributed processing. Large relations can be approximated by their subsets and supersets, i.e., lower and upper bounds, that factorize much better than the relations themselves. Factorizing relations, which represent intermediate results shuffled between servers in distributed processing, can effectively reduce the communication cost and improve the latency of the system.

The key deliverables will be novel algorithms that combine distribution, approximation, and factorization for computing mixed loads of queries and predictive and descriptive analytics on large-scale data. This research will result in fundamental theoretical contributions, such as complexity results for large-scale processing and tractable algorithms, and also in a scalable factorized data management system that will exploit these theoretical insights. We will collaborate with industrial partners, who are committed to assist in providing datasets and realistic workloads, infrastructure for large-scale distributed systems, and support for transferring the products of the research to industrial users.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
683253	**GraphInt**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. PHILIPPE CUDRE-MAUROUX**
Host Institution: Universite De Fribourg, CH

Principles of Graph Data Integration

The present proposal tackles fundamental problems in data management, leveraging expressive, large-scale and heterogeneous graph structures in order to integrate both unstructured (e.g., text) and structured (e.g., relational) content. Integrating heterogeneous content has become a key hurdle in the deployment of Big Data applications, due to the meteoric rise of both machine and user-generated data storing information in a variety of formats. Traditional integration techniques cleaning up, fusing and then mapping heterogeneous data onto rigid abstractions fall short of accurately capturing the complexity and wild heterogeneity of today's information. Having closely followed the emergence of heterogeneous information sources online, I am convinced that only an interdisciplinary approach drawing both from classical data management and from large-scale Web information processing techniques can solve the formidable data integration challenges that they pose. The following project proposes an ambitious overhaul of information integration techniques embracing the scale and heterogeneity of today's data. I propose the use of expressive and heterogeneous graphs of entities to continuously and dynamically interrelate disparate pieces of content while capturing their idiosyncrasies. The following project focuses on three core issues related to large-scale and heterogeneous information graphs: i) the effective extraction of fined-grained information from unstructured sources and their proper integration into large-scale heterogeneous and probabilistic graphs, ii) the creation of novel physical storage structures and primitives to durably and efficiently manage the profusion of data considered by such graphs using clusters of commodity machines, and iii) the development of logical data abstraction mechanisms facilitating the effective and efficient resolution of complex analytic and data integration queries on top of the physical layer.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694980	**Synth**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. LUC DE RAEDT**
Host Institution: Katholieke Universiteit Leuven, BE

Synthesising Inductive Data Models

Inspired by recent successes towards automating highly complex jobs like programming and scientific experimentation, the ultimate goal of this project is to automate the task of the data scientist when developing intelligent systems, which is to extract knowledge from data in the form of models. More specifically, this project wants to develop the foundations of a theory and methodology for automatically synthesising inductive data models.

An inductive data model (IDM) consists of 1) a data model (DM) that specifies an adequate data structure for the dataset (just like a database), and 2) a set of inductive models (IMs), that is, a set of patterns and models that have been discovered in the data. While the DM can be used to retrieve information about the dataset and to answer questions about specific data points, the IMs can be used to make predictions, propose values for missing data, find inconsistencies and redundancies, etc. The task addressed in this project is to automatically synthesise such IMs from past data and to use these to support the user when making decisions.

It will be assumed that the data set consists of a set of tables, that the end-user interacts with the IDM via a visual interface, and the data scientist via a unifying IDM language offering a number of core IMs and learning algorithms.

The key challenges to be tackled in SYNTH are: 1) the synthesis system must ”learn the learning task”, that is, it should identify the right learning tasks and learn appropriate IMs for each of these; 2) the system may need to restructure the data set before IM synthesis can start; and 3) a unifying IDM language for a set of core patterns and models must be developed.

The approach will be implemented in open source software and evaluated on two challenging application areas: rostering and sports analytics.

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

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:
742178	**ALEXANDRIA**	**PE6** Computer Science and Informatics

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

Large-Scale Formal Proof for the Working Mathematician

Mathematical proofs have always been prone to error. Today, proofs can be hundreds of pages long and combine results from many specialisms, making them almost impossible to check. One solution is to deploy modern verification technology. Interactive theorem provers have demonstrated their potential as vehicles for formalising mathematics through achievements such as the verification of the Kepler Conjecture. Proofs done using such tools reach a high standard of correctness.

However, existing theorem provers are unsuitable for mathematics. Their formal proofs are unreadable. They struggle to do simple tasks, such as evaluating limits. They lack much basic mathematics, and the material they do have is difficult to locate and apply.

ALEXANDRIA will create a proof development environment attractive to working mathematicians, utilising the best technology available across computer science. Its focus will be the management and use of large-scale mathematical knowledge, both theorems and algorithms. The project will employ mathematicians to investigate the formalisation of mathematics in practice. Our already substantial formalised libraries will serve as the starting point. They will be extended and annotated to support sophisticated searches. Techniques will be borrowed from machine learning, information retrieval and natural language processing. Algorithms will be treated similarly: ALEXANDRIA will help users find and invoke the proof methods and algorithms appropriate for the task.

ALEXANDRIA will provide (1) comprehensive formal mathematical libraries; (2) search within libraries, and the mining of libraries for proof patterns; (3) automated support for the construction of large formal proofs; (4) sound and practical computer algebra tools.

ALEXANDRIA will be based on legible structured proofs. Formal proofs should be not mere code, but a machine-checkable form of communication between mathematicians.

Project End Date: **31-AUG-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:
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:
758985	**TrueBrainConnect**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. STEFAN HAUFE**
Host Institution: Charite - Universitaetsmedizin Berlin, DE

Advancing the non-invasive assessment of brain communication in neurological disease

Pathological communication between different brain regions has been implicated in various neurological disorders. However, the computational tools for assessing such communication from neuroimaging data are not sufficiently developed. The goal of TrueBrainConnect is to establish brain connectivity analysis using non-invasive electrophysiology as a practical and reliable neuroscience tool. To achieve this, we will develop novel signal processing and machine learning techniques that address shortcomings in state-of-the-art reconstruction and localization of neural activity from sensor data, the estimation of genuine neural interactions, the prediction of external (e.g., clinical) variables from estimated neural interactions, and the interpretation of the resulting models. These techniques will be thoroughly validated and then made publicly available. We will use the TrueBrainConnect methodology to characterize the neural bases underlying dementia and Parkinson's disease (PD), two of the most pressing neurological health challenges of our time. In collaboration with clinical experts, we will address practically relevant issues such as how to determine the onset of 'freezing' episodes in PD patients, and how to detect different variants and precursors of dementia. The outcome of TrueBrainConnect will be a versatile methodology allowing researchers, for the first time, to reliably estimate and anatomically localize important types of interactions between different brain structures in humans within known confidence bounds. The proposed clinical applications will improve our understanding of the studied diseases and will lay the foundation for the development of novel diagnostic markers for these diseases.

Project End Date: **31-DEC-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:
771527	**Browsec**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. MATTEO MAFFEI**
Host Institution: Technische Universitaet Wien, AT

Foundations and Tools for Client-Side Web Security

The constantly increasing number of attacks on web applications shows how their rapid development has not been accompanied by adequate security foundations and demonstrates the lack of solid security enforcement tools. Indeed, web applications expose a gigantic attack surface, which hinders a rigorous understanding and enforcement of security properties. Hence, despite the worthwhile efforts to design secure web applications, users for a while will be confronted with vulnerable, or maliciously crafted, code. Unfortunately, end users have no way at present to reliably protect themselves from malicious applications. BROWSEC will develop a holistic approach to client-side web security, laying its theoretical foundations and developing innovative security enforcement technologies. In particular, BROWSEC will deliver the first client-side tool to secure web applications that is practical, in that it is implemented as an extension and can thus be easily deployed at large, and also provably sound, i.e., backed up by machine-checked proofs that the tool provides end users with the required security guarantees. At the core of the proposal lies a novel monitoring technique, which treats the browser as a blackbox and intercepts its inputs and outputs in order to prevent dangerous information flows. With this lightweight monitoring approach, we aim at enforcing strong security properties without requiring any expensive and, given the dynamic nature of web applications, statically infeasible program analysis.
BROWSEC is thus a multidisciplinary research effort, promising practical impact and delivering breakthrough advancements in various disciplines, such as web security, JavaScript semantics, software engineering, and program verification.

Project End Date: **31-MAY-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:
787367	**PaVeS**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. JAVIER ESPARZA**
Host Institution: Technische Universitaet Muenchen, DE

Parametrized Verification and Synthesis

Parameterized systems consist of an arbitrary number of replicated agents with limited computational power, interacting to achieve common goals. They pervade computer science. Classical examples include families of digital circuits, distributed algorithms for leader election or byzantine agreement, routing algorithms, and multithreaded programs. Modern examples exhibit stochastic interaction between mobile agents, and include robot swarms, molecular computers, and cooperating ant colonies.

A parameterized system is in fact an infinite collection of systems, one for each number of agents. Current verification technology of industrial strength can only check correctness of a few instances of this collection. For example, model checkers can automatically prove a distributed algorithm correct for a small number of processes, but not for any number. While substantial progress has been made on the theory and applications of parameterized verification, in order to achieve large impact the field has to face three ``grand challenges'':

- Develop novel algorithms and tools for p-verification of classical p-systems that bypass the high complexity of current techniques.

-Develop the first algorithms and tools for p-verification of modern stochastic p-systems.

-Develop the first algorithms and tools for synthesis of correct-by-construction p-systems.

Addressing these challenges requires fundamentally new lines of attack. The starting point of PaVeS are two recent breakthroughs in the theory of Petri nets and Vector Addition Systems, one of them achieved by the PI and his co-authors. PaVeS will develop these lines into theory, algorithms, and tools for p-verification and p-synthesis, leading to a new generation of verifiers and synthesizers.

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:	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:
787703	**PRECRIME**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. PAOLO TONELLA**
Host Institution: Universita Della Svizzera Italiana, CH

Self-assessment Oracles for Anticipatory Testing

One of the long-lasting dreams in science fiction is the ability to arrest criminals before they even commit crimes. Software testing researchers have a similar dream: when the context for a bug manifestation occurs in the field, the goal is to discover and fix the bug before it causes any in-field failure. In fact, current practice of pre-release testing is severely limited when dealing with autonomous AI (Artificial Intelligence) systems (such as self-driving cars, robots, automated traders, virtual doctors and customer service chatbots), running in complex, rapidly changing environments, which cause their run-time adaptation, learning and knowledge acquisition, because pre-release testing cannot exhaustively explore all different contexts and states in which the software will be running.

The PRECRIME project introduces a new, disruptive view on testing, called anticipatory testing and aimed at fixing bugs before they even manifest themselves in the field. Anticipatory testing is activated at run-time by a new type of oracles, called self-assessment oracles, which observe and report unexpected execution contexts. A self-assessment oracle is an estimator of the system's confidence in being able to handle a new execution context correctly. The goal of anticipatory testing is to anticipate any failure that might occur in the field due to unexpected execution contexts. Whenever an execution context monitored at runtime by self-assessment oracles is estimated as a low confidence context for the system, anticipatory testing exercises the software automatically and extensively in similar contexts. Timely activation of anticipatory testing by runtime observations results in early, anticipatory fault detection. Combined with automated patch synthesis, anticipatory testing leads to the release of a patch for the fault before any software failure occurs in the field.

Project End Date: **31-DEC-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:
803096	**SPEC**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. CLAUDIO ORLANDI**
Host Institution: Aarhus Universitet, DK

Secure, Private, Efficient Multiparty Computation

MPC is a cryptographic technique that allows a set of mutually distrusting parties to compute any joint function of their private inputs in a way that preserves the confidentiality of the inputs and the correctness of the result. Examples of MPC applications include secure auctions, benchmarking, privacy-preserving data mining, etc.

In the last decade, the efficiency of MPC has improved significantly, especially with respect to evaluating functions expressed as Boolean and arithmetic circuits. These advances have allowed several companies worldwide to implement and include MPC solutions in their products.

Unfortunately, it now appears (and it's partially confirmed by theoretical lower bounds) that we have reached a wall with respect to possible optimizations of current building blocks of MPC, which prevents MPC to be used in critical large-scale applications. I therefore believe that a radical paradigm-shift in MPC research is needed in order to make MPC truly practical.

With this project, I intend to take a step back, challenge current assumptions in MPC research and design novel MPC solutions. My hypothesis is that taking MPC to the next level requires more realistic modelling of the way that security, privacy and efficiency are defined and measured. By combining classic MPC techniques with research in neighbouring areas of computer science I will fulfill the aim of the project and in particular:
1) Understand the limitations of current abstract models for MPC and refine them to more precisely capture real world requirements in terms of security, privacy and efficiency.
2) Use the new models to guide the developments of the next generation of MPC protocols, going beyond current performances and therefore enabling large-scale applications.
3) Investigate the necessary privacy-utility trade-offs that parties undertake when participating in distributed computations and define MPC functionalities that encourage cooperation for rational parties.

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:
804476	**SCARE**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. BILLY BRUMLEY**
Host Institution: Tampereen Korkeakoulusaatio Sr, FI

Side-Channel Aware Engineering

As the recent "HeartBleed" bug in OpenSSL demonstrates, the security of cryptographic software and devices cannot be understated. They build the foundation for basic security guarantees such as confidentiality and authentication, enabling technologies such as secure communication. For example, Transport Layer Security enables e-commerce, a 1.9 trillion USD global industry in 2016.

The more modern trend, especially in the embedded space, is towards hardware-assisted security. Here the aim is to leverage hardware to accomplish security goals that are simply unrealistic in software-only solutions. One example is Trusted Execution Environments (TEE) that provide a secure sandbox to execute security-critical software. TEEs, often driven by ARM TrustZone Technology, are present in the majority of smartphones on the market today.

Side-channel analysis (SCA) is a cryptanalytic technique that targets not the formal description of a cryptographic primitive but the implementation of it. Examples of side-channels include power consumption, electro-magnetic radiation, acoustic emanations, and various timings. Attackers then use this auxiliary signal to recover critical algorithm state and, in combination with cryptanalytic techniques, secret key material. This is a young but very active field within security and cryptography stemming from covert channels.

SCA is the focus of SCARE. Objectives include the discovery of next generation covert channels, paving the way for novel SCA classes, and extending these to full-fledged end-to-end SCA attacks by identifying specific vulnerabilities in widely-deployed cryptography software libraries such as OpenSSL and hardware-assisted security technologies such as TEEs. In turn, SCARE will deliver a methodology for SCA security assurance: not just development, evaluation, and deployment of acute countermeasures, but bringing SCA into the product life cycle as part of continuous integration.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
805223	**ScaleML**	**PE6** Computer Science and Informatics

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

Elastic Coordination for Scalable Machine Learning

Machine learning and data science are areas of tremendous progress over the last decade, leading to exciting research developments, and significant practical impact. Broadly, progress in this area has been enabled by the rapidly increasing availability of data, by better algorithms, and by large-scale platforms enabling efficient computation on immense datasets. While it is reasonable to expect that the first two trends will continue for the foreseeable future, the same cannot be said of the third trend, of continually increasing computational performance. Increasing computational demands place immense pressure on algorithms and systems to scale, while the performance limits of traditional computing paradigms are becoming increasingly apparent. Thus, the question of building algorithms and systems for scalable machine learning is extremely pressing. The project will take a decisive step to answer this challenge, developing new abstractions, algorithms and system support for scalable machine learning. In a nutshell, the line of approach is elastic coordination: allowing machine learning algorithms to approximate and/or randomize their synchronization and communication semantics, in a structured, controlled fashion, to achieve scalability. The project exploits the insight that many such algorithms are inherently stochastic, and hence robust to inconsistencies. My thesis is that elastic coordination can lead to significant, consistent performance improvements across a wide range of applications, while guaranteeing provably correct answers. ScaleML will apply elastic coordination to two specific relevant scenarios: scalability inside a single multi-threaded machine, and scalability across networks of machines.
Conceptually, the project's impact is in providing a set of new design principles and algorithms for scalable computation. It will develop these insights into a set of tools and working examples for scalable distributed machine learning.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818616	**DIAPASoN**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. UGO DAL LAGO**
Host Institution: Alma Mater Studiorum-Universita Di Bologna, IT

Differential Program Semantics

Traditionally, program semantics is centered around the notion of program identity, that is to say of program equivalence: a program is identified with its meaning, and programs are considered as equal only if their meanings are the same. This view has been extremely fruitful in the past, allowing for a deep understanding of highly interactive forms of computation as embodied by higher-order or concurrent programs. The byproducts of all this lie everywhere in computer science, from programming language design to verification methodologies. The emphasis on equality — as opposed to differences — is not however in line with the way programs are written and structured in modern complex software systems. Subtasks are delegated to pieces of code which behave as expected only up to a certain probability of error, and only if the environment in which they operate makes this possible deviation irrelevant. These aspects have been almost neglected by the program semantics community until recently, and still have a marginal role. DIAPASON's goal is to study differences between programs as a constitutive and informative concept, rather than by way of relations between them. This will be accomplished by generalizing four major frameworks of program semantics, traditionally used for giving semantics to programs, comparing them, proving properties of them, and controlling their usage of resources: logical relations, bisimulation, game semantics, and linear logic.

Project End Date: **29-FEB-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:
819536	**ScienceGraph**	**PE6** Computer Science and Informatics

Principal Investigator: **Dr. SÖREN AUER**
Host Institution: Gottfried Wilhelm Leibniz Universitaet Hannover, DE

Knowledge Graph based Representation, Augmentation and Exploration of Scholarly Communication

Despite an improved digital access to scientific publications in the last decades, the fundamental principles of scholarly communication remain unchanged and continue to be largely document-based. The document-oriented workflows in science have reached the limits of adequacy as highlighted by recent discussions on the increasing proliferation of scientific literature, the deficiency of peer-review and the reproducibility crisis.

In ScienceGRAPH we aim to develop a novel model for representing, analysing, augmenting and exploiting scholarly communication in a knowledge-based way by expressing and linking scientific contributions and related artefacts through semantically rich, interlinked knowledge graphs. The model is based on deep semantic representation of scientific contributions, their manual, crowd-sourced and automatic augmentation and finally the intuitive exploration and interaction employing question answering on the resulting ScienceGRAPH base.

Currently, knowledge graphs are still confined to representing encyclopaedic, factual information. ScienceGRAPH advances the state-of-the-art by enabling to represent complex interdisciplinary scientific information including fine-grained provenance preservation, discourse capture, evolution tracing and concept drift. Also, we will demonstrate that we can synergistically combine automated extraction and augmentation techniques, with large-scale collaboration to reach an unprecedented level of knowledge graph breadth and depth.

As a result, we expect a paradigm shift in the methods of academic discourse towards knowledge-based information flows, which facilitate completely new ways of search and exploration. The efficiency and effectiveness of scholarly communication will significant increase, since ambiguities are reduced, reproducibility is facilitated, redundancy is avoided, provenance and contributions can be better traced and the interconnections of research contributions are made more explicit and transparent.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677854	**BEACON**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. DENIZ GUNDUZ**
Host Institution: Imperial College Of Science, Technology And Medicine, UK

Hybrid Digital-Analog Networking under Extreme Energy and Latency Constraints

The objective of the BEACON project is to (re-)introduce analog communications into the design of modern wireless networks. We argue that the extreme energy and latency constraints imposed by the emerging Internet of Everything (IoE) paradigm can only be met within a hybrid digital-analog communications framework. Current network architectures separate source and channel coding, orthogonalize users, and employ long block-length digital source and channel codes, which are either suboptimal or not applicable under the aforementioned constraints. BEACON questions these well-established design principles, and proposes to replace them with a hybrid digital-analog communications framework, which will meet the required energy and latency constraints while simplifying the encoding and decoding processes. BEACON pushes the performance of the IoE to its theoretical limits by i) exploiting signal correlations that are abundant in IoE applications, given the foreseen density of deployed sensing devices, ii) taking into account the limited and stochastic nature of energy availability due to, for example, energy harvesting capabilities, iii) using feedback resources to improve the end-to-end signal distortion, and iv) deriving novel converse results to identify fundamental performance benchmarks.

The results of BEACON will not only shed light on the fundamental limits on the performance any coding scheme can achieve, but will also lead to the development of unconventional codes and communication protocols that can approach these limits, combining digital and analog communication techniques. The ultimate challenge for this project is to exploit the developed hybrid digital-analog networking theory for a complete overhaul of the physical layer design for emerging IoE applications, such as smart grids, tele-robotics and smart homes. For this purpose, a proof-of-concept implementation test-bed will also be built using software defined radios and sensor nodes.

Project End Date: **30-SEP-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
678763	**NANOthermMA**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. NEOPHYTOS NEOPHYTOU**
Host Institution: The University Of Warwick, UK

Advanced Simulation Design of Nanostructured Thermoelectric Materials with Enhanced Power Factors

Roughly one-third of all energy consumption ends up as low-grade heat. Thermoelectric (TE) materials could potentially convert vast amounts of this waste heat into electricity and reduce the dependence on fossil fuels. State-of-the-art nanostructured materials with record-low thermal conductivities (κ~1-2W/mK) have recently demonstrated large improvements in conversion efficiencies, but not high enough to enable large scale implementation. Central to this low efficiency problem lies the fact that the Seebeck coefficient (S) and the electrical conductivity (σ), the parameters that determine the TE power factor (σS2), are inversely related. Relaxing this inverse interdependence has never been achieved, and TE efficiency remains low. My recent work in nanostructured materials, however, demonstrated for the first time how such a significant event can be achieved, and unprecedentedly large power factors compared to the corresponding bulk material were reported. This project focuses around four ambitious objectives: i) Theoretically establish and generalize the strategies that relax the adverse interdependence of σ and S in nanostructures and achieve power factors >5× compared to the state-of-the-art; ii) Experimentally validate the theoretical propositions through well-controlled material design examples; iii) Provide a predictive, state-of-the-art, high-performance, electro-thermal simulator to generalize the concept and guide the design of the entirely new nanostructured TE materials proposed. Appropriate theory and techniques will be developed so that the tool includes all relevant nanoscale transport physics to ensure accuracy in predictions. Simulation capabilities for a large selection of materials and structures will be included; iv) Develop robust, 'inverse-design' optimization capabilities within the simulator, targeting maximum performance. In the long run, the simulator could evolve as a core platform that impacts many different fields of nanoscience as well.

Project End Date: **30-JUN-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
678919	**DEEPVISION**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. IVO VELLEKOOP**
Host Institution: Universiteit Twente, NL

Information-age microscopy for deep vision imaging of biological tissue

Modern biology could not exist without the optical microscope. Hundreds of years of research have seemingly developed microscopes to perfection, with one essential limitation: in turbid biological tissue, not even the most advanced microscope can penetrate deeper than a fraction of a millimetre. At larger depths light scattering prevents the formation of an image. DEEP VISION takes a radically new approach to microscopy in order to lift this final limitation.

Microscopes are based on the idea that light propagates along a straight line. In biological tissue, however, this picture is naive: light is scattered by every structure in the specimen. Since the amount of 'non-scattered' light decreases exponentially with depth, a significant improvement of the imaging depth is fundamentally impossible, unless scattered light itself is used for imaging.

In 2007, Allard Mosk and I pioneered the field of wavefront shaping. The game-changing message of wavefront shaping is that scattering is not a fundamental limitation for imaging: using a spatial light modulator, light can be focused even inside the most turbid materials, if 'only' the correct wavefront is known.

DEEP VISION aims to initiate a fundamental change in how we think about microscopy: to use scattered light rather than straight rays for imaging. The microscope of the future is no longer based on Newtonian optics. Instead, it combines new insights in scattering physics, wavefront shaping, and compressed sensing to extract all useful information from a specimen.

Whereas existing microscopes are ignorant to the nature of the specimen, DEEP VISION is inspired by information theory; imaging revolves around a model that integrates observations with statistical a-priori information about the tissue. This model is used to calculate the wavefronts for focusing deeper into the specimen. Simulations indicate that my approach will penetrate at least four times deeper than existing microscopes, without loss of resolution.

Project End Date: **28-FEB-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679228	**L-SID**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. AVI ZADOK**
Host Institution: Bar Ilan University, IL

Light and sound waves in silicon and nonlinear glass waveguides

The interplay of light and sound waves in matter has attracted the attention of researchers for decades and has found many technological applications. Photonic integrated circuits (PICs) provide an exciting playground for such investigations, due to wavelength-scale guiding structures, periodicity in one or two dimensions, and high-quality resonance structures. The objectives of this proposal are to introduce, investigate and employ interactions between guided optical modes and hyper-sonic acoustic waves, within PICs in silicon and in chalCoGenide glass media. Both these platforms are extremely important: silicon for its potential for integration of photonics and digital micro-electronics and mature fabrication technology, and chalCoGenides for their unique nonlinear-optical and photo-sensitive properties. However, the introduction of hyper-sonic acoustic waves to both materials is highly challenging, due to the absence of piezoelectricity.

To address these challenges, this project is based on developing and validating two alternative methods for the generation of high-frequency acoustic waves. First, photo-acoustic absorption of intense, ultrafast laser pulses by periodic, metallic patterns will be employed. The technique is being used in bulk silicon substrates, and will be carried over and adapted for use in silicon and chalCoGenide glass PICs. Second, carefully controlled stimulated Brillouin scattering (SBS) processes will be used to excite acoustic waves along chalCoGenide PICs in a highly localized fashion.

Prospective outcomes include new fundamental insights into the opto-mechanical properties of materials, films and periodic structures; novel functionalities of silicon and chalCoGenide PICs, such as acousto-optic modulation, dynamic gratings and elasto-optic super-lattices; new types of sensors, such as chip-level distributed measurements of strain, temperature and modal profile; and a first look at non-local behaviour of SBS.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679820	**MYKI**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. CHRISTIAN CIPRIANI**
Host Institution: Scuola Superiore Di Studi Universitari E Di Perfezionamento S Anna, IT

A Bidirectional MyoKinetic Implanted Interface for Natural Control of Artificial Limbs

MYKI aims at developing and clinically evaluating a dexterous hand prosthesis with tactile sensing which is naturally controlled and perceived by the amputee. This will be possible by overcoming the conventional approaches based on recording electrical signals from the peripheral nervous system (nerves or skeletal muscles) through the development of a radically new Human-Machine Interface (HMI) based on magnetic field principles, both able to decode voluntary motor commands and to convey sensory feedback to the individual. Core of this system is a multitude of magnets implanted in independent muscles and external magnetic readers/drivers (MRDs) able to (i) continuously localize the movements of the magnets and, at specific times, (ii) induce subtle movements in specific magnets. In fact, as a magnet is implanted it will travel with the muscle it is located in, and its localization will provide a direct measure of the contraction/elongation of that muscle, which is voluntarily controlled by the central nervous system. In this way it will be possible to decode the efferent signals sent by the brain by observing a by-product of the muscle fibres recruitment. On the other hand, a movement induced in the implanted magnet by the external MRD, could provide a perceivable stimulus, conveyed to the brain by means of the peripheral sensory receptors present in the muscle (e.g. muscle spindles or Golgi tendon organ) or in the neighbouring skin (tactile mechanoreceptors). In this way we aim to provide tactile and/or proprioceptive sensory information to the brain, thus restoring the physiological sensorimotor control loop. Remarkably, with passive magnetic tags (that do not require to be powered-on) and wearable readers/drivers, it will be possible to implement a wireless, bidirectional HMI with dramatically enhanced capabilities with respect to the state of the art interfaces, as illustrated in this proposal.

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

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-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
683108	**TransPhorm**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. MELISSA MATHER**
Host Institution: University Of Keele, UK

Single molecule imaging of transmembrane protein structure and function in their native state

TransPhorm will pioneer a transformative technology platform based on Nitrogen Vacancy (NV) magnetometry to enable the structure and function of transmembrane proteins (TMPs) to be studied in their native state with unprecedented sensitivity and resolution. TMPs reside in the membrane of biological cells and are critical to cellular function and communication. It is essential that TMPs are characterised in their native state as their structure and function is dependent on their interaction with the local environment. This is technically demanding and despite previous attempts using a multitude of complementary techniques no single method has provided a suitable solution. Here a breakthrough approach will be taken to demonstrate in situ TMP characterisation with single molecule sensitivity, nanoscale spatial resolution and millisecond measurement speed.

The concepts proposed in TransPhorm are distinct from current implementations of NV magnetometry for detection and mapping of weak magnetic fields originating from external nuclear spins. Here magnetic field mapping will be achieved using a totally new approach based on widefield, high speed structured illumination total internal reflection microscopy. The concepts TransPhorm are built on will also enable structural and functional single molecular characterisation with high specificity by exploiting the outstanding sensitivity to the local environment of Fluorine 19 Nuclear Magnetic Resonance (NMR) reporters and the ion selectivity of Sodium 23 and Potassium 39 NMR spectroscopy.

In short TransPhorm will deliver a ground-breaking technology to far surpass current State-of-the-Art techniques and provide the extreme sensitivity needed to understand the molecular scale dynamic changes that underpin TMP function. Overall the strategy and technologies proposed here will pave an untraveled path to the realisation of nanoscale NMR imaging and deliver tremendous scientific gains.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694209	**Scale-FreeBack**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. CARLOS CANUDAS DE WIT**
Host Institution: Centre National De La Recherche Scientifique Cnrs, FR

Scale-Free Control for Complex Physical Network Systems

Technology achievements were typically built upon fundamental theoretical findings, but nowadays technology seems to be evolving faster than our ability to develop new concepts and theories. Intelligent traffic systems benefit from many technical innovations, for example. Mobile phones, radars, cameras and magnetometers can be used to measure traffic evolution and provide large sets of valuable data. Vehicles can communicate with the network infrastructure, as well as each other. However, these huge technological advances have not been used to the full so far. Traffic lights are far from functioning optimally and traffic management systems do not always prevent the occurrence of congestions. So what is missing? Such systems affect our daily life; why aren't them on pace with technology advances? Possible because they have become far more complex than the analytical tools available for managing them. Systems have many components, communicate with each other, have self-decision-making mechanisms, share an enormous amount of information, and form networks. Research in control systems has challenged some of these features, but not in a very concerted way. There is a lack of "glue" relating the solutions to each other. In the Scale-FreeBack project, it is proposed to approach this problem with a new holistic vision. Scale-FreeBack will first investigate appropriate scale-free dynamic modeling approaches breaking down system's complexity, and then develop control and observation algorithms which are specifically tailored for such models. Scale-FreeBack will also investigate new resilient issues in control which are urgently required because of the increasing connectivity between systems and the external world. Road traffic networks will be used in proof-of-concept studies based on field tests performed at our Grenoble Traffic Lab (GTL) and in a large-scale microscopic simulator.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694504	**SYSDYNET**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. PAUL VAN DEN HOF**
Host Institution: Technische Universiteit Eindhoven, NL

Data-driven Modelling in Dynamic Networks

Dynamic models play a key role in many branches of science. In engineering they have a paramount role in model-based simulation, monitoring, control and optimization. The accuracy of the models is key to their subsequent use in model-based operations. With the growing spatial complexity of engineering systems, e.g., in power networks, transportation networks and industrial production systems, also referred to as cyber-physical systems of systems, there is a strong need for effective modelling tools for dynamic networks, being considered as interconnected dynamic systems, whose spatial topology may change over time.

Data-driven modelling and statistical parameter estimation are established fields for estimating models of dynamical systems on the basis of measurement data from dedicated experiments. The currently available methods, however, are limited to relatively simple structures, as open-loop or closed-loop (controlled) system configurations.

In this project I will make the fundamental step towards data-driven modelling (identification) methods for dynamic networks by developing a comprehensive theory with the target to identify local dynamical models as well as the interconnection structure of the network. I will incorporate the selection of sensing and excitation locations, data synchronization, and the optimal accuracy of estimated models in view of their use for distributed control.
Solving these problems is by far beyond the current abilities of the existing identification frameworks in the systems and control community. My internationally reCoGnized expertise in the field of system identification and model-based control, together with recent work on dynamic networks, warrants the feasibility of the project.
Identification methods for dynamic networks will become essential tools in the high-level future ICT environment for monitoring, control and optimization of these cyber-physical systems of systems, as well as in many other domains of science.

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

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-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694974	**POSTCELL**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. ANGEL LOZANO**
Host Institution: Universitat Pompeu Fabra, ES

Post-Cellular Wireless Networks

POSTCELL aims at laying the foundation for future generations of wireless networks as they move past the reigning cell-centric paradigm and into the post-cellular era. This entails the definition of a new architecture for such networks and the characterization of the ensuing performance. For the future of wireless communications, the implications would be far-reaching.

The growth of wireless traffic is relentless, and it is actually gaining new momentum on account of fresh mechanisms: smartphones, cloud computing, and machine-to-machine communication. As a result, the volume of wireless traffic is poised to increase to truly staggering levels and, to face this challenge, wireless networks need to enter a new stage.

There is a fledging awareness that this challenge can only be fended off by a process of network massification, with two views about it. In the first view, densification is the only strategy through which dramatic improvements can be attained hereafter; this leads to a vision where base stations become tiny and exceedingly abundant. The second view, in turn, is built on the idea of dramatically scaling the number of colocated antennas per base station from the current handful to possibly hundreds. One of the seeds of POSTCELL is that, since neither form of massification can by itself resolve the challenge facing wireless systems, the two forms will have to end up coexisting.

Reconciling these two forms of massification and enabling a truly phenomenal scaling calls for an entirely new architecture where cells and physical base stations become things of the past, replaced by dynamically defined virtual base stations, powerful caches, and the possibility of device clustering, among other leaps forward. The signal processing needs to shift away from base stations, which become deconstructed, so as to gather at new places. POSTCELL seeks to drive this transformation and to gauge the performance of post-cellular wireless networks.

Project End Date: **30-SEP-21**

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:
714663	**APROCS**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. ROLAND TOTH**
Host Institution: Technische Universiteit Eindhoven, NL

Automated Linear Parameter-Varying Modeling and Control Synthesis for Nonlinear Complex Systems

Linear Parameter-Varying (LPV) systems are flexible mathematical models capable of representing Nonlinear (NL)/Time-Varying (TV) dynamical behaviors of complex physical systems (e.g., wafer scanners, car engines, chemical reactors), often encountered in engineering, via a linear structure. The LPV framework provides computationally efficient and robust approaches to synthesize digital controllers that can ensure desired operation of such systems - making it attractive to (i) high-tech mechatronic, (ii) automotive and (iii) chemical-process applications. Such a framework is important to meet with the increasing operational demands of systems in these industrial sectors and to realize future technological targets. However, recent studies have shown that, to fully exploit the potential of the LPV framework, a number of limiting factors of the underlying theory ask a for serious innovation, as currently it is not understood how to (1) automate exact and low-complexity LPV modeling of real-world applications and how to refine uncertain aspects of these models efficiently by the help of measured data, (2) incorporate control objectives directly into modeling and to develop model reduction approaches for control, and (3) how to see modeling & control synthesis as a unified, closed-loop system synthesis approach directly oriented for the underlying NL/TV system. Furthermore, due to the increasingly cyber-physical nature of applications, (4) control synthesis is needed in a plug & play fashion, where if sub-systems are modified or exchanged, then the control design and the model of the whole system are only incrementally updated. This project aims to surmount Challenges (1)-(4) by establishing an innovative revolution of the LPV framework supported by a software suite and extensive empirical studies on real-world industrial applications; with a potential to ensure a leading role of technological innovation of the EU in the high-impact industrial sectors (i)-(iii).

Project End Date: **31-AUG-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:
725046	**TIMING**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. MARCO PECCIANTI**
Host Institution: University Of Sussex, UK

Time-Resolved Nonlinear Ghost Imaging

The proposal addresses major challenges in Terahertz (THz) sensing at the forefront of the experimental and theoretical investigation. The results will have far-reaching implications in complex science, while targeting the next generation of THz imagers, acknowledged as unique diagnostic tools in cross-disciplinary fields in light of the THz's distinctive ability to unambiguously discriminate molecular compounds. The project objectives are: (i) to develop a comprehensive programme for time-resolved, nonlinear statistical imaging, specifically tailored for timesensitive detection and nonlinear generation systems; (ii) to introduce a novel approach to time-sensitive THz microscopy. The Time-Resolved Nonlinear Ghost Imaging (TIMING) will establish approaches for the nonlinear conversion and control of spatially incoherent optical pulses into broadband, lower-frequency radiation. It is tailored for THz technologies and allows reconstructing images without the need of THz sensitive cameras by exploiting a single THz detector and a standard optical imaging system. Such novel approach recalls modern echography, probing the object in the full three-dimensional space, and with resolution beyond the crucial diffraction limit. The newly developed background will have widespread implications in statistical waveform control, particularly suitable for imaging through opaque, i.e. complex, materials. This will directly impact transverse fields like acoustic, microwaves and optics where complex imaging is strongly investigated. The results obtained here will show that THz imaging in a harsh environment is not only feasible, but can provide sub-wavelength resolution.

Project End Date: **31-MAY-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:
742299	**VIDEO HOLOGRAPHY**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. JAN GENOE**
Host Institution: Interuniversitair Micro-Electronica Centrum Vzw, BE

video-rate holographic projection by novel meta-materials

Today, despite many efforts by researchers world-wide, there are no holographic projectors that allow video-rate electronically controlled projection of complex holograms. Optically re-write-able holograms exist, but they are too slow; Acoustically-formed holograms can be switched fast but the image complexity is very limited. We identify the essential roadblock as one that we intend to clear by a breakthrough innovation coming from a combination of electronics, optics and material science.

We propose a radically novel way to make and control holograms, that will be based on the direct, analog, nanometer-resolution and nanosecond-speed control over the local refractive index of a slab waveguide core over several square centimetres. Holograms will be formed by leaky waves evanescent from the waveguide, and controlled by the refractive-index modulation profile in the core. That profile will be controlled and modulated by electrical fields applied with nano-precision through one of the cladding layers of the waveguide. To that end, a novel metamaterial is proposed for this cladding. Also novel driving schemes will be needed to control the new holographic projecting method.

With this combined radical innovation in architecture, materials and driving schemes, it is the goal of this project to fully prove the concept of video-rate electrically-controlled holographic projection. This will be the basis for many future innovations and applications, in domains such as augmented reality, automotive, optical metrology (LIDAR, microscopy, ...), mobile communication, education, safety, etc..., and result in a high economic and social impact.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
742648	**AGNOSTIC**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. BJÖRN OTTERSTEN**
Host Institution: Universite Du Luxembourg, LU

Actively Enhanced CoGnition based Framework for Design of Complex Systems

Parameterized mathematical models have been central to the understanding and design of communication, networking, and radar systems. However, they often lack the ability to model intricate interactions innate in complex systems. On the other hand, data-driven approaches do not need explicit mathematical models for data generation and have a wider applicability at the cost of flexibility. These approaches need labelled data, representing all the facets of the system interaction with the environment. With the aforementioned systems becoming increasingly complex with intricate interactions and operating in dynamic environments, the number of system configurations can be rather large leading to paucity of labelled data. Thus there are emerging networks of systems of critical importance whose CoGnition is not effectively covered by traditional approaches. AGNOSTIC uses the process of exploration through system probing and exploitation of observed data in an iterative manner drawing upon traditional model-based approaches and data-driven discriminative learning to enhance functionality, performance, and robustness through the notion of active CoGnition. AGNOSTIC clearly departs from a passive assimilation of data and aims to formalize the exploitation/exploration framework in dynamic environments. The development of this framework in three applications areas is central to AGNOSTIC. The project aims to provide active CoGnition in radar to learn the environment and other active systems to ensure situational awareness and coexistence; to apply active probing in radio access networks to infer network behaviour towards spectrum sharing and self-configuration; and to learn and adapt to user demand for content distribution in caching networks, drastically improving network efficiency. Although these CoGnitive systems interact with the environment in very different ways, sufficient abstraction allows cross-fertilization of insights and approaches motivating their joint treatment.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
742671	**ARS**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. PAOLO FIORINI**
Host Institution: Universita Degli Studi Di Verona, IT

Autonomous Robotic Surgery

The goal of the ARS project is the derivation of a unified framework for the autonomous execution of robotic tasks in challenging environments in which accurate performance and safety are of paramount importance. We have chosen surgery as the research scenario because of its importance, its intrinsic challenges, and the presence of three factors that make this project feasible and timely. In fact, we have recently concluded the I-SUR project demonstrating the feasibility of autonomous surgical actions, we have access to the first big data made available to researchers of clinical robotic surgeries, and we will be able to demonstrate the project results on the high performance surgical robot “da Vinci Research Kit”. The impact of autonomous robots on the workforce is a current subject of discussion, but surgical autonomy will be welcome by the medical personnel, e.g. to carry out simple intervention steps, react faster to unexpected events, or monitor the insurgence of fatigue. The framework for autonomous robotic surgery will include five main research objectives. The first will address the analysis of robotic surgery data set to extract action and knowledge models of the intervention. The second objective will focus on planning, which will consist of instantiating the intervention models to a patient specific anatomy. The third objective will address the design of the hybrid controllers for the discrete and continuous parts of the intervention. The fourth research objective will focus on real time reasoning to assess the intervention state and the overall surgical situation. Finally, the last research objective will address the verification, validation and benchmark of the autonomous surgical robotic capabilities. The research results to be achieved by ARS will contribute to paving the way towards enhancing autonomy and operational capabilities of service robots, with the ambitious goal of bridging the gap between robotic and human task execution capability.

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

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:
756225	**blackQD**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. EMMANUEL LHUILLIER**
Host Institution: Centre National De La Recherche Scientifique Cnrs, FR

Optoelectronic of narrow band gap nanocrystals

Over the past decades, silicon became the most used material for electronic, however its indirect band gap limits its use for optics and optoelectronics. As a result alternatives semiconductor such as III-V and II-VI materials are used to address a broad range of complementary application such as LED, laser diode and photodiode. However in the infrared (IR), the material challenge becomes far more complex.

New IR applications, such as flame detection or night car driving assistance are emerging and request low cost detectors. Current technologies, based on epitaxially grown semiconductors are unlikely to bring a cost disruption and organic electronics, often viewed as the alternative to silicon based materials is ineffective in the mid-IR. The blackQD project aims at transforming colloidal quantum dots (CQD) into the next generation of active material for IR detection. CQD are attracting a high interest because of their size tunable optical features and next challenges is their integration in optoelectronic devices and in particular for IR features.

The project requires a combination of material knowledge, with clean room nanofabrication and IR photoconduction which is unique in Europe. I organize blackQD in three mains parts. The first part relates to the growth of mercury chalCoGenides nanocrystals with unique tunable properties in the mid and far-IR. To design devices with enhanced properties, more needs to be known on the electronic structure of these nanomaterials. In part II, I propose to develop original methods to probe static and dynamic aspects of the electronic structure. Finally the main task of the project relates to the design of a new generation of transistors and IR detectors. I propose several geometries of demonstrator which for the first time integrate from the beginning the colloidal nature of the CQD and constrain of IR photodetection. The project more generally aims to develop a tool box for the design of the next generation of low cost IR.

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:
757958	**MUSE**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. RICHARD LOPATA**
Host Institution: Technische Universiteit Eindhoven, NL

Multi-perspective Ultrasound Strain Imaging & Elastography

Ultrasound (US) is the modality of choice for imaging and functional measurements of the cardiovascular system due to its high spatial and temporal resolution. In recent years, the use of US has been on the rise owing to huge advancements in acquisition speed and resolution. Nevertheless, because of physical constraints, several issues —limited field-of-view, refraction, resolution and, contrast anisotropy— cannot be resolved using a single probe.

This proposal will aim at tackling these issues introducing Multi-perspective Ultrasound Strain Imaging & Elastography (MUSE). MUSE will push the frontiers of 3-D US imaging by introducing a novel, multi-perspective 3-D US system. The revolutionary system will consist of two synchronously controlled 3-D matrix arrays and advanced signal and image processing to improve geometric and functional measurements (strain, elasticity). Validation will be performed for two applications: cardiac strain imaging in patients with aortic valve stenosis (AoS) and elastography of abdominal aortic aneurysms (AAA).

Fusion of dual-probe data will be challenged and achieved by new algorithms, preserving important features and improving both contrast and field-of-view. Advanced 3-D processing of the raw US data will be developed for motion and strain imaging. A novel compounding technique, fusion strain imaging, will combine multi-perspective strain data to improve accuracy and precision. A comprehensive framework for system verification and validation will be built, comprising US simulations, ex vivo experiments, and in vivo pilot studies on healthy volunteers. The proposed technique will be validated in AoS and AAA patients.

Ultimately, MUSE will introduce a non-invasive, ground-breaking US platform for functional screening and follow-up, and a breakthrough in early diagnosis, clinical decision making, and risk assessment of cardiovascular disease. Moreover, MUSE has the potential to replace invasive or costly imaging modalities with US.

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

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:
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:
771878	**FRECOM**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. DARKO ZIBAR**
Host Institution: Danmarks Tekniske Universitet, DK

Nonlinear-Distortion Free Communication over the Optical Fibre Channel

Motivation. The enormous growth in the Internet of Things and server farms for cloud services has increased the strain on the optical communication infrastructure. By 2025, our society will require data rates that are physically impossible to implement using current state-of-the-art optical communication technologies. This is because fibre-optic communication systems are rapidly approaching their fundamental capacity limits imposed by the Kerr nonlinearity of the fibre. Nonlinear distortion limits the ability to transport and detect the information stream. This is a very critical problem for increasing the data rates of any optical fibre communication system. Proposed research. The only physical quantities not affected by the nonlinearity are eigenvalues, associated with the optical fibre propagation equation. Eigenvalues are thereby ideal candidates for information transport. The concept of eigenvalues is derived under the assumption that the fibre is lossless and that there is no noise in the system which is not strictly correct. Therefore, novel methodologies and concepts for the design of a noise mitigating receiver and a noise robust transmitter are needed to reap the full benefits of optical communication systems employing eigenvalues. This proposal will develop such strategies. This will be achieved by combining, for the first time, the fields of nonlinear optics, optical communication and nonlinear digital signal processing. The results from the project will be verified experimentally, and will form the basis for a new generation of commercial optical communication systems. Preliminary results. Our proof-of-concept results demonstrate, for the first time, that noise can be handled by employing novel receiver concepts. An order of magnitude improvement compared to the state-of-the-art is demonstrated. Environment. The research will be carried out in close cooperation with leading groups at Stanford University and Technical University of Munich.

Project End Date: **28-FEB-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:
773196	**CONSYN**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. HEINZ KOEPPL**
Host Institution: Technische Universitaet Darmstadt, DE

Contextualizing biomolecular circuit models for synthetic biology

Synthetic biology is the bottom-up engineering of new molecular functionality inside a biological cell. Although it aims at a quantitative and compositional approach, most of today's implementations of synthetic circuits are based on inefficient trial-and-error runs. This approach to circuit design does not scale well with circuit complexity and is against the basic paradigm of synthetic biology. This unsatisfactory state of affairs is partly due to the lack of the right computational methodology that can support the quantitative characterization of circuits and their significant context dependency, i.e., their change in behavior upon interactions with the host machinery and with other circuit elements.

CONSYN will contribute computational methodology to overcome the trial-and-error approach and to ultimately turn synthetic circuit design into a rational bottom-up process that heavily relies on computational analysis before any actual biomolecular implementation is considered. In order to achieve this goal, we will work on the following agenda: (i) develop biophysical and statistical models of biomolecular contexts into which the synthetic circuit or synthetic part can be embedded in silico; (ii) devise new statistical inference methods that can deliver accurate characterization of circuits and their context dependency by making use of cutting-edge single-cell experimental data; (iii) derive new context-insensitive circuit designs through in silico sensitivity analysis and application of filtering theory; (iv) optimize protocols and measurement infrastructure using model-based experimental design yielding a better circuit and context characterization; (v) experimentally build synthetic circuits in vivo and in cell-free systems in order to validate and bring to life the above theoretical investigations. We are in the unique position to also address (v) in-house due to the experimental wetlab facilities in our group.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
773228	**IONOS**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. ALIBART FABIEN**
Host Institution: Centre National De La Recherche Scientifique Cnrs, FR

An iono-electronic neuromorphic interface for communication with living systems

While our understanding of the brain have made huge progresses, we are still inefficient in interfacing biological systems with electronics, both in terms of energy and integration potential. Pushed by the need to use conventional computers for building complex systems dedicated to brain interface applications, we have mostly capitalized on technologies and architectures inherits from microelectronic that are intrinsically not adapted to interface living systems. The IONOS project will shift the brain interface paradigm by developing new technologies designed to interact intimately with biological cells and capitalizing heavily on bio-inspiration. To reach this goal, the IONOS project will explore how to sense, stimulate and compute biological signals from in-vitro neural cells' assembly based on iono-electronic materials and devices. These emerging devices offer basics functionalities such as memory, ion-electron signal's transduction, and amplification paving the way to a new field of device and circuit engineering that could efficiently reproduce key biological functions such as learning and spatio-temporal processing of information. This project will demonstrate how these concepts associated to the bio-inspired computing paradigm can unlock our fundamental limitations for communicating with living neural cells. Proof of concept will show how an artificial system can efficiently send, receive and compute information from a biological one, which constitutes the basic of communication.

Project End Date: **31-OCT-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:
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:
802682	**MODES**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. MASSIMILIANO GUASONI**
Host Institution: University Of Southampton, UK

Multimode light shaping: from optical fibers to nanodevices

The project MODES arises in the framework of the emerging interest for nonlinear multimode processes in optical fibers, and wants to extend it to on-chip waveguides and nanoparticles, where the study of the nonlinear multimode dynamics is still on its infancy.
This project is based on a central key-idea: by properly engineering a multimode system, we can shape and master the nonlinear interaction between the modes into play, and finally exploit it for novel applications in several strategic areas.
This project has therefore a dual nature: one key-idea but multidisciplinary, heterogeneous applications. It focuses on 4 main strategic areas (SA) and identifies an objective (OBJ) for each one, which is related to the exploitation of a specific nonlinear multimode process:

SA1: Support technology for Spatial Division Multiplexing (SDM) >>> OBJ1: the project investigates the development of wideband multimode wavelength converters and amplifiers

SA2: High-capacity SDM data-transmission >>>OBJ2: the project investigates the existence of multimode solitons leading to an undistorted, high-quality propagation in multicore and multimode optical fibers

SA3: On-chip infrared optical sources >>>OBJ3: the project targets the development of on-chip, widely tunable optical sources that may be used to selectively detect important environmental gases in the whole infrared spectrum

SA4: Shaping the nonlinear radiation at nanoscale >>>OBJ4: the project aim at developing a new theoretical insight into the way higher-harmonic radiation is emitted in complex nanostructures. Finally, it wants to and to exploit this new knowledge in view of an ultrafast conversion from invisible to visible light.

To conclude, by addressing new theoretical problems and unveiling a new multimode technology, MODES aim at opening new frontiers in nonlinear optics and being pioneer in the field of nonlinear multimode nanophotonics.

Project End Date: **30-NOV-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:
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:
819440	**TIMP**	**PE7** Systems and Communication Engineering

Principal Investigator: **Dr. OREN COHEN**
Host Institution: Technion - Israel Institute Of Technology, IL

Ultrahigh-speed nanometer-scale microscopy

Ultrahigh-speed microscopy at Tera-scale frames per second frame-rate is essential for various applications in science and technology. In particular, it is critical for observing ultrafast non-repetitive events, for which the pump-probe technique is inapplicable. The spatial resolutions of such microscopes is to date limited to the micrometer scale.

I propose to develop such microscopes with nanometric resolution.

The Tera-scale frames per second frame rate microscopes with nanometric resolution will be based on a new approach for ultrahigh-speed imaging that we recently proposed: time-resolved imaging by multiplexed ptychography (TIMP). In TIMP, multiple frames of the object are recovered algorithmically from data measured in a single CCD exposure of a single-shot ptychographic microscope. The frame rate is determined by the light source (burst of pulses) and it is largely uncoupled from the microscope spatial resolution, which can be sub-wavelength. Also important, TIMP yields movies of both the amplitude and phase dynamics of the imaged object. It is simple and versatile, thus it can be implemented across the electromagnetic spectrum, as well as with other waves.

I aim to develop TIMP-based microscopes, in the visible, extreme UV and x-ray spectral regions with Tera-scale frames per second frame rate and nanometric resolution. We will utilize the unprecedented imaging capabilities in applications, including exploring ultrafast phase transitions, ultrafast dynamics in nanostructures, and tracking the spatiotemporal dynamics during passive mode-locking build-up in lasers and Kerr micro-resonators.

This program, if successful, will bring the field of imaging into a new era, where ultrafast dynamics of non-repetitive transient complex-valued objects can be viewed at nanometric resolution.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647863	**COMIET**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. ELENA MARTÍNEZ FRAIZ**
Host Institution: Instituto De Bioingenieria De Cataluna - Ibec, ES

Engineering Complex Intestinal Epithelial Tissue Models

Epithelial barriers protect the body against physical, chemical, and microbial insults. Intestinal epithelium is one of the most actively renewing tissues in the body and a major site of carcinogenesis. Functional in vitro models of intestinal epithelium have been pursued for a long time. They are key elements in basic research, disease modelling, drug discovery, and tissue replacing and have become prime models for adult stem cell research. By taking advantage of the self-organizing properties of intestinal stem cells, intestinal organoids have been recently established, showing cell renewal's kinetics resembling to the one found in vivo. However, the development of in vitro 3D tissue equivalents accounting for the dimensions, architecture and access to the luminal contents of the in vivo human intestinal tissue together with its self-renewal properties and cell complexity, remains a challenge. The goal of this project is to engineer intestinal epithelial tissue models that mimic physiological characteristics found in in vivo human intestinal tissue, to open up new areas of research on human intestinal diseases. The proposed models will address the in vivo intestinal epithelial cell renewal and migration, the multicell-type differentiation and the epithelial cell interactions with the underlying basement membrane while providing access to the luminal content to go beyond the state-of-the-art organoid models. To do this, we propose to develop an experimental setup that combines microfabrication techniques, tissue engineering components and recent advances in intestinal stem cell research, exploiting stem cell self-organizing characteristics. We anticipate this setup to recapitulate the 3D morphology, the spatio-chemical gradients and the dynamic microenvironment of the living tissue. We expect the new device to prove useful in understanding cell physiology, adult stem cell behaviour, and organ development as well as in modelling human intestinal diseases.

Project End Date: **30-NOV-20**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
670747	**FireBar-Concept**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. SERGE BOURBIGOT**
Host Institution: Universite De Lille, FR

MULTI-CONCEPTUAL DESIGN OF FIRE BARRIER: A SYSTEMIC APPROACH

The development of science and technology provides the availability of sophisticated products but concurrently, increases the use of combustible materials, in particular organic materials. Those materials are easily flammable and must be flame retarded to make them safer. In case of fire, people must be protected by materials confining and stopping fire. It is one of the goals of the FireBar-Concept project to design materials and assembly of materials exhibiting low flammability, protecting substrates and limiting fire spread.
The objective of FireBar-Concept is to make a fire barrier formed at the right time, at the right location and reacting accordingly against thermal constraint (fire scenario). This fire barrier can be developed in several ways according to the chemical nature of the material and/or of its formulation:

- Heat barrier formed by inherently flame retarded materials (e.g. mineral fibers, ceramic …) and exhibiting low thermal conductivity (note the assembly of those materials can also provide low thermal conductivity controlling porosity and its distribution)
- Evolution of reactive radicals poisoning the flame and forming a protective ‘umbrella’ avoiding the combustion of the material
- Additives promoting charring of the materials and forming an expanding carbonaceous protective coating or barrier (intumescence)
- Additives forming a physical barrier limiting mass transfer of the degradation products to the flame

The FireBar-Concept project is multidisciplinary and it requires expertise in material science, chemical engineering, chemistry, thermal science and physics. The approach is to make 5 actions linked together by transverse developments (3) according to this scheme: (i) fundamentals of fire barrier, (ii) multi-material and combination of concepts, (iii) modeling and numerical simulation, (iv) design and development of experimental protocols and (v) optimization of the systems.

Project End Date: **31-DEC-20**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677169	**MicroParticleControl**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. SIMON KUHN**
Host Institution: Katholieke Universiteit Leuven, BE

Controlled synthesis of particulate matter in microfluidics

Despite the many advantages of microchemical systems and their successful applications in chemical engineering research, one major drawback greatly limiting their use is their susceptibility to channel clogging for flows containing particulate matter. Hence, the aim of the proposed research is to overcome the challenge of clogging in microfluidic devices and to design microfluidic systems that can tolerate particulate matter and synthesize solid materials according to their specifications (e.g. size, purity, morphology). To reach this goal, we apply a combined experimental and theoretical approach, in which the experimental results will lead to model development reflecting the particle formation and interaction kinetics and their coupling to the hydrodynamics. The novel concept of the proposal is to devise engineering strategies to handle the particulate matter inside the reactor depending on if the solid material is i) an unwanted and insoluble by-product of a reaction, or ii) the target compound (e.g. nanoparticle synthesis or crystallization of organic molecules). Depending on the case we will design different ultrasound application strategies and introduce nucleation sites to control the location of particle formation within the microchannel. This project will provide fundamental insight into the physico-chemical phenomena that result in particle formation, growth and agglomeration processes in continuous flow microdevices, and will provide a theoretical tool for the prediction of the dynamics of particle-particle, particle-wall and particle-fluid interactions, leading to innovative microreactor designs.

Project End Date: **28-FEB-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679086	**COMPASS**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. CAMILLA COLOMBO**
Host Institution: Politecnico Di Milano, IT

Control for Orbit Manoeuvring through Perturbations for Application to Space Systems

Space benefits mankind through the services it provides to Earth. Future space activities progress thanks to space transfer and are safeguarded by space situation awareness. Natural orbit perturbations are responsible for the trajectory divergence from the nominal two-body problem, increasing the requirements for orbit control; whereas, in space situation awareness, they influence the orbit evolution of space debris that could cause hazard to operational spacecraft and near Earth objects that may intersect the Earth. However, this project proposes to leverage the dynamics of natural orbit perturbations to significantly reduce current extreme high mission cost and create new opportunities for space exploration and exploitation.

The COMPASS project will bridge over the disciplines of orbital dynamics, dynamical systems theory, optimisation and space mission design by developing novel techniques for orbit manoeuvring by “surfing” through orbit perturbations. The use of semi-analytical techniques and tools of dynamical systems theory will lay the foundation for a new understanding of the dynamics of orbit perturbations. We will develop an optimiser that progressively explores the phase space and, though spacecraft parameters and propulsion manoeuvres, governs the effect of perturbations to reach the desired orbit. It is the ambition of COMPASS to radically change the current space mission design philosophy: from counteracting disturbances, to exploiting natural and artificial perturbations.

COMPASS will benefit from the extensive international network of the PI, including the ESA, NASA, JAXA, CNES, and the UK space agency. Indeed, the proposed idea of optimal navigation through orbit perturbations will address various major engineering challenges in space situation awareness, for application to space debris evolution and mitigation, missions to asteroids for their detection, exploration and deflection, and in space transfers, for perturbation-enhanced trajectory design.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679646	**PHOTOTUNE**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. ARRI PRIIMÄGI**
Host Institution: Tampereen Korkeakoulusaatio Sr, FI

Tunable Photonic Structures via Photomechanical Actuation

The next frontier in photonics is to achieve dynamic and externally tunable materials that allow for real-time, on-demand control over optical responses. Light is in many ways an ideal stimulus for achieving such control, and PHOTOTUNE aims at devising a comprehensive toolbox for the fabrication of light-tunable solid-state photonic structures. We harness light to control light, by making use of photoactuable liquid-crystal elastomers, which display large light-induced deformations through coupling between anisotropic liquid-crystal order and elasticity brought about by the polymer network.

We will take liquid-crystal elastomers into a new context by intertwining photomechanics and photonics. Specifically, PHOTOTUNE is built around the following two objectives:

(i) Tunable photonic bandgaps and lasing in photoactuable layered structures: The aim is to take photomechanical materials into the scale of optical wavelengths and utilize them in thickness-tunable liquid-crystal elastomer films. Such films will be further integrated into layered structures to obtain photonic crystals and multilayer distributed feedback lasers whose properties can be tuned by light.

(ii) Photomechanical control over plasmonic enhancement on nanostructured elastomeric substrates: Fabrication of metal nanostructures on substrates that can contract and expand in response to light comprises a perfect, yet previously unexplored, nanophotonic platform with light-tunable lattice parameters. We will apply such tunable photoelastomeric substrates for surface-enhanced Raman scattering and phototunable nonlinear plasmonics.

We expect to present a wholly new technological toolbox for tunable optical components and sensing platforms and beyond: The horizons of PHOTOTUNE are as far-reaching as in studying distance-dependent physical phenomena, controlling the speed of light in periodic structures, and designing actively-tunable optical metamaterials.

Project End Date: **30-APR-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679891	**IntelGlazing**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. IOANNIS PAPAKONSTANTINOU**
Host Institution: University College London, UK

Intelligent functional glazing with self-cleaning properties to improve the energy efficiency of the built environment

The latest forecast by the International Energy Agency predicts that the CO2 emissions from the built environment will reach 15.2Gt in 2050, double their 2007 levels. Buildings consume 40% of the primary energy in developed countries with heating and cooling alone accounting for 63% of the energy spent indoors. These trends are on an ascending trajectory - e.g. the average energy demand for air-conditioning has been growing by ~17% per year in the EU. Counterbalancing actions are urgently required to reverse them.

The objective of this proposal is to develop intelligent window insulation technologies from sustainable materials. The developed technologies will adjust the amount of radiation escaping or entering a window depending upon the ambient environmental conditions and will be capable of delivering unprecedented reductions to the energy needed for regulating the temperature in commercial and residential buildings.

ReCoGnising the distinct requirements between newly built and existing infrastructure, two parallel concepts will be developed: i) A new class of intelligent glazing for new window installations, and, ii) a flexible, intelligent, polymer film to retrofit existing window installations. Both solutions will be enhanced with unique self-cleaning properties, bringing about additional economic benefits through a substantial reduction in maintenance costs.

Overall, we aim to develop intelligent glazing technologies that combine: i) power savings of >250 W/m2 of glazing capable of delivering >25% of energy savings and efficiency improvements >50% compared with existing static solutions; ii) visible transparency of >60% to comply with the EU standards for windows ,and, iii) self-cleaning properties that introduce a cost balance.

A number of technological breakthroughs are required to satisfy such ambitious targets which are delivered in this project by the seamless integration of nanotechnology engineering, novel photonics and advanced material synthesis.

Project End Date: **28-FEB-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681434	**EpiMech**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. MARINO ARROYO**
Host Institution: Universitat Politecnica De Catalunya, ES

Epithelial cell sheets as engineering materials: mechanics, resilience and malleability

The epithelium is a cohesive two-dimensional layer of cells attached to a fluid-filled fibrous matrix, which lines most free surfaces and cavities of the body. It serves as a protective barrier with tunable permeability, which must retain integrity in a mechanically active environment. Paradoxically, it must also be malleable enough to self-heal and remodel into functional 3D structures such as villi in our guts or tubular networks. Intrigued by these conflicting material properties, the main idea of this proposal is to view epithelial monolayers as living engineering materials. Unlike lipid bilayers or hydrogels, widely used in biotechnology, cultured epithelia are only starting to be integrated in organ-on-chip microdevices. As for any complex inert material, this program requires a fundamental understanding of the structure-property relationships. (1) Regarding their effective in-plane rheology, at short time-scales epithelia exhibit solid-like behavior while at longer times they flow as a consequence of the only qualitatively understood dynamics of the cell-cell junctional network. (2) As for material failure, excessive tension can lead to epithelial fracture, but as we have recently shown, matrix poroelasticity can also cause hydraulic fracture under stretch. However, it is largely unknown how adhesion molecules, membrane, cytoskeleton and matrix interact to give epithelia their robust and flaw-tolerant resilience. (3) Regarding shaping 3D epithelial structures, besides the classical view of chemical patterning, mechanical buckling is emerging as a major morphogenetic driving force, suggesting that it may be possible design 3D epithelial structures in vitro by mechanical self-assembly. Towards understanding (1,2,3), we will combine a broad range of theoretical, computational and experimental methods. Besides providing fundamental mechanobiological understanding, this project will provide a framework to manipulate epithelia in bioinspired technologies.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681652	**UTOPES**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. LOTHAR WONDRACZEK**
Host Institution: Friedrich-Schiller-Universitat Jena, DE

Unifying concepts in the topological design of non-crystalline materials

Glasses have traditionally been enabling materials to major societal challenges. Significant breakthroughs on many areas of technological progress have been very closely linked to the exploitation of glassy materials. It is strong consensus that this key role will persist in the emerging solutions to major global challenges in living, energy, health, transport and information processing, provided that the fundamental limitations of the presently available empirical or semi-empirical approaches to glass processing can be overcome.

In the coming decade, it is therefore a major task to take the step towards ab initio exploitation of disordered materials through highly-adapted processing strategies. This requires pioneering work and in-depth conceptual developments which combine compositional design, structural evolution and the thermo-kinetics of material deposition into holistic tools. Only those would significantly contribute to solving some of the most urgent materials needs for glass applications in functional devices, be it in the form of thin films, particles or bulk materials.

The present project challenges today's engineering concepts towards the conception of such tools. For that, melt deposition, isothermal deposition from liquid phases, and gas-phase deposition of non-crystalline materials will be treated - within the class of inorganic glasses - in a generalist approach, unified by the understanding that glass formation represents the only strict deviation from self-organization, and that, hence, the evolution of structural complexity in glassy materials can be tailored on any length-scale through adequate processing. Providing a topological scheme for the quantification and chemical tailoring of structural complexity, UTOPES will answer to the challenge of finding order in disorder, and will thus break the grounds for the third generation of glasses with properties beyond what is presently thought as the limits of physical engineering.

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

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:
682001	**BoneImplant**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. GUILLAUME HAIAT**
Host Institution: Centre National De La Recherche Scientifique Cnrs, FR

Monitoring bone healing around endosseous implants: from multiscale modeling to the patient's bed

Implants are often employed in orthopaedic and dental surgeries. However, risks of failure, which are difficult to anticipate, are still experienced and may have dramatic consequences. Failures are due to degraded bone remodeling at the bone-implant interface, a multiscale phenomenon of an interdisciplinary nature which remains poorly understood. The objective of BoneImplant is to provide a better understanding of the multiscale and multitime mechanisms at work at the bone-implant interface. To do so, BoneImplant aims at studying the evolution of the biomechanical properties of bone tissue around an implant during the remodeling process. A methodology involving combined in vivo, in vitro and in silico approaches is proposed.

New modeling approaches will be developed in close synergy with the experiments. Molecular dynamic computations will be used to understand fluid flow in nanoscopic cavities, a phenomenon determining bone healing process. Generalized continuum theories will be necessary to model bone tissue due to the important strain field around implants. Isogeometric mortar formulation will allow to simulate the bone-implant interface in a stable and efficient manner.

In vivo experiments realized under standardized conditions will be realized on the basis of feasibility studies. A multimodality and multi-physical experimental approach will be carried out to assess the biomechanical properties of newly formed bone tissue as a function of the implant environment. The experimental approach aims at estimating the effective adhesion energy and the potentiality of quantitative ultrasound imaging to assess different biomechanical properties of the interface.

Results will be used to design effective loading clinical procedures of implants and to optimize implant conception, leading to the development of therapeutic and diagnostic techniques. The development of quantitative ultrasonic techniques to monitor implant stability has a potential for industrial transfer.

Project End Date: **30-SEP-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682444	**E-motion**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. LOUIS DE SMET**
Host Institution: Wageningen Universiteit, NL

Electro-motion for the sustainable recovery of high-value nutrients from waste water

Current water treatment technologies are mainly aimed to improve the quality of water. High-value nutrients, like nitrate and phosphate ions, often remain present in waste streams. Electro-driven separation processes offer a sustainable way to recover these nutrients. Ion-selective polymer membranes are a strong candidate to achieve selectivity in such processes.

The aim of E-motion is to chemically modify porous electrodes with membranes to introduce selectivity in electro-driven separation processes. New, ultrathin ion-selective films will be designed, synthesized and characterized. The films will be made by successively adsorbing polycations and polyanions onto the electrodes. Selectivity will be introduced by the incorporation of ion-selective receptors. The adsorbed multilayer films will be studied in detail regarding their stability, selectivity and transport properties under varying experimental conditions of salinity, pH and applied electrical field, both under adsorption and desorption conditions.

The first main challenge is to optimize and to understand the film architecture in terms of 1) stability towards an electrical field, 2) ability to facilitate ion transport. Also the influence of ion charge and ion size on the transport dynamics will be addressed. The focus of E-motion is set on phosphate ions, which is rather complex due to their large size, pH-dependent speciation and the development of phosphate-selective materials. Theoretical modelling of the solubility equilibria and electrical double layers will be pursued to frame the details of the electrosorption of phosphate.

E-motion represents a major step forward in the selective recovery of nutrients from water in a cost-effective, chemical-free way at high removal efficiency. The proposed surface modification strategies and the increased understanding of ion transport and ionic interactions in membrane media offer also applications in the areas of batteries, fuel cells and solar fuel devices.

Project End Date: **31-OCT-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: **31-AUG-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695638	**CORREL-CT**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. PHILIP WITHERS**
Host Institution: The University Of Manchester, UK

Correlative tomography

Proposal summary (half page)

The vision is firstly, to develop correlative tomography to radically increase the nature and level of information (morphological, structural and chemical) that can be obtained for a 3D volume of interest (VoI) deep within a material or component by coupling non-destructive (3D+time) X-ray tomography with destructive (3D) electron tomography and, secondly to exploit this new approach to shed light on damage accumulation processes arising under demanding conditions. Successful completion of this project will provide new 3D & 4D insights across many areas and yield key experimental data for multiscale models.

Objective 1: To build the capability of correlative tomography

- To connect platforms across scales and modalities in order to track a VoI that may be located deep below the surface and to combine multiple techniques within a single platform.
- To add new facets to correlative tomography including

+ 3D chemical imaging
+ 3D crystal grain mapping
+ the local stress distribution
+ mechanical performance mapping at the VoI scale

Objective 2: To apply it to gain new insights into damage accumulation

Correlative tomography will provide a much richer multi-faceted hierarchical picture of materials behaviour from life science to food science from geology to cultural heritage. This project will focus specifically on identifying the nucleation, propagation and aggregation of damage processes in engineering materials.

- We will identify and track the mechanisms that control the progressive degradation of conventional bulk engineering materials operating under demanding conditions.
- We will examine the hierarchical strategies nature uses to control failure in natural materials through heterogeneous chemistry, morphology and properties. Alongside this we will examine the behaviour of man-made nano-structured analogues and whether we can exploit some of these strategies.

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

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:
714317	**DAMOC**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. JAVIER RAMON**
Host Institution: Instituto De Bioingenieria De Cataluna - Ibec, ES

Diabetes Approach by Multi-Organ-on-a-Chip

Insulin secretion and insulin action are critical for normal glucose homeostasis. Defects in both of these processes lead to type 2 diabetes (T2D). Unravelling the mechanisms that lead to T2D is fundamental in the search of new molecular drugs to prevent and control this disease. Organ-on-a-chip devices offer new approaches for T2D disease modelling and drug discovery by providing biologically relevant models of tissues and organs in vitro integrated with biosensors. As such, organ-on-a-chip devices have the potential to revolutionize the pharmaceutical industry by enabling reliable and high predictive in vitro testing of drug candidates. The capability to miniaturize biosensor systems and advanced tissue fabrication procedures have enabled researchers to create multiple tissues on a chip with a high degree of control over experimental variables for high-content screening applications. The goal of this project is the fabrication of a biomimetic multi organ-on-a-chip integrated device composed of skeletal muscle and pancreatic islets for studying metabolism glucose diseases and for drug screening applications. Engineered muscle tissues and pancreatic islets are integrated with the technology to detect the glucose consumption, contraction induced glucose metabolism, insulin secretion and protein biomarker secretion of cells. We aim to design a novel therapeutic tool to test drugs with a multi organ-on-a-chip device. Such finding would improve drug test approaches and would provide for new therapies to prevent the loss of beta cell mass associated with T2D and defects in the glucose uptake in skeletal muscle.

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

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 Vzw, 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:
715403	**SmartCore**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. ANNA MARIA COCLITE**
Host Institution: Technische Universitaet Graz, AT

Smart Core/shell nanorod arrays for artificial skin

The replication of the circle of information coming from the environment, to the skin, to an action mediated by the brain, requires a lot of advances in smart technology and materials development. Embedding sensors in smart architectures that record the stimulus from the environment and transform it into action is the objective of artificial skins. At the moment, different sensors have to be implemented in the artificial skin matrix for each stimulus.

The goal of this project is to develop a single multi-stimuli responsive material, which would allow a simplification of the artificial skin and enable unprecedented spatial resolution. The material will be comprised of a smart core, responsive to temperature and humidity, and a piezoelectric shell for pressure sensing. The swelling of the smart core upon stimuli will be sensed by the piezoelectric shell and produce a measurable potential. This architecture will be achieved thanks to the use of novel vapor-based technologies for material processing that allow fabrication at the nanoscale. The advantage of using a dry, vapor-based, polymerization for the smart core is that it will be possible to cumulate different functionalities and engineered composition gradients, which are difficult to obtain by conventional synthesis. Nano-structuration of such materials in core-shell site-specific arrays will allow to create a sensing network with spatial resolution down to 1mm and lower. The network will respond to the stimuli coming from the environment and reCoGnize them in terms of location and type of stimuli.

The successful execution of the SmartCore project will have a strong impact in the design and production of future structures, with consequences in sensoring, biotechnology and tissue engineering.

Project End Date: **30-NOV-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715788	**WoCaFi**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. MICHAEL HUMMEL**
Host Institution: Aalto-Korkeakoulusaatio, FI

Unlocking the Entire Wood Matrix for the Next Generation of Carbon Fibers

WoCaFi envisions a game-changing approach for the production of bio-based carbon fibers in which the drawbacks of traditional cellulose and lignin fibers are entirely bypassed by a new type of hybrid precursor fibers containing simultaneously all wood biopolymers cellulose, hemicellulose and lignin.
These unique fully wood-based multi-component filaments are accessible via a novel ionic liquid-based dry-jet wet spinning technique. The process provides the possibility to orientate lignin and hemicellulose embedded in a cellulose matrix. The special morphology of the resulting composite filaments is envisioned to increase the mechanical properties of thereof derived carbon fibers significantly, targeting 2000 MPa tensile strength and 200 GPa tensile modulus. These bio-based, low cost carbon fibers will reduce the dependency on non-renewable petroleum-based feedstocks and are highly suitable for lightweight applications in the automotive, sports and leisure sectors.
Most distinctively, our technique also enables us to spin wood almost in its native form. Thus, the pretreatment steps and intensity can be reduced drastically and pronounced synergistic effects between the bio-polymers are created. This will lead to higher carbon yields and a significantly enhanced graphitization. In very recent initial trials on a continuous single tow carbonization line we found indicators that the oxidation step, typically accounting for almost 50% of the carbonization heating energy costs, can be reduced or omitted completely depending on the lignin content of the precursor fiber.
This – in combination with activated wood as low cost raw material – would be the absolute game changer in developing low-cost, bio-based carbon fibers.

In this project the PI, who has developed the spinning technique and a strong background in organic chemistry and spinning physics, will lead a group of 2 PhD students and 1 Postdoc. The Postdoc will complement the team with enhanced spectroscopic knowledge.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715832	**NANOPHOM**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. GABRIEL LOZANO**
Host Institution: Agencia Estatal Consejo Superior De Investigaciones Cientificas, ES

Nanophosphor-based photonic materials for next generation light-emitting devices

Energy-efficient and environmentally friendly light sources are an essential part of the global strategy to reduce the worldwide electricity consumption. Light-emitting diodes (LEDs) emerge as a key alternative to conventional lighting, due to their high power-conversion efficiency, long lifetime, fast switching, robustness, and compact size. Nonetheless, their implementation in the consumer electronic industry is hampered by the limited control over brightness, colour quality and directionality of LED emission that conventional optical elements relying on geometrical optics provide.

This project exploits new ways of controlling the emission characteristics of nanophosphors, surpassing the limits imposed by conventional optics, through the use of exciting nanophotonic concepts - an approach that has not been explored so far due to the strong multiple light-scattering that standard micrometre-sized phosphors present. The development of reliable and scalable nanophosphor-based photonic materials will allow ultimate spectral and angular control over the light emission properties, addressing the critical shortcomings of current LEDs. The new optical design of these devices will be based on multilayers, surface textures and nano-scatterers of controlled composition, size and shape, to attain large-area materials possessing photonic properties that will enable a precise management of the visible radiation. To prove and on-demand control over the colour appearance and the angular emission pattern of emitting devices, the project will culminate in an experimental demonstration of two paradigmatic cases: i) directional white-light emission within a narrow angular cone; ii) omnidirectional emission of monochromatic light.

Nanophom will significantly advance our comprehension of fundamental phenomena like the formation of photonic modes in complex optical media to which light can couple, as well as advancing the state of the art of high-efficiency solid-state lighting devices.

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

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:
725142	**FastMat**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. NICOLAS RANC**
Host Institution: Centre National De La Recherche Scientifique Cnrs, FR

Fast determination of fatigue properties of materials beyond one billion cycles

Many mechanical structures are submitted to repeated loadings and can break under stress lower than the ultimate tensile stress. This phenomenon is called the fatigue of materials and can be found in many industrial sectors, such as the transport industry, aeronautic industry and energy production. Fatigue design is thus crucial in engineering and it requires the precise characterization of material behavior under cyclic loadings to ensure the safety and reliability of structures throughout their life. An increase in the life span of a structure or a reduction in the number of maintenance phases leads to an increases in the number of cycles applied to this structure. It is presently common to find mechanical systems subjected to several billion cycles, in what is called the gigacycle fatigue domain. The characterization of the fatigue behavior of materials requires fatigue tests to be conducted until fracture for different stress amplitudes. One problem with this method is the test duration, which becomes excessive and beyond possible, particularly for a very high number of cycles. The goal of FastMat is to develop a new method that reduces considerably the duration of fatigue characterization. This method involves the use of only short interrupted tests coupled with a self-heating measurement to characterize the fatigue behavior for very low stress amplitudes. The scientific objective is to develop simultaneously experimental and numerical tools for the fast determination of fatigue behavior. The experimental approach will be developed to estimate simultaneously the dissipation and the stored energy, which directly reflect fatigue damage. For the numerical approach, discrete dislocation dynamics simulations will be developed to establish links between the fatigue damage associated with the evolution of dislocation structures, the stored energy and the dissipated energy.

Project End Date: **30-JUN-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:
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:
726380	**NanoMOFdeli**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. DAVID FAIREN-JIMENEZ**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

Design of NanoMOFs Capsules for Drug Delivery and Bioimaging.

Cancer is a major health problem worldwide, being the most common cause of death after cardiovascular diseases. The major goal of new anticancer therapies is to specifically kill tumour cells while leaving healthy cells unharmed. A main challenge to achieve this aim is the development of better drugs, including novel treatments based on the use of siRNAs. These macromolecules are potentially the most powerful anti-cancer drugs that exist, but still there is no efficient way of getting them delivered specifically to the tumour. Indeed, lifetime of such molecules is generally too short and therefore need to be protected in a carrier until they are delivered into tumour target cells.

This project focuses in the development of nanocarriers based on metal-organic frameworks (MOFs), one of the most exciting developments in recent porous materials science. The study of the mechanisms that control drug delivery is of critical importance to nanomedicine applications, where nanotechnology has the potential to revolutionise cancer therapy. Given the challenging nature of the drug delivery problem for cancer therapy, this project builds on 4 interrelated main concepts: i) the design of bio-compatible MOFs for drug delivery applications; ii) the post-synthesis engineering of MOFs to enhance stability, controlled drug release, and targeting; iii) the identification of optimal textural properties (i.e. pore size distribution, surface area, pore volume) and surface chemistry of MOFs for siRNA delivery using experiments and molecular simulation techniques; iv) the assessment of their performance in vitro and in vivo, giving a translational dimension to the proposed research. The novelty of this work lies therefore in the synergistic combination of tools from different areas and disciplines (chemistry, biochemical engineering and medicine) to produce advances that are of both fundamental scientific interest and of bioengineering relevance in nanomedicine applications.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
741273	**THUNDERR**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. GIOVANNI SOLARI**
Host Institution: Universita Degli Studi Di Genova, IT

Detection, simulation, modelling and loading of thunderstorm outflows to design wind-safer and cost-efficient structures

Wind actions are crucial for the safety and cost of structures.
The wind climate of Europe and many parts of the world is dominated by synoptic extra-tropical cyclones and mesoscale thunderstorm outflows. Thunderstorms are frequent events causing wind speeds often higher than cyclones.
In spite of an impressive amount of research, there is not yet a model for thunderstorm outflows and their actions on structures like that for cyclones. Thus, thunderstorm actions on structures are still determined using the cyclone model developed half a century ago and engineering practice often leads to unsafe or too expensive construction.
This happens because the complexity of thunderstorms makes it difficult to develop realistic and simple models. Their short duration and small size make the available data very poor. There is a great gap between research in wind engineering and atmospheric sciences.
The realization of an unprecedented wind monitoring network, the role of the PI and his novel vision, a project team leader in wind engineering with interdisciplinary skill in atmospheric sciences, the chance to simulate large-scale thunderstorms in a new unique laboratory, the recent advance in CFD simulations, the success and synergy of previous and on-going projects, and a top host institution represent extraordinary conditions to overcome these shortcomings.
THUNDERR is an acronym of THUNDERstorm that points out the ground-breaking Roar of this project. It aims to detect novel thunderstorm measurements, to create a huge dataset of field acquisitions and a new interpretation of their weather scenarios, to conduct unique wind tunnel tests and CFD analyses, to formulate a thunderstorm model that is physically correct and suitable to develop a loading scheme easily transferable to engineering and codification, to radically change the existing wind loading format and the engineering practice, to design safer and cost-efficient structures producing a deep social and economic impact.

Project End Date: **31-AUG-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:
742930	**INTELLICORR**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. ANNE NEVILLE**
Host Institution: University Of Leeds, UK

Intelligent corrosion management underpinned by advanced engineering science

Our planet's population will continue to grow rapidly; between 2010 and 2025 the population will grow by 1.1bn. Urbanisation and growth of the consumer class in developing countries will lead to unprecedented demands on energy. There is arguably no bigger challenge to society than ensuring the security of affordable and environmentally-sustainable energy.

Hydrocarbons will provide a large proportion of the world's energy for the foreseeable future. There is no escape from the critically low oil price worldwide. Innovation becomes important in this price environment. "Easy" oil has already been found; future supply will come from complex reservoirs requiring enhanced oil recovery (EOR). There is a massive growth in renewables technology; the EU is making steady progress towards its 2020 target. The EU renewables energy share increased from 8% to 15% in the decade to 2013. Energy supply and consumption brings with it the global issue of climate change as emissions from industry and transport increase. Inextricably linked to energy is the reduction of the global carbon footprint and Carbon Capture and Storage (CCS) offers the only real technology that can handle the already produced carbon dioxide.

Corrosion in energy and environmental control linking to energy supply provide the underpinning rationale for this proposal. Corrosion is one of the major life-limiting factors for energy supply (oil and gas, renewables, EOR) and in environmental pollution control (CCS) and is estimated to cost 3% GDP. This proposal brings some of the most exciting experimental and modelling engineering science to create a framework for the intelligent management of corrosion. INTELLICORR will use synchrotron techniques, advanced microscopy, numerical methods and environmental/cost analysis to bring about unprecedented advances in (a) prediction and management of localised pitting corrosion and (b) novel methods for green corrosion protection using the natural corrosion product layer

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
743116	**cool innov**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. OLIVER GUTFLEISCH**
Host Institution: Technische Universitaet Darmstadt, DE

Turning the concept of magnetocaloric cooling on its head

Twenty years of research in magnetocaloric materials has failed to provide the necessary breakthrough that will lead to a commercial realisation of this technology and satisfy the urgent global need for more efficient refrigeration. We strongly believe that this is a result of looking in the wrong direction. The cool innov project will achieve this breakthrough by rethinking the whole concept of caloric cooling. We are rejecting the conventional idea of squeezing the best out of magneto-structural phase-change materials in relatively low magnetic fields, and instead we introduce a second stimulus in the form of pressure so that we can exploit, rather than avoid, the hysteresis that is inherent in these materials. The hysteresis will allow us to lock-in the magnetisation at saturation as the magnetising field is removed, so that magnetic fields persisting over a large area will no longer be required (instead, we can use a very focused field), and then demagnetise the material in a second step with an applied stress, enabling us to extract a lot more heat. In this case we only need to apply the magnetic field to a small volume of material, making it a completely new application for commercially available, high-temperature, YBCO-type, bulk superconducting permanent magnets. With the high-field, multi-stimuli approach proven, we will develop new magneto/mechanocaloric materials that match the new high-field, hysteresis-positive approach and start to fabricate novel heat-exchanger structures using additive manufacturing, so that we can combine a mechanically sound heat exchanger having a complex geometry with locally tailored, magneto/mechanocaloric properties. The success of cool innov will be game changing. We are being very ambitious in targeting a revolution in cooling technology, but if we succeed, we will have a huge impact on global energy consumption through greater efficiency, thanks to the novel energy materials that will be discovered within cool innov.

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:
757343	**ShapingRoughness**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. PASTEWKA LARS**
Host Institution: Albert-Ludwigs-Universitaet Freiburg, DE

Emergence of Surface Roughness in Shaping, Finishing and Wear Processes

Roughness on most natural and man-made surfaces shares a common fractal character from the atomic to the kilometer scale, but there is no agreed-upon understanding of its physical origin. Yet, roughness controls many aspects of engineered devices, such as friction, adhesion, wear and fatigue. Engineering roughness in surface finishing processes is costly and resource intensive. Eliminating finishing steps by controlling roughness in primary shaping or in subsequent wear processes could therefore revolutionize the way we manufacture, but this requires a deep understanding of the relevant processes that is presently lacking. Roughness emerges during mechanical deformation in processes such as folding, scratching or chipping that shape surfaces. Deformation occurs in the form of avalanches, individual bursts of irreversible motion of atoms. The central hypothesis of this project is that roughness is intrinsically linked to these deformation avalanches, which themselves are well-documented to be fractal objects. This hypothesis will be tested in large-scale atomic- and mesoscale simulations of plastic forming and fracture on state of the art high performance computing platforms. Results of these calculations will be used to develop process models for evolving the topography of large surface areas under the action of an external mechanical force, such as experienced in shaping, finishing or wear. In addition to these simulations, a public repository for sharing topography data will be build. This repository is the connection to experiments: It is a database of experimental topographies whose contents will be mined for features identified in simulations. Beyond the present project, this web-repository will advance sharing, visualization and analysis of topography data, and aid researchers to correlate surface topography with surface functionality and processing. Simulations and database lay the foundation for a rational design of surface functionality in manufacturing.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757923	**CAD4FACE**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. SILVIA SCHIEVANO**
Host Institution: University College London, UK

Computational modelling for personalised treatment of congenital craniofacial abnormalities

Craniosynostosis is a group of congenital craniofacial abnormalities consisting in premature fusion (ossification) of one or more cranial sutures during infancy. This results in growth restriction perpendicular to the axis of the suture and promotes growth parallel to it, causing physical deformation of the cranial and facial skeleton, as well as distortion of the underling brain, with potential detrimental effects on its function: visual loss, sleep apnoea, feeding and breathing difficulties, and neurodevelopment delay. Conventional management of craniosynostosis involves craniofacial surgery delivered by excision of the prematurely fused sutures, multiple bone cuts and remodelling of the skull deformities, with the primary goal of improving patient function, while normalising their appearance. Cranial vault remodelling surgical procedures, aided by internal and external devices, have proven functionally and aesthetically effective in correcting skull deformities, but final results remain unpredictable and often suboptimal because of an incomplete understanding of the biomechanical interaction between the device and the skull.

The overall aim of this grant is to create a validated and robust computational framework that integrates patient information and device design to deliver personalised care in paediatric craniofacial surgery in order to improve clinical outcomes. A virtual model of the infant skull with craniosynostosis, including viscoelastic properties and mechano-biology regulation, will be developed to simulate device implantation and performance over time, and will be validated using clinical data from patient populations treated with current devices. Bespoke new devices will be designed allowing for pre-programmed 3D shapes to be delivered with continuous force during the implantation period. Patient specific skull models will be used to virtually test and optimise the personalised devices, and to tailor the surgical approach for each individual case.

Project End Date: **28-FEB-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:
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:
759001	**ImageToSim**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. DOMINIK SCHILLINGER**
Host Institution: Gottfried Wilhelm Leibniz Universitaet Hannover, DE

Multiscale Imaging-through-analysis Methods for Autonomous Patient-specific Simulation Workflows

Due to the intricate process of transferring diagnostic imaging data into patient-specific models, simulation workflows involving complex physiological geometries largely rely on the manual intervention of specially trained analysts. This constitutes a significant roadblock for a wider adoption of predictive simulation in clinical practice, as the associated cost and response times are incompatible with tight budgets and urgent decision-making. Therefore, a new generation of imaging-through-analysis tools is needed that can be run autonomously in hospitals and medical clinics. The overarching goal of ImageToSim is to make substantial progress towards automation by casting image processing, geometry segmentation and physiology-based simulation into a unifying finite element framework that will overcome the dependence of state-of-the-art procedures on manual intervention. In this context, ImageToSim will fill fundamental technology gaps by developing a series of novel comprehensive variational multiscale methodologies that address robust active contour segmentation, upscaling of voxel-scale parameters, transition of micro- to macro-scale failure and flow through vascular networks of largely varying length scales. Focusing on osteoporotic bone fracture and liver perfusion, ImageToSim will integrate the newly developed techniques into an imaging-through-analysis prototype that will come significantly closer to automated operation than any existing framework. Tested and validated in collaboration with clinicians, it will showcase pathways to new simulation-based clinical protocols in osteoporosis prevention and liver surgery planning. Beyond its technical scope, ImageToSim will help establish a new paradigm for patient-specific simulation research that emphasizes full automation as a key objective, accelerating the much-needed transformation of healthcare from reactive and hospital-centered to preventive, proactive, evidence-based, and person-centered.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759212	**MemoMOFEnergy**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. MONIQUE VAN DER VEEN**
Host Institution: Technische Universiteit Delft, NL

Constructing polar rotors in metal-organic frameworks for memories and energy harvesting

I seek to develop new ferroelectrics based on metal-organic frameworks with dipolar rotors. Ferroelectrics are targeted to be used as physically flexible memories and mechanical energy harvesters for biocompatible sensors and implantable monitoring devices.

As ferroelectrics can store and switch their polarity, they can be used as memories. Via the piezoelectric effect, they can harvest mechanical vibrations. The materials most compatible with flexible substrates, are soft matter materials. However, these so far don't meet the requirements. Especially lacking is a combination of i) polarisation stability, ii) a sufficiently low energy barrier for polarisation switching and iii) fast switching. As energy harvesters, soft matter materials are hampered by low piezoelectric coefficients.

The main objective of this proposal is rational design of ferroelectrics by obtaining a fundamental understanding of the relation between structure and properties. I will achieve this by uniquely synthesizing polar rotors into 3D crystalline scaffolds that allow to alter the rotors' nano-environement. I will achieve this via polar ligands in metal-organic frameworks (MOFs). The variability of MOFs allows to tune the nature of the hindrance towards rotation of the polar rotors. The tuneable flexibility allows to regulate the energy harvesting efficiency. Moreover, MOFs have already shown potential as biocompatible materials that can be integrated on physically flexible substrates.

The research consists of i) synthesis of polar rotor MOFs with targeted variations, ii) reliable characterisation and computational modelling of the electronic properties, iii) nanoscopic insight in the switching dynamics. The approach allows to understand how ferro- and piezoelectricity are related to the materials' structure, and hence to develop materials with exceptional performance. My recent observation of the ferroelectric behaviour of a nitrofunctionalised MOF is the basis for this proposal.

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

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:
771575	**PROMOFS**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. JIN-CHONG TAN**
Host Institution: The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Nanoengineering and Processing of Metal-Organic Framework Composites for Photonic Sensors

The project is in the field of nanoporous materials engineering, focusing on the discovery, characterisation and application of metal-organic frameworks (MOFs) as an innovative platform to afford disruptive photonics sensing technology. Compared to the traditional material options (e.g. metal oxides and nitrides), MOFs offer several key advantages. The vast inorganic-organic (hybrid) structural diversity of MOFs implies a huge prospect to tune the desirable physical and chemical properties for engineering bespoke applications. Their 3D crystalline framework meant there is long-range periodicity, translating into continuous pathways to facilitate energy transfer and transport mechanisms. Significantly, the nanoscale pores within MOFs can be used as a vessel to host functional guests, in this context: to confine light-emitting complexes and emissive molecules creating unconventional Guest@MOF photoluminescent systems. Having established the project feasibility through pilot studies and further demonstrated the promising potential to fabricate photonic sensors, it is timely to address the outstanding challenges in this nascent field:-

(1) To establish facile processing of new Guest@MOF photonic materials and composite systems, utilising in-situ nanoscale confinement strategy in conjunction with supramolecular processing method

(2) To characterise photophysical and photochemical properties controlling the performance of Guest@MOF systems, and, to understand fundamental mechanisms at the nanoscale

(3) To employ ab-initio computational modelling to gain deeper insights into host-guest interactions, and, to predict structure-property relations informing the design of customised materials

(4) To innovate in materials patterning technology for versatile materials-to-device manufacturing processes

(5) To apply Guest@MOF materials in nanoengineering of tuneable photonics sensors

(6) To quantify and enhance stability of Guest@MOF materials central to practical applications

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
772418	**INSITE**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. LIESBET GERIS**
Host Institution: Universite De Liege, BE

Development and use of an integrated in silico-in vitro mesofluidics system for tissue engineering

Tissue Engineering (TE) refers to the branch of medicine that aims to replace or regenerate functional tissue or organs using man-made living implants. As the field is moving towards more complex TE constructs with sophisticated functionalities, there is a lack of dedicated in vitro devices that allow testing the response of the complex construct as a whole, prior to implantation. Additionally, the knowledge accumulated from mechanistic and empirical in vitro and in vivo studies is often underused in the development of novel constructs due to a lack of integration of all the data in a single, in silico, platform.

The INSITE project aims to address both challenges by developing a new mesofluidics set-up for in vitro testing of TE constructs and by developing dedicated multiscale and multiphysics models that aggregate the available data and use these to design complex constructs and proper mesofluidics settings for in vitro testing. The combination of these in silico and in vitro approaches will lead to an integrated knowledge-rich mesofluidics system that provides an in vivo-like time-varying in vitro environment. The system will emulate the in vivo environment present at the (early) stages of bone regeneration including the vascularization process and the innate immune response. A proof of concept will be delivered for complex TE constructs for large bone defects and infected fractures.

To realize this project, the applicant can draw on her well-published track record and extensive network in the fields of in silico medicine and skeletal TE. If successful, INSITE will generate a shift from in vivo to in vitro work and hence a transformation of the classical R&D pipeline. Using this system will allow for a maximum of relevant in vitro research prior to the in vivo phase, which is highly needed in academia and industry with the increasing ethical (3R), financial and regulatory constraints.

Project End Date: **31-AUG-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 Cnrs, 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:
789119	**DYNACEUTICS**	**PE8** Products and Processes Engineering

Principal Investigator:	**Dr. ALICIA EL HAJ**
Host Institution:	The University Of Birmingham, UK

Remote control healing: Next generation mechano-nano-therapeutics

Imagine if doctors could heal patients via remote control. Following simple injections into regions of the body, they could activate internal cells by an external bandage. In this way, they could remotely control the ways tissue heal. This Advanced grant sets out to understand, design and develop the mechano-nano-magnetic platform that will underpin this therapeutic strategy for the future – DYNACEUTICS.

Key receptors have been identified such as ion channels, integrins and growth factors which respond to mechanical cues on the membrane and activate downstream pathways. How do we 'bottle' an agonist like a drug which can influence or regulate mechano-sensors on the membrane and can be controlled remotely? This project tackles this complex interdisciplinary question through breakthrough nanotechnologies. We aim to expand and develop a platform technology using magnetic particle tagging which will allow us to direct cells for therapeutic purposes.

Specifically, we aim

• to identify mechano-receptor binding sites on stem and mature cells which will enable remote activation of signalling pathways via magnetic fields,

• to design and test magnetic particles with tailored tagging strategies using single cell through 3D human organoid models to in vivo disease models,

• to tailor and design external remote control devices

• to create clinically relevant treatment modalities for remote control healing.

This proposal presents a unique opportunity to launch a new dynamic treatment platform, DYNACEUTICS, which we propose will extend the therapeutic horizon and provide a new form of remote controlled healing.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802648	**EUVPLASMA**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. OSCAR VERSOLATO**
Host Institution: Stichting Nederlandse Wetenschappelijk Onderzoek Instituten, NL

Laser-driven plasma sources of extreme ultraviolet light for nanolithography

Moore's law is not dead. Keeping it alive is of significant importance to society and to the economy. The prediction that the number of transistors in computer and memory chips doubles every two years, has pushed innovative, disruptive technologies, enabling the smartphone and driving tomorrow's green automotive industries. It changes society.

The density of elements realized on a chip is defined by one essential step in their production: lithography. Moore's law thus provides a challenge to science and industry to develop beyond state of the art lithographic technologies. This challenge is being met by introducing extreme ultraviolet (EUV) lithography in high-volume manufacturing. This is happening right now. Generating the required EUV light – from tin-microdroplet-based laser-driven plasma sources – of sufficient power, reliability, and stability, presents a formidable, multi-faceted task, combining industrial innovations with attractive scientific questions.

My proposal addresses this EUV source challenge through the following objectives: (1) create insight into tin-droplet deformation and fragmentation for optimal target preparation through laser-pulse impact, the first step of the two-step sequence used to produce EUV light; (2) provide understanding of the myriad of atomic plasma processes responsible for the emission of EUV light in the second step of the process; (3) understand and push the fundamental limit of this plasma-conversion of laser light into EUV light; and (4) explain and control how the laser-produced plasma expands. Each of these objectives has a significant potential impact in its own field of science and technology. This proposal as a whole has a further goal, namely to use the knowledge gained to transition from the CO2-laser technology currently in use for driving EUV sources to the superior, modern, solid-state lasers, to achieve the industrial dream of a plasma EUV light source that is one order of magnitude brighter.

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

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 Cnrs, 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: **31-DEC-23**

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:
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:
803621	**LINCE**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. MARIA ROSA ANTOGNAZZA**
Host Institution: Fondazione Istituto Italiano Di Tecnologia, IT

Light INduced Cell control by Exogenous organic semiconductors

LINCE will develop light-sensitive devices based on organic semiconductors (OS) for optical regulation of living cells functions.

The possibility to control the activity of biological systems is a timeless mission for neuroscientists, since it allows both to understand specific functions and to manage dysfunctions. Optical modulation provides, respect to traditional electrical methods, unprecedented spatio-temporal resolution, lower invasiveness, and higher selectivity. However, the vast majority of animal cells does not bear specific sensitivity to light. Search for new materials capable to optically regulate cell activity is thus an extremely hot topic. OS are ideal candidates, since they are inherently sensitive to visible light and highly biocompatible, sustain both ionic and electronic conduction, can be functionalized with biomolecules and drugs. Recently, it was reported that polymer-mediated optical excitation efficiently modulates the neuronal electrical activity.

LINCE will significantly broaden the application of OS to address key, open issues of high biological relevance, in both neuroscience and regenerative medicine. In particular, it will develop new devices for: (i) regulation of astrocytes functions, active in many fundamental processes of the central nervous system and in pathological disorders; (ii) control of stem cell differentiation and tissue regeneration; (iii) control of animal behavior, to first assess device biocompatibility and efficacy in vivo. LINCE tools will be sensitive to visible and NIR light, flexible, biocompatible, and easily integrated with any standard physiology set-up. They will combine electrical, chemical and thermal stimuli, offering high spatio-temporal resolution, reversibility, specificity and yield. The combination of all these features is not achievable by current technologies. Overall, LINCE will provide neuroscientists and medical doctors with an unprecedented tool-box for in vitro and in vivo investigations.

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

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:
804108	**MULT2D**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. TED VAUGHAN**
Host Institution: National University Of Ireland, Galway, IE

Multiscale Mechanics of Bone Fragility in Type-2 Diabetes

Type-2 (T2) Diabetes is associated with a 3-fold increase in bone fracture risk, despite the fact that bone volume is not reduced. This implies that T2 diabetes impairs bone quality, whereby the intrinsic material properties of the bone matrix are altered. However, current diagnostic techniques are unable to predict fracture probability in T2 diabetes as they are based on measures of bone quantity. While it is believed that non-enzymatic cross-linking of organic proteins (also known as AGE accumulation) in the bone matrix is responsible for bone fragility in T2 diabetes, there is a distinct lack of understanding how altered protein configurations impair whole-bone biomechanics. In this project, the applicant will embark on frontier research that will develop a state-of-the-art multiscale computational framework that couples behaviour from the molecular to whole-bone level, providing a basis to interrogate and elucidate the physical mechanisms that are responsible for diabetic bone fragility. A multiscale experimental framework will, for the first time, establish relationships between AGE crosslink-density and whole-bone fragility in animal and human T2 diabetic bone tissue. Together, this data will inform a probabilistic mutli-level model of hip fracture, which will be used to quantitatively evaluate the relationship between hip fracture probability, bone quantity and bone quality. The research programme will also establish a novel strategy for clinical fracture risk assessment that employs existing protocols to measure bone quantity, in combination with a surrogate measure of bone quality. The surrogate measure of bone quality proposed is a systemic measure of AGE content, which is clinically-obtainable through a blood sample and therefore widely-applicable. Overall, the project will provide a ground-breaking advance in our understanding of bone fragility, with remarkable potential to innovate novel solutions for clinical assessment of T2 diabetic bone disease.

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

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:
817615	**CeraText**	**PE8** Products and Processes Engineering

Principal Investigator: **Dr. RAUL BERMEJO**
Host Institution: Montanuniversitaet Leoben, AT

Tailoring Microstructure and Architecture to Build Ceramic Components with Unprecedented Damage Tolerance

Advanced ceramics are often combined with metals, polymers or other ceramics to produce structural and functional systems with exceptional properties. Examples are resistors and capacitors in microelectronics, piezo-ceramic actuators in car injection devices, and bio-implants for hip joint replacements. However, a critical issue affecting the functionality, lifetime and reliability of such systems is the initiation and uncontrolled propagation of cracks in the brittle ceramic parts, yielding in some cases rejection rates up to 70% of components production.

The remarkable “damage tolerance” found in natural materials such as wood, bone or mollusc, has yet to be achieved in technical ceramics, where incipient damage is synonymous with catastrophic failure. Novel “multilayer designs” combining microstructure and architecture could change this situation. Recent work of the PI has shown that tuning the location of “protective” layers within a 3D multilayer ceramic can increase its fracture resistance by five times (from ~3.5 to ~17 MPa·m1/2) relative to constituent bulk ceramic layers, while retaining high strength (~500 MPa). By orienting the grain structure, similar to the textured and organized microstructure found in natural systems such as nacre, the PI has shown that crack propagation can be controlled within the textured ceramic layer. Thus, I believe tailored microstructures with controlled grain boundaries engineered in a layer-by-layer 3D architectural design hold the key to a new generation of “damage tolerant” ceramics.

This proposal outlines a research program to establish new scientific principles for the fabrication of innovative ceramic components that exhibit unprecedented damage tolerance. The successful implementation of microstructural features (e.g. texture degree, tailored internal stresses, second phases, interfaces) in a layer-by-layer architecture will provide outstanding lifetime and reliability in both structural and functional ceramic devices.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818762	**SPECTRACON**	**PE8** Products and Processes Engineering

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

Materials Engineering of Integrated Hybrid Spectral Converters for Next Generation Luminescent Solar Devices

Solar energy conversion will play a key role in our transition to a carbon-neutral society. However, single junction photovoltaic (PV) cells fail to achieve their theoretical efficiency due to an inability to harness all wavelengths of the solar spectrum. Spectral losses may be overcome through the addition of a spectral converter coating to the surface of a finished PV cell, which, through a photoluminescence process, converts solar photons into wavelengths suitable for use. Nonetheless, spectral converters currently fail to deliver their promise to significantly boost PV cell performance due to the difficulties of translating luminescent molecules (lumophores) from solution into efficient solid-state materials.

By considering the lumophore-host material as an integrated unit, rather than discrete components, in SPECTRACON, I take a radically new approach to the design of spectral converters. Organic-inorganic hybrid polymer hosts incorporating covalently-grafted lumophores will be rationally engineered to deliver spectral converters with the tailored optical, structural, viscoelastic and mechanical properties needed for high performance solid-state conversion, which has so far been unattainable. Using cheap materials and a solution-based process suitable for scalable manufacturing, these spectral converters will be integrated with PV cells to realise next generation luminescent solar devices which display record levels of efficiency and reduced costs.

A scientific breakthrough that demonstrates efficient solar spectral conversion in the solid-state would enable immediate deployment of luminescent solar devices to the commercial market, thus accelerating progress to an all-renewables society and delivering unprecedented impact on the quality of life of future generations. Moreover, the fundamental knowledge gleaned on the design of efficient solid-state emitters will open up new frontiers for application in light-emitting displays, optical storage and sensing.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
639459	**PROMISE**	**PE9** Universe Sciences

Principal Investigator: **Dr. JOUNI KAINULAINEN**
Host Institution: Chalmers Tekniska Hoegskola Ab, SE

Origins of the Molecular Cloud Structure

Understanding the physical processes that control the life-cycle of the interstellar medium (ISM) is one of the key themes in the astrophysics of galaxies today. This importance originates from the role of the ISM as the birthplace of new stars, and therefore, as an indivisible component of galaxy evolution. Exactly how the conversion of the ISM to stars takes place is intricately linked to how the internal structure of the cold, molecular clouds in the ISM forms and evolves. Despite this pivotal role, our picture of the molecular cloud structure has a fundamental lacking: it is based largely on observations of low-mass molecular clouds. Yet, it is the massive, giant molecular clouds (GMCs) in which most stars form and which impact the ISM of galaxies most. I present a program that will fill this gap and make profound progress in the field. We have developed a new observational technique that provides an unparalleled view of the structure of young GMCs. I also have developed a powerful tool to study the most important structural characteristics of molecular clouds, e.g., the probability distribution of volume densities, which have not been accessible before. With this program, the full potential of these tools will be put into use. We will produce a unique, high-fidelity column density data set for a statistically interesting volume in the Galaxy, including thousands of molecular clouds. The data set will be unmatched in its quality and extent, providing an unprecedented basis for statistical studies. We will then connect this outstanding observational view with state-of-the-art numerical simulations. This approach allows us to address the key question in the field: Which processes drive the structure formation in massive molecular clouds, and how do they do it? Most crucially, we will create a new, observationally constrained framework for the evolution of the molecular cloud structure over the entire mass range of molecular clouds and star formation in the ISM.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679633	**EXO-ATMOS**	**PE9** Universe Sciences

Principal Investigator: **Dr. JEAN-MICHEL DESERT**
Host Institution: Universiteit Van Amsterdam, NL

Exploring the Plurality of New Worlds: Their Origins, Climate and Habitability

Recent surveys have revealed an amazing, and yet unexplained, diversity of planets orbiting other stars. The key to understanding and exploiting this diversity is to study their atmospheres. This is because exoplanets' atmospheres are unique laboratories that hold the potential to transform our understanding of planet formation, physics, and habitability. This is a new opportunity to place the Solar System and the Earth's ecosystem in a broader context; one of the main goals of modern astrophysics.

The aim of this proposal is to leverage exoplanet detections, as well as observational capabilities and theoretical frameworks, to deepen and broaden our understanding of planetary physics. This project will transform the field of exoplanet atmospheres by contributing to three major advances. We will: i) push exoplanet characterization new frontiers by providing the largest in-depth study of atmospheres through the measurements of precise spectra, and the retrieval of their composition, in order to constrain their origins; ii) reveal for the first time global exo-climate through a novel method to probe atmospheric structure and dynamics; and iii) pioneer an innovative approach that uses robotic small telescopes to estimate the impact of stellar radiation on atmospheres, with a particular focus on their habitability. Theses objectives will be achieved via an ambitious portfolio of cutting-edge observations, combined with state-of-the-art modelling for their interpretation. Their accomplishment would be a major breakthrough, culminating in a comprehensive comparative exoplanetology, which in turn will open up new key discoveries in planetary formation and evolution. Our expertise will also enable predictions on conditions for habitability and direct the search atmospheric biosignatures with upcoming capabilities. The impact of our discoveries will go well beyond the scientific community since the quest of our origins is of interest to mankind.

Project End Date: **28-FEB-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679852	**RadFeedback**	**PE9** Universe Sciences

Principal Investigator: **Dr. STEFANIE WALCH-GASSNER**
Host Institution: Universitaet Zu Koeln, DE

The radiative interstellar medium

The pressure, radiation, and ionization from the warm (UV emitting) and hot (X-ray emitting) gas has a significant impact on the cold, star-forming interstellar medium. We propose to carry out a comprehensive 3D study of the turbulent, multi-phase ISM in different environments that includes, for the first time, a proper treatment of UV and X-ray emission from stellar (primary) sources and extended (secondary) sources like cooling shock fronts and evaporating clouds. We do this by means of massively parallel, high-resolution 3D simulations that capture the complex interplay of gravity, magnetic fields, feedback from massive stars (ionizing radiation, radiation pressure, stellar winds, supernovae), heating and cooling including X-rays and cosmic rays, and chemistry. We are developing a novel, original and highly efficient method to accurately treat the transfer of radiation from multiple point and extended sources in the 3D simulations. Radiation and chemistry will be coupled to achieve self-consistent heating, cooling, and ionization rates. Moreover, accurate synthetic observations covering the large dynamic range from X-rays down to radio emission will be generated to set the results in the proper observational context. This will enable us to address the key science questions: How efficient is stellar feedback in different environments and which feedback process is dominant? What is the precise role of UV radiation and X-rays, also from secondary sources? Are the observations following the key dynamical players? How do we best interpret ISM observations from ALMA, SKA, or ATHENA? How do we assist in designing future observations? With the resources requested here we will perform the most self-consistent theoretical study of the multi-phase ISM so far, thus building up a leading group for ISM research in Europe. To stimulate worldwide scientific activities and interactions we will make all data available to the community through an open-access web interface.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682115	**INTERCLOUDS**	**PE9** Universe Sciences

Principal Investigator: **Dr. MARIA-ROSA CIONI**
Host Institution: Leibniz-Institut Fur Astrophysik Potsdam (Aip), DE

Using the Magellanic Clouds to Understand the Interaction of Galaxies

The Magellanic Clouds are the nearest gas-rich dwarf satellites of the Milky Way and illustrate a typical example of an early phase of a minor merger event, the collision of galaxies that differ in mass by at least a factor of ten. In spite of their important role in supplementing material to the Milky Way halo and the numerous investigations made in the last decade, there remain several uncertainties. Their origin is still a matter of debate, their satellite status is unclear, their mass is uncertain, their gravitational centres are undefined, their structure depends strongly on stellar populations and is severely shaped by interactions, their orbital history is only vaguely associated to star forming events, and their chemical history rests upon limited data. This proposal aims to remedy this lack of knowledge by providing a comprehensive analysis of the stellar content of the Magellanic Clouds and dissect the substructures that are related to their accretion history and the interaction with the Milky Way. Their internal kinematics and orbital history, establishing their bound/unbound status, will be resolved thanks to the analysis of state-of-the art proper motions from the VMC survey and the Gaia mission, and the development of sophisticated theoretical models. Multi-wavelength photometric observations from ongoing large-scale projects will be analysed together to characterise the stellar population of the Magellanic Clouds as has never been previously attempted, including the effects of separate structural components. New large-scale spectroscopic survey projects in preparation will resolve metallicity dependencies and complete the full six-phase space information (distance, position, and motion). This proposal will have a tremendous impact on our understanding of the consequences of minor mergers, and will offer a firm perspective of the Magellanic Clouds.

Project End Date: **30-SEP-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682393	**AWESoMeStars**	**PE9** Universe Sciences

Principal Investigator: **Dr. SEAN MATT**
Host Institution: The University Of Exeter, UK

Accretion, Winds, and Evolution of Spins and Magnetism of Stars

This project focuses on Sun-like stars, which possess convective envelopes and universally exhibit magnetic activity (in the mass range 0.1 to 1.3 MSun). The rotation of these stars influences their internal structure, energy and chemical transport, and magnetic field generation, as well as their external magnetic activity and environmental interactions. Due to the huge range of timescales, spatial scales, and physics involved, understanding how each of these processes relate to each other and to the long-term evolution remains an enormous challenge in astrophysics. To face this challenge, the AWESoMeStars project will develop a comprehensive, physical picture of the evolution of stellar rotation, magnetic activity, mass loss, and accretion.

In doing so, we will

(1) Discover how stars lose the vast majority of their angular momentum, which happens in the accretion phase

(2) Explain the observed rotation-activity relationship and saturation in terms of the evolution of magnetic properties & coronal physics

(3) Characterize coronal heating and mass loss across the full range of mass & age

(4) Explain the Skumanich (1972) relationship and distributions of spin rates observed in young clusters & old field stars

(5) Develop physics-based gyrochronology as a tool for using rotation rates to constrain stellar ages.

We will accomplish these goals using a fundamentally new and multi-faceted approach, which combines the power of multi-dimensional MHD simulations with long-timescale rotational-evolution models. Specifically, we will develop a next generation of MHD simulations of both star-disk interactions and stellar winds, to model stars over the full range of mass & age, and to characterize how magnetically active stars impact their environments. Simultaneously, we will create a new class of rotational-evolution models that include external torques derived from our simulations, compute the evolution of spin rates of entire star clusters, & compare with observations.

Project End Date: **30-JUN-21**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
683184	**LEGA-C**	**PE9** Universe Sciences

Principal Investigator: **Dr. ARJEN VAN DER WEL**
Host Institution: Universiteit Gent, BE

The Physics of Galaxies 7 Gyr Ago

Over the past decade, redshift surveys and multi-wavelength imaging campaigns have drawn up an empirical picture of how many stars had formed in which types of galaxies over the history of the universe. However, we have yet to unravel the individual pathways along which galaxies evolve, and the physical processes that drive them. Continuing with the previous approach -- larger and deeper photometric samples -- is not adequate to achieve this goal. A change of focus is required. In this ERC project I will embark on a new way to address the question of galaxy evolution. I will do so as Principle Investigator of the recently approved LEGA-C observing program that has been allocated 128 nights of observation time over the next 4 years with ESO's flagship facility the Very Large Telescope. This new survey will produce for 2500 distant (at z~1) galaxies with, for the first time, sufficient resolution and S/N to measure ages and chemical compositions of their stellar populations as well as internal velocity dispersions and dynamical masses. This will provide an entirely new physical description of the galaxy population 7 Gyr ago, with which I will finally be able solve long-standing questions in galaxy formation that were out of reach before: what is the star-formation history of individual galaxies, why and how is star-formation ``quenched'' in many galaxies, and to what extent do galaxies grow subsequently through merging afterward? LEGA-C is worldwide the largest spectroscopic survey of distant galaxies to date, and ERC funding will be absolutely critical in harvesting this unparallelled database. I am seeking to extend my research group to realize the scientific potential of this substantial investment (6.5M Eur) of observational resources by the European astronomy community. Timing of the execution of the VLT program is perfectly matched with the timeline of this ERC program.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695175	**TReX**	**PE9** Universe Sciences

Principal Investigator: **Dr. TSVI PIRAN**
Host Institution: The Hebrew University Of Jerusalem., IL

Transient Relativistic eXplosions

The recent and upcoming deep and large field of view surveys has ascribed transient sources an ever-increasing role in 21st century astronomy. We propose to explore three relativistic transients: Compact binary mergers; Stellar disruption by massive black holes (TDEs) and Gamma-Ray Bursts (GRBs). Mergers are the prime targets of advanced Gravitational Waves (GW) detectors. Their detection will open a new window on the Universe. However localization, based on electromagnetic (EM) counterparts, that we propose to study here, is essential for GW Astronomy. TDEs provide a novel view on galactic centers' massive black holes. However, TDE observations pose some puzzles, suggesting that a revision of the current tidal disruption theory is needed. New observations provide a wealth of data on GRBs and this is the time to determine their inner workings and to obtain a clear model for the prompt emission mechanism – a long standing puzzle. This project includes theoretical modeling of these events as well as phenomenology of the observations and even some data analysis and observations. Mergers, TDEs and GRBs, are tightly interconnected and share similar physical mechanisms. The theory of merger radio flares and of TDE's radio emission draws, for example, on GRBs' afterglow theory and the interpretation of TDE high-energy emission is based on concepts borrowed from the prompt emission of GRBs. A coordinated theoretical study will reveal and utilize the commonalities of these phenomena and has a strong potential to obtain far reaching results beyond the current state of the art with possible implications to other high energy astrophysical phenomena. While this is a theoretical proposal we address at all stages directly observational issues. Hence the proposal is closely related to observations - interpreting existing puzzling observations, predicting new ones or suggesting strategies how to obtain them.

Project End Date: **30-SEP-21**

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: Magyar Tudomanyos Akademia 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:
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:
724560	**RADIOSTAR**	**PE9** Universe Sciences

Principal Investigator: **Dr. MARIA LUGARO**
Host Institution: Magyar Tudomanyos Akademia Csillagaszati Es Foldtudomanyi Kutatokozpont, HU

Radioactivities from Stars to Solar Systems

RADIOSTAR will exploit radioactive nuclei produced by nuclear reactions inside stars and ejected by stellar winds and supernova explosions to fill the missing pieces of the puzzle of the origin of our Solar System: What were the circumstances of the birth of our Sun? Were they similar to those of the majority of other stars in our Galaxy, or were they special? Radioactive nuclei are the key to answer these questions because meteoritic analysis has proven that many of them were present at the time of the birth of the Sun. Their origin, however, has been so far elusive. RADIOSTAR steps beyond the state-of-the-art to answer these open questions by (i) combining the evolution of radioactive nuclei in the Galaxy and within molecular clouds and (ii) considering all the seventeen radionuclides of interest and all their stellar sources and analysing the effects of uncertainties in their stellar production. This will allow us to:

- Use the decay of radioactive nuclei produced by the chemical evolution of the Galaxy as a clock to measure the lifetime of the Sun's parent molecular cloud prior to the Sun's birth;
- Calculate the self-pollution of this molecular cloud from the ejecta of stars with lives shorter than such lifetime;
- Discover if such self-pollution can fully explain the abundances of radioactive nuclei present at the time of the birth of the Sun, or whether special conditions are required.

RADIOSTAR will also have a far-reaching impact on our understanding of exoplanetary systems because the heat produced by radioactivity affects the evolution of planetesimals, with implications for the amount of water on terrestrial planets in the habitable zone. RADIOSTAR will open a new window into research on the effect of radioactivity on the evolution of planetesimals outside our Solar System.

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 Di Pisa, 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:
742095	**SPIDI**	**PE9** Universe Sciences

Principal Investigator: **Dr. JEROME BOUVIER**
Host Institution: Centre National De La Recherche Scientifique Cnrs, 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:
743029	**EASY**	**PE9** Universe Sciences

Principal Investigator: **Dr. THOMAS RAY**
Host Institution: Dublin Institute For Advanced Studies, IE

Ejection Accretion Structures in YSOs (EASY)

For a number of reasons, in particular their proximity and the abundant range of diagnostics to determine their characteristics, outflows from young stellar objects (YSOs) offer us the best opportunity of discovering how astrophysical jets are generated and the nature of the link between outflows and their accretion disks. Models predict that the jet is initially launched from within 0.1 to a few au of the star and focused on scales at most ten times larger. Thus, even for the nearest star formation region, we need high spatial resolution to image the “central engine” and test current models.

With these ideas in mind, and the availability of a whole new set of observational and computational resources, it is proposed to investigate the origin of YSO jets, and the jet/accretion zone link, using a number of highly novel approaches to test magneto-hydrodynamic (MHD) models including:

(a) Near-infrared interferometry to determine the spatial distribution and kinematics of the outflow as it is launched as a way of discriminating between competing models,

(b) A multi-epoch study of the strength and configuration of the magnetic field of the parent star to see whether model values and geometries agree with observations and the nature of its variability,

(c) Examining, through high spatial resolution radio observations, how the ionized component of these jets are collimated very close to the source and how shocks in the flow can give rise to low energy cosmic rays,

(d) Use the James Webb Space Telescope (JWST) and, in particular, the Mid-Infrared Instrument (MIRI) and Near-Infrared Spectrograph (NIRSpec) to investigate with high spatial resolution atomic jets from protostars that are still acquiring most of their mass. In addition, we will study how accretion is affected by metallicity by studying young solar-like stars in the low metallicity Magellanic Clouds.

In all cases the required observational campaigns have been approved.

Project End Date: **30-SEP-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:
758638	**SUPERSTARS**	**PE9** Universe Sciences

Principal Investigator: **Dr. KATE MAGUIRE**
Host Institution: The Queen'S University Of Belfast, UK

Type Ia supernovae: from explosions to cosmology

Type Ia supernovae (SNe Ia) are the incredibly luminous deaths of white dwarfs in binaries. They play a vital role in chemical enrichment, galaxy feedback, stellar evolution, and were instrumental in the discovery of dark energy. However, what are the progenitor systems of SNe Ia, and how they explode remains a mystery. My recent work has concluded the controversial result that there may be more than one way to produce SNe Ia. As SN Ia cosmology samples reach higher precision, understanding subtle differences in their properties becomes increasingly important. A surprising diversity in white-dwarf explosions has also been uncovered, with a much wider-than-expected range in luminosities, light-curve timescales and spectral properties. A key open question is 'What explosion mechanisms result in normal SNe Ia compared to more exotic transients?'

My team will use novel early-time observations (within hours of explosion) of 100 SNe Ia in a volume-limited search (<75 Mpc). The targets will come from the ATLAS and Pan-STARRS surveys that will provide unprecedented sky coverage and cadence (>20000 square degrees, up to four times a night). These data will be combined with key progenitor diagnostics of each SN (companion interaction, circumstellar material, central density studies). The observed zoo of transients predicted to result from white-dwarf explosions (He-shell explosions, tidal-disruption events, violent mergers) will also be investigated, with the goal of constraining the mechanisms by which white dwarfs can explode. My access to ATLAS/Pan-STARRS and my previous experience puts me in a unique position to obtain 'day-zero' light curves, rapid spectroscopic follow-up, and late-time observations. The data will be analysed with detailed spectral modelling to unveil the progenitors and diversity of SNe Ia. This project is timely with the potential for significant breakthroughs to be made before the start of the next-generation 'transient machine', LSST in ~2021.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
770017	**DEMOBLACK**	**PE9** Universe Sciences

Principal Investigator: **Dr. MICHELA MAPELLI**
Host Institution: Universita Degli Studi Di Padova, IT

Demography of black hole binaries in the era of gravitational wave astronomy

The first direct detection of gravitational waves demonstrated that double black hole (BH) binaries exist, and can host surprisingly massive objects (> 20 solar masses). Most theoretical models do not predict the existence of such massive BHs, and the formation channels of BH binaries are essentially unconstrained. Dynamically formed BH binaries are the most elusive ones: current models either neglect them or study them in idealized systems. With DEMOBLACK, I will draw the first satisfactory picture of BH binary demography, by modeling realistic BH dynamics in a well-motivated cosmological context. I propose a novel approach for the study of BH dynamics: I will simulate the formation of BH binaries in star clusters self-consistently, starting from the hydrodynamics of the parent molecular cloud and accounting for the impact of stellar evolution, feedback, and dynamics on BH binaries. The key tool of DEMOBLACK is SEVN, my new population-synthesis code. With SEVN, I predicted the formation of massive BHs from metal-poor stars, before the first direct detection of gravitational waves. I will interface SEVN with a hydrodynamical code and with an N-body code, to study the formation of BH binaries self-consistently. I will then model the history of BH binaries across cosmic time, accounting for the evolution of metallicity. This novel approach is decisive to break degeneracies between dynamically formed and primordial BH binaries, and to make predictions for future observations by ground-based and space-borne gravitational wave interferometers.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
771282	**PASIPHAE**	**PE9** Universe Sciences

Principal Investigator: **Dr. KONSTANTINOS TASSIS**
Host Institution: Foundation For Research And Technology Hellas, GR

Overcoming the Dominant Foreground of Inflationary B-modes: Tomography of Galactic Magnetic Dust via Measurements of Starlight Polarization

An inflation-probing B-mode signal in the polarization of the cosmic microwave background (CMB) would be a discovery of utmost importance in physics. While such a signal is aggressively pursued by experiments around the world, recent Planck results have showed that this breakthrough is still out of reach, because of contamination from Galactic dust. To get to the primordial B-modes, we need to subtract polarized emission of magnetized interstellar dust with high accuracy. A critical piece of this puzzle is the 3D structure of the magnetic field threading dust clouds, which cannot be accessed through microwave observations alone, since they record integrated emission along the line of sight. Instead, observations of a large number of stars at known distances in optical polarization, tracing the same CMB-obscuring dust, can map the magnetic field between them. The Gaia mission is measuring distances to a billion stars, providing an opportunity to produce, the first-ever tomographic map of the Galactic magnetic field, using optical polarization of starlight. Such a map would not only boost CMB polarization foreground removal, but it would also have a profound impact in a wide range of astrophysical research, including interstellar medium physics, high-energy astrophysics, and galactic evolution. Taking advantage of our privately-funded, novel-technology, high-accuracy WALOP optopolarimeters currently under construction, we propose an ambitious optopolarimetric program of unprecedented scale that can meet this challenge: a survey of both northern and southern Galactic polar regions targeted by CMB experiments, covering >10,000 square degrees, which will measure linear optical polarization at 0.2% accuracy of over 360 stars per square degree (over 3.5M stars, a 1000-fold increase over the state of the art), combining wide-field-optimized instruments and an extraordinary commitment of observing time by Skinakas Observatory and the South African Astronomical Observatory.

Project End Date: **31-MAY-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:
786780	**D5S**	**PE9** Universe Sciences

Principal Investigator: **Dr. STEVEN TOBIAS**
Host Institution: University Of Leeds, UK

Direct Statistical Simulation of the Sun and Stars

This proposal (D5S) addresses a key problem of astrophysics – the origin of magnetic activity in the sun and solar-type stars. This is a problem not only of outstanding theoretical importance but also significant practical impact – solar activity has major terrestrial consequences. An increase in activity can lead to an increase in the number and violence of solar flares and coronal mass ejections, with profound consequences for our terrestrial environment, causing disruption to satellites and power. Predictions of magnetic activity are highly desired by government and industry groups alike. A deep understanding of the mechanisms leading to solar magnetic activity is required. The variable magnetic field is generated by a dynamo in the solar interior. Though this mechanism is known to involve the interaction of magnetohydrodynamic (MHD) turbulence with rotation, no realistic model for dynamo action currently exists. D5S utilises two recent significant breakthroughs to construct new models for magnetic field generation in the sun and other solar-type stars. The first of these involves an entirely new approach termed Direct Statistical Simulation (DSS) (developed by the PI), where the statistics of the astrophysical flows are solved directly (enabling the construction of more realistic models). This approach is coupled to a breakthrough (recently published by the PI in Nature) in our understanding of the physics of MHD turbulence at the extreme parameters relevant to solar interiors. D5S also uses the methodology of DSS to provide statistical subgrid models for Direct Numerical Simulation (DNS). This will increase the utility, fidelity and predictability of such models for solar magnetic activity. Either of these new approaches, taken in isolation, would lead to significant progress in our understanding of magnetic field generation in stars. Taken together, as in this proposal, they will provide a paradigm shift in our theories for solar magnetic activity.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787622	**Auger-Horizon**	**PE9** Universe Sciences

Principal Investigator: **Dr. JÖRG HÖRANDEL**
Host Institution: Stichting Katholieke Universiteit, NL

A large-scale radio detector for the Pierre Auger cosmic-ray Observatory – precision measurements of ultra-high-energy cosmic rays

Cosmic Rays (ionized atomic nuclei) are the only matter from beyond our solar system or even from extragalactic space, that we can directly investigate. Up to energies of 10^17 eV they most likely originate in our Galaxy. The highest-energy cosmic rays (>10^18 eV) cannot be magnetically bound any more to the Galaxy and are most likely of extragalactic origin.
The pure existence of these particles raises the question about their origin – how and where are they accelerated? How do they propagate through the universe and interact? How can we directly probe extragalactic matter and how can we locate its origin?
A key to understand the origin of cosmic rays is to measure the particle species (atomic mass). A precise mass measurement will allow discriminating astrophysical models and will clarify the reason for the observed suppression of the cosmic-ray flux at the highest energies, namely the maximum energy of the accelerators or the energy losses during propagation.
I address these questions by employing a new technique to precisely measure the cosmic-ray mass composition, which my group pioneered, the radio detection of air showers (induced by high-energy cosmic rays in the atmosphere) on very large scales, detecting horizontal air showers with zenith angles from 60° to 90°.
The new set-up will be the world-largest radio array, operated together with the well-established Auger surface and fluorescence detectors, forming a unique set-up to measure the properties of cosmic rays with unprecedented precision for energies above 10^17.5 eV. The radio technique is a cost-effective and robust method to measure the cosmic-ray energy and mass, complementary to established techniques. The energy scale of the radio measurements is established from first principles. The proposed detectors will also enhance the detection capabilities for high-energy neutrinos and the search for new physics through precision measurements of the electromagnetic and muonic shower components.

Project End Date: **30-SEP-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:
789410	**HIDDeN**	**PE9** Universe Sciences

Principal Investigator:	**Dr. SUSANNE AALTO**
Host Institution:	Chalmers Tekniska Hoegskola Ab, SE

HIDDeN - Exploring the Hidden Dusty Nuclei of Galaxies

Luminous infrared galaxies (LIRGs) emit most of their bolometric luminosity in the far-infrared. They are mainly powered by extreme bursts of star formation and/or Active Galactic Nuclei (AGNs; accreting
supermassive black holes (SMBHs)) in their centers. LIRGs are the closest examples of rapid evolution in galaxies and a detailed study of LIRGs is critical for our understanding of the cosmic evolution of galaxies and SMBHs. Centers of some LIRGs are deeply obscured and unreachable at optical, IR and even X-ray wavelengths. These hidden nuclei therefore represent a largely unexplored phase of the growth of central regions with their SMBHs. The largest growth spurts are suspected to occur when the
SMBHs are deeply embedded. Obscured AGNs thus can provide new constraints on the AGN duty cycle, give the full range of environments and astrophysical processes that drive the growth of SMBHs,
and help to complete the picture of connections between the host galaxy and SMBH. Many dust embedded AGNs are still to be discovered as studies suggest that (Alexander+11) of the intermediate mass SMBHs may be obscured.
In the HIDDeN project we use mm and submm observational methods to reach behind the curtain of dust in the most obscured centers of LIRGs, allowing us to undertake ground-breaking studies of heretofore hidden rapid evolutionary phases of nearby galaxy nuclei. HIDDeN takes advantage of emerging opportunities to address the nature of near-field, and redshift z=1-2, obscured
AGNs/starbursts and their associated molecular inflows and outflows in the context of their evolution
and the starburst-AGN connection. In particular we use the ALMA and NOEMA telescopes, supported by JVLA, LOFAR, HST and future JWST observations, to address four interconnected goals: A.
Probing the Dusty Interiors of Compact Obscured Nuclei (CONs), B. The cold winds of change - Molecular Outflows from LIRGs and AGNs, C. The Co-Evolution of Starbursts and AGNs and D. Are there hidden CONs at z=1-2?

Project End Date: **30-SEP-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, 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 Di Trieste, 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: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

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:
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:
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:
759885	**MIRAGE**	**SH1** Markets, Individuals and Institutions

Principal Investigator:	**Dr. RUBEN DURANTE**
Host Institution:	Universitat Pompeu Fabra, ES

Independence and quality of mass Media in the InteRnet AGE

The Internet was expected to make citizens considerably more informed and better able to hold politicians and powerful interests accountable. Many predicted it would also effectively complement traditional media and improve news reporting. These expectations have not been met. There is no evidence that citizens have become more informed; they have, however, become more ideologically polarized, possibly due to online media overexposing users to like-minded content. At the same time, traditional media are struggling: competition from online platforms has slashed advertising revenues forcing newspapers to close or downsize. These changes risk undermining the quality of reporting and making media more vulnerable to capture by special interests.

My project examines how the Internet has transformed the way news is produced and disseminated, both directly and through its influence on traditional media, and its ultimate effect on media independence and content quality. To this end, I tackle four distinct but intertwined questions. First, I examine to what extent Google search results are tailored to users' political views, and whether personalized results increase ideological polarization. Second, I study how lower advertising revenues affect newspapers' organization and content quality by exploiting the staggered introduction of advertising platform Craigslist across the US. Third, I examine how media dependence on advertisers influences news bias by testing the relationship between advertising spending by car manufacturers and coverage of car safety recalls in US newspapers. Finally, I study how the dependence of media on banks affects coverage of financial issues; focusing on Europe's sovereign debt crisis, I test whether newspapers linked to banks with higher exposure to risky debt endorsed different crisis-management measures.

My results will shed light on the deep transformations the media industry is undergoing and their implications for the quality of democracy.

Project End Date: **31-OCT-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:
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:
819752	**DEVORHBIOSHIP**	**SH1** Markets, Individuals and Institutions

Principal Investigator: **Dr. GABRIELLA CONTI**
Host Institution: University College London, UK

The Developmental Origins of Health: Biology, Shocks, Investments, and Policies

What are the origins of inequalities in health? A recent literature in economics has established causal impacts of early life shocks, investments and policies on lifelong health. However, several unknowns remain. The mechanisms through which shocks, investments, and policies interact are just beginning to be understood. Our knowledge of sensitive periods is imprecise. Little is also known about the impact of shocks and policies across different ages. Commonly used health capital measures, such as birth weight, lack sensitivity and specificity. The interplay between genes and environments in the formation of health inequalities is poorly understood.

To fill these gaps, I will build on insights from my earlier work, and use a combination of high-quality data, more sensitive measures, robust identification strategies and richer models to untangle the complex interactions between biology, shocks, investments and policies.

First, I will investigate causal impacts and mechanisms of two public health policies on child health and development: medical treatments for pregnancy complications and prenatal home visiting programmes. Second, I will examine the effects of two environmental shocks (pollution and influenza) on the formation of early health and human capital, and their interplay with maternal investments in nutrition. Third, I will study interactions between shocks, investments and policies from birth to adulthood, to understand the dynamic interplay between SES and health. Throughout, I will explore their interactions with genetic susceptibility or potential.

I will analyse administrative records, registries linked to survey data, cohort data with biomarkers; and a randomized controlled trial. I will use state-of-the-art econometric techniques for observational and experimental data. My findings will have direct policy implications and will help understand whether and to which extent early life interventions are a cost-effective mean to promote health.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647943	**JCR**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. MICHAL ALBERSTEIN**
Host Institution: Bar Ilan University, IL

Judicial Conflict Resolution: Examining Hybrids of Non-adversarial Justice

In the past few decades, the role of judges has changed dramatically and its nature has remained largely unexplored. To date, most cases settle or reach plea-bargaining, and the greater part of judges' time is spent on managing cases and encouraging parties to reach consensual solutions. Adjudication based on formal rules is a rare phenomenon which judges mostly avoid.

The hypothesis underlying JCR is that the various Conflict Resolution methods which are used outside the courtroom, as alternatives to adjudication, could have a strong and positive influence, both theoretical and practical, on judicial activities inside the courts. Judicial activities may be conceptualised along the lines of generic modes of conflict resolution such as mediation and arbitration. Judicial conflict resolution activity is performed in the shadow of authority and in tension with it, and crosses the boundaries between criminal and civil conflicts. It can be evaluated, studied and improved through criteria which go beyond the prevalent search for efficiency in court administration.

Empirically, JCR will study judicial activities in promoting settlements comparatively from a quantitative and qualitative perspective, by using statistical analysis, in-depth interviews, mapping and framing legal resources, court observations and narrative analysis. Theoretically, JCR will develop a conflict resolution jurisprudence, which prioritises consent over coercion as a leading value for the administration of justice. Prescriptively, JCR will promote a participatory endeavour to build training programs for judges that implement the research findings regarding the judicial role. Following such findings, JCR will also consider generating recommendations to change legal rules, codes of ethics, measures of evaluation, and policy framings. JCR will increase accountability and access to justice by introducing coherence into a mainstream activity of processing legal conflicts.

Project End Date: **31-DEC-20**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
648693	**EVILTONGUE**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. KAROLY TAKACS**
Host Institution: Linkopings Universitet, SE

No Sword Bites So Fiercly as an Evil Tongue?
Gossip Wrecks Reputation, but Enhances Cooperation

Social norms in general, and norms of cooperation in particular, are the cement of all human societies. For the difficult problems of the maintenance and enforcement of social norms and of cooperation, humans have developed surprisingly complex solutions. Reputation mechanisms and gossip are certainly among the compound informal solutions.

According to common wisdom, gossip channels mainly negative and often fictitious information. If it is so, how can dishonest gossip and the resulting biased reputations legitimize social order and promote cooperation?

This is the main puzzle we tackle in the proposed project exploiting a wide scale of instruments. We use analytical modeling and agent-based simulation to derive hypotheses. We test simple hypotheses in small group experiments. We develop new methodological tools to appropriately analyze the triadic nature of gossip embedded in network flows of information. We utilize dynamic network datasets from primary and secondary school classes, and we gather qualitative and quantitative information from organizations to test conditional hypotheses about the role that gossip plays in reputation and cooperation in different developmental and social contexts of life. In addition, we apply new communication technologies currently under development to explore the hidden world of gossip and the dynamics of reputations in dormitories and organizations.

With the insights gained, we can overcome common stereotypes about gossip and highlight how gossip is related to credible reputational signals, cooperation, and social order. Expected results will help us to outline the conditions that can promote cooperativeness in work groups, and they will help to construct successful prevention strategies of social exclusion and other potentially harmful consequences of the evil tongue.

Project End Date: **30-NOV-20**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679362	**PRILA**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator:	**Dr. MARY ROGAN**
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

Prisons: the Rule of Law, Accountability and Rights

PRILA will create the first account of how mechanisms for securing rights, ensuring accountability and achieving adherence to the rule of law are experienced in European prisons. Prisons are places where considerable power differentials exist, and are unique sites for the expression of the values which underpin public and prison law. Systems to ensure that prisoners are treated fairly and that rights are upheld are essential to ensure that imprisonment is conducted in ways that are just and promote good order. These are fundamental principles of the 'European' way in penal policy and penal law. Existing accounts of the deployment of penal power overlook key elements of how accountability, the rule of law, and rights are experienced. PRILA will document how prisoners, prison staff, staff of accountability bodies experience structures for ensuring decisions and actions taken in prison are fair, transparent, consistent, subject to appeal and review, and in compliance with principles of human rights. In doing so, PRILA will transform and extend accounts of legitimacy in prisons, judicial review of administrative action, the pains of imprisonment, and understandings of how penal power is experienced. Drawing on the disciplines of public and prison law, human rights, comparative law, and the sociology of punishment, the project will utilise legal, qualitative and quantitative research methods to create an account of how 'accountability work' is experienced. It will also examine how accountability structures are manifestations of penal ideologies or types of prison regimes. The project will advance current judicial and legal conceptions of accountability, the rule of law, and fairness, by reference to how these concepts are experienced in practice, and examine whether and how they are distinctively 'European'. The project will thereby support the creation of better penal policies and practices aimed at the protection of the rule of law and rights in the prison context.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
680102	**DIPLOFACE**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. REBECCA ADLER-NISSEN**
Host Institution: Kobenhavns Universitet, DK

Diplomatic Face-Work - between confidential negotiations and public display

The rise of social media, coupled with intensifying demands for more transparency and democracy in world politics, brings new challenges to international diplomacy. State leaders and diplomats continue to react to traditional media, but now also attempt to present themselves proactively through tweets and public diplomacy.

These efforts often take place simultaneously and sometimes interfere directly with closed-door negotiations and its codes of restraint, discretion and secrecy. Yet the relationship between confidential diplomacy and public representation remains understudied. International Relations scholars lack theoretical and methodological tools
to grasp how the information revolution transforms diplomacy.

DIPLOFACE will develop a sociologically and anthropologically informed approach to studying how state leaders and diplomats manage their nation's 'faces' or 'images of self' in the information age. DIPLOFACE will explore the relationship and tensions between confidential diplomatic negotiations and publicly displayed interventions in the media, taking the micro-sociological concept of 'face-work' to the international level.

Diplomatic face-work is increasingly important for decision-makers who perform simultaneously on the 'backstage' and the 'front-stage' of international relations. DIPLOFACE will identify, theorize and analyse the repertoire of face-saving, face-honouring and face-threatening techniques practices employed in confidential
negotiations and in public.

DIPLOFACE advances our theoretical understanding of diplomacy in the 21st century significantly beyond existing International Relations and diplomatic theory. DIPLOFACE will combine participant observation, interviews and media analysis, generating important new knowledge about the relationship between public and confidential multilateral negotiation, how state leaders and diplomats handle new media, and the role of facesaving and face-threatening strategies in international relations.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
680958	**NEWFAMSTRAT**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. LYNN COOKE**
Host Institution: University Of Bath, UK

The New Shape of Family-Related Gender Stratification

A mountain of evidence fails to account for gender inequalities in employment, earnings and unpaid work predicted by partnership and parenthood, leading scholars to deem the hoped-for gender equality revolution "stalled." We argue the revolution continues, but pockets of progress are only located when unpacking within-gender differences in effects at individual, couple, and employer levels. This research advances state-of-the-art by revealing how sources and outcomes of gender inequalities predicted by partnership and parenthood vary among women and among men in Finland, Germany, and the UK, three countries with contrasting gender, labor market, and welfare regimes. The "shape" of family-related gender stratification is mapped in each country through four comparative subprojects answering the following questions:

1) What does variation in partnership or parental bonuses or penalties across women's and men's earnings distributions tell us about within-gender differences in the sources of economic inequalities in all three countries?
2) What do within-gender differences in the impact of unpaid domestic work on family-related earnings premiums or penalties in Germany and the UK tell us about the tradeoff between paid and unpaid work effort? How does the impact of household equity in paid and unpaid work on couple stability vary across the earnings distribution?
3) How does possible British, Finnish, and German employer gender discrimination in hiring vis-à-vis parenthood vary across job skill levels?
4) What is the contribution of employer discrimination to gender-class earnings inequalities predicted by partnership and parenthood in Finland and Germany?

Data include several existing national panel and linked employee-employer panel datasets to be analyzed with cutting-edge fixed-effects semi-parametric techniques, as well as new primary data to be gathered on real-time employer hiring decisions via coordinated field correspondence studies.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681489	**IN-TOUCH**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. CAREY JEWITT**
Host Institution: University College London, UK

IN-TOUCH: Digital Touch and Communication

The rapid expansion of digital touch technologies is set to reconfigure touch and the tactile in significant ways, much as optical technologies transformed sight and the visual. This has immense social significance for communication. There are, however, major gaps in our understanding of touch as it is digitally mediated, and methods are under-developed for a social account of digital touch communication. This project will break new ground as the first comprehensive study of digital touch communication. It aims to obtain a deep understanding of the social and semiotic character of touch as it is mediated by digital technologies and its consequences and impact on human communication, through four objectives, to:

1. Develop innovative methodologies for researching digital touch communication;
2. Describe, explore and critically analyze the social and semiotic understanding of the communicative potentials and consequences of digital touch;
3. Advance new theoretical insights on digital touch communication;
4. Make a major contribution to knowledge on digital touch interventions and design.

Digital touch will be brought into sharp focus through the development of a novel socially oriented framework and methods that integrate the micro-lens of multimodality, the broad-ethnographic lens of sensory anthropology, and the experiential-lens of the arts. Eight in-depth case studies will be conducted in world-leading centres of digital touch innovation, with designers and users of digital touch communication in the wild (e.g. museums) and labs. These will investigate how the digital can supplement, heighten, extend, and reconfigure touch communication across a range of contexts (health, learning, work, leisure); re-shape what can be touched, lead to new touch-based capacities, practices and new forms of knowledge about the world.

Project End Date: **30-SEP-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682110	**POLICYAID**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. KLAUS HOEYER**
Host Institution: Kobenhavns Universitet, DK

Policy, practice and patient experience in the age of intensified data sourcing

The European healthcare services have begun collecting tissue samples and healthcare data from patients on an unprecedented scale. With POLICYAID we suggest the term 'intensified data sourcing' to describe these attempts at getting more data, on more people, of better quality while simultaneously making the data available for multiple uses. Data are used for research, for financial remuneration purposes, for quality assurance, to attract capital and even for police work. POLICYAID investigates how the diverse agendas interact in the making of a new infrastructure for healthcare.
POLICYAID ambitiously aims to understand the drivers for and implications of intensified data sourcing in the biomedical realm across three levels: 1) policymaking, 2) everyday clinical practices, and 3) citizen experiences of health, illness, rights and duties. To achieve this aim we compare four different forms of intensified data sourcing, and analyze the regulatory frameworks guiding the data procurement and use in Denmark, the EU and beyond.

Based on PI's strong inter-disciplinary background and experience, we fuse legal, sociological, anthropological and public health scholarship and develop new methodologies for policy analysis by combining document analysis, interviews, participant observation and register-based methodologies. Instead of simply assuming that data sourcing can be reduced to matters of surveillance, we open up the black box of data sourcing by describing how data are selected; financed; what they are used for; how data practices relate to the involved stakeholders' hopes and concerns, and; who gains which rights to the data. We can thereby explore how intensified data sourcing affects clinical routines and patient experience, as well as understand how Big Data for medical research emerges. POLICYAID thereby arrives at novel understandings of both policy making and what it means to be patient in the age of intensified data sourcing.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682758	**DEBUNKER**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. JASON REIFLER**
Host Institution: The University Of Exeter, UK

The Problem of European Misperceptions in Politics, Health, and Science: Causes, Consequences, and the Search for Solutions

While some people may simply lack relevant factual knowledge, others may actively hold incorrect beliefs. These factual beliefs that are not supported by clear evidence and expert opinion are what scholars call misperceptions (Nyhan and Reifler 2010). This project is principally about misperceptions—the "facts" that people believe that simply are not true. What misperceptions do Europeans hold on issues like immigration, vaccines, and climate change? Who holds these misperceptions? What demographic and attitudinal variables are correlated with holding misperceptions? And ultimately, what can be done to help reduce misperceptions?

Misperceptions are an important topic for study because they distort public preferences and outcomes. This research program investigating misperceptions is currently at the state of the art in political science. To date, only a handful of published studies by political scientists have examined how corrective information changes underlying factual beliefs. The results of these studies are uniformly troubling—among those vulnerable to holding a given misperception, corrective efforts often make misperceptions worse or decrease the likelihood to engage in desired behaviors.

This ambitious project has three primary objectives. First, the project will assess levels of misperceptions in Europe on three specific issues (immigration, vaccines, and climate change) that represent three different substantive domains of knowledge (politics, health, and science). Second, the project will examine a variety of approaches and techniques for combatting misperceptions and generating effective corrections. Third, the project will take what is learned from the first two stages and transmit the findings back to relevant academic and policy-maker audiences in order to aid policy design and communication efforts on important policy issues.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
683133	**GROUPVIOLENCE**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. DON WEENINK**
Host Institution: Universiteit Van Amsterdam, NL

Groups and Violence: A Micro-sociological Research Programme

The Group Violence research programme aims to understand how group behaviour affects the likelihood and severity of violence in public space. While the prevailing social scientific focus remains on individual perpetrators and background factors, the empirical reality of public violence is one of multiple attackers, multiple victims and multiple bystanders. The research proposed here furthers the study of violence with a novel theory that identifies how group behaviour affects the outcome of antagonistic situations – and with comparative empirical studies to test the theory. The central question is how and to what extent 1) mutual alignment of attention and action, and 2) a sense of moral community enable group members to commit violence. Project 1 (PI and post-doc) considers mutual alignment down to the minutest detail, based on close-up qualitative and quantitative video analyses of sequences of bodily cues. Based on judicial case files, project 2 (PI and assistants) will quantitatively analyse mutual alignment in an extensive range of violent interactions. Four PhD projects compare the role of mutual alignment and moral community in antagonistic situations in groups that differ from each other in these respects: police teams (project 3), street youth (4), football hooligans (5), and bouncers (6). Relying on an innovative method to reconstruct antagonistic situations by repeated and comparative qualitative interviewing, projects 3-6 will also relate the meanings of violence and masculine identity to the moral community of the group. Project 7 (PI and post-doc) uses qualitative and statistical analyses of the interview data generated in projects 3-6 for an extensive comparison of group behaviour in antagonistic situations. The ambition is to produce exemplary understanding of the crucial role that groups play in violence. This proposal shows how: through detailed and extensive comparative empirical testing that will further develop the new theory.

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

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:
715631	**TechEvo**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. DIETER FRANZ KOGLER**
Host Institution: University College Dublin, National University Of Ireland, Dublin, IE

Technology Evolution in Regional Economies

The creation and accumulation of knowledge are processes at the heart of technological change and economic growth. Attention has been directed at aggregate measures of knowledge production in regional and national contexts, but little consideration has been given to the properties of knowledge produced in specific places. How does the nature of knowledge that is produced vary over space, what conditions the scope of technologies generated in different locations, and how do these knowledge sets impact the performance of local firms and industries?

To date, the way in which specific regional knowledge capabilities influence the evolution of local technology trajectories and thus shape geographies of economic prosperity have not yet been considered systematically. The objective of the “Technology Evolution in Regional Economies” (TechEvo) project is to address these significant shortcomings. Focusing on the evolution of scientific and technical knowledge, as indicated by patent, trademark and scientific literature records, the point of departure is the pan-European knowledge space for all 28 European Union member countries, plus Norway and Switzerland, over the time period 1981-2015. The knowledge space, based on the co-occurrence matrix of particular knowledge domains (629), maps the proximity of patent technology classes and enables the development of regional measures of knowledge specialization for all 1,369 (NUTS3) regions. Set in an evolutionary framework the investigation provides ground breaking insights into how innovative entities and individual inventors are embedded in social and CoGnitive local and non-local networks, and how regional technology trajectories are shaped through entry, exit, and selection processes. TechEvo will provide a wealth of indicators, models and tools that will assist firms and policy makers in place-based investment decisions, and deliver a science and technology policy evaluation tool capable of assessing impact.

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:
725240	**European Unions**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. ROLAND ERNE**
Host Institution: University College Dublin, National University Of Ireland, Dublin, IE

Labour Politics and the EU's New Economic Governance Regime

Trade unions play a major role in democratic interest intermediation. This role is currently threatened by the increasingly authoritarian strain in EU's new economic governance (NEG). This project aims to explore the challenges and possibilities that the NEG poses to labour politics. Until recently, European labour politics has mainly been shaped by horizontal market integration through the free movement of goods, capital, services and people. After the financial crisis, the latter has been complemented by vertical integration effected through the direct surveillance of member states. The resulting NEG opens contradictory possibilities for labour movements in Europe.

On the one hand, the reliance of the NEG on vertical surveillance makes decisions taken in its name more tangible, offering concrete targets for contentious transnational collective action. On the other hand however, the NEG mimics the governance structures of multinational firms, by using key performance indicators that put countries in competition with one another. This constitutes a deterrent to transnational collective action. The NEG's interventionist and competitive strains also pose the threat of nationalist counter-movements, thus making European collective action ever more vital for the future of EU integration and democracy.

This project has the following objectives:

1. To understand the interrelation between NEG and existing 'horizontal' EU economic governance; and the shifts in labour politics triggered by NEG;
2. To open up novel analytical approaches that are able to capture both national and transnational social processes at work;
3. To analyse the responses of established trade unions and new social movements to NEG in selected subject areas and economic sectors at national and EU levels, and their feedback effects on NEG;
4. To develop a new scientific paradigm capable of accounting for the interplay between EU economic governance, labour politics and EU democracy.

Project End Date: **30-SEP-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:
741538	**UneqDems**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. JONAS PONTUSSON**
Host Institution: Universite De Geneve, CH

Unequal Democracies

The proposed research program explores the implications of rising income inequality for the political process in advanced democracies and for the policies produced by competition among political parties and organized interests. The program posits that the political implications of inequality operates through two channels: inequality influences what citizens want from government, but it also affects political participation and influence and hence, by extension, government responsiveness to the preferences of different citizens. Students of the politics of inequality have tended to focus on only one channel, to the neglect of the other. The fundamental objective of the proposed research program is to develop a unified framework that draws on both research traditions and, in so doing, addresses lacunae in each. Another objective is to explore how the political consequences of low-end inequality (growing separation of the poor from the middle class) differ from the political consequences of high-end inequality (the growing concentration of income at the very top of the income distribution). The core questions that animate the research program are "macro" questions, pertaining processes and outcomes that are observed at the country level (or, in other words, the political-system level), but these questions will be addressed, in part, through analyses of individual attitudes, preferences and behavior. The latter analyses will involve a couple of original surveys, including a survey of attitudes towards the rich, as well as the use of existing national and cross-national survey data. With respect to macro-level comparisons, the research program will emphasize changes over time: changes in the structure of inequality as well as the level of inequality, changes in preferences and coalitions among citizens and organized interests and, finally, changes in income (or class) bias in democratic representation.

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

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
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Project ID:	Project Acronym:	Evaluation Panel:
757395	**WorkOD**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. RUTH DUKES**
Host Institution: University Of Glasgow, UK

Work on Demand: Contracting for Work in a Changing Economy

Labour law as a scholarly discipline is widely believed to be in crisis. Since the time of its birth, both the nature of working relationships and the context within which they are formed and regulated have changed significantly. The difficulty for scholars is that old concepts don't perform the function anymore of making sense of the field. Old arguments about the need to protect workers' interests are met with counterarguments, informed by neoclassical economics, that protective measures inhibit economic growth and increase unemployment.

The WorkOD project aspires to nothing less than a fundamental transformation of the discipline of labour law across the whole of Europe and beyond. Understanding the crisis to have at its heart a crisis of methodology, it aims to develop a new methodology for the study of the key legal concept of the contract for work. It aims to explain trends in the field of work organisation and working relationships and to assess the significance of particular labour market institutions to the achievement of policy goals in a way that is useful to scholars and policy-makers. And it aims to pave the way for future contributions by scholars to policy debates, so that they may influence in positive ways the identification of new economically and socially sustainable solutions to the problem of the division of responsibilities and risks between workers and those for whom they work.

In a marked departure from the state of the art, the project defines contracting for work as an instance of economic, social and legal behaviour, influenced in a variety of ways by the institutional context within which it proceeds. Rejecting the reframing of labour law according to a full blown market paradigm, it argues instead for the utility of sociological methods. Its development of a new methodology begins from a combination of micro and macro perspectives, and a synthesis of approaches drawn from economic sociology, political economy and the sociology of law.

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

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:
758671	**GLOBTAXGOV**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. IRMA JOHANNA MOSQUERA VALDERRAMA**
Host Institution: Universiteit Leiden, NL

A New Model of Global Governance in International Tax Law Making

The overall aim of this research project is to assess the feasibility and legitimacy of the current model of global tax governance and the role of the OECD and EU in international tax lawmaking. Unlike the former OECD projects that only provide for exchange of information between countries, in the BEPS Project, the EU Anti-Tax Avoidance Directive, the EU state aid investigations and the EU External Strategy, the OECD and the EU focus on substantive issues that when implemented will change the international tax architecture of developed and developing countries. These initiatives aim to ensure that governments engage in fair competition and that multinationals pay their fair share. Even though these objectives are legitimate, these developments raise the questions what is the role of the OECD and the EU in global tax governance? and under what conditions can the model of global tax governance be feasible and legitimate for both developed and developing countries? These initiatives have generated tensions between developed and developed countries and between EU and third (non-EU) countries. The tensions between countries call for the articulation of a new framework of global tax governance that is legitimate and based on considerations of fairness for all countries participating.

Against this background, my project will first assess the feasibility of the legal transplant of the BEPS minimum standards into the tax systems of 12 countries of research by asking three sub-questions (i) why are these countries participating in the BEPS Project? (ii) how will the BEPS minimum standards be transplanted into the tax system of these countries? and (iii) how can the differences in tax systems and tax cultures of these countries influence the content of these minimum standards? Thereafter, the conditions for the legitimacy of the role of the OECD and the EU will be provided in light of the theories of legitimacy and governance.

Project End Date: **31-JAN-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:
771676	**EUGenDem**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. JOHANNA KANTOLA**
Host Institution: Tampereen Korkeakoulusaatio Sr, FI

Gender, party politics and democracy in Europe: A study of European Parliament's party groups

Given the crucial importance of European Parliament's party groups to democratic representation in the European Union, it is surprising that there is limited empirical and theoretical understanding that relates to how they conceive of gender, gender hierarchies and gendered relations, or how they seek to address gender inequalities. Nor do we know what the conditions are for increasing a gender equal democracy in the EU in the face of the current political context shaped by political crises. This project aims to provide a systematic analysis of the gendered policies and practices of European party politics. The research comprises a comparative study of the eight European Parliament (EP) party groups and generates empirical findings about the significance of gender in the current party political transformations in Europe.

Further potential lies in the key methodological innovation whereby the proposed project links informal institutions and discourses to affects and emotions, generating research designs with which the persistence of gender inequalities can be analysed more thoroughly than current gender and politics research allows. More nuanced conceptualizations, and theories about inclusive representation, gender justice and democracy at the transnational level, are a likely consequence of adopting an innovative methodological approach where empirical findings inform the theoretical level. Therefore, the project may have a high societal impact as it speaks directly to the current political crises in Europe, and provides an understanding of their gendered underpinnings.

Thus, the key ambition of this research project is: based on a thorough empirical understanding of gender and party politics at the European Parliament to build novel methodologies, concepts and theories about inclusive representation, gender justice and democracy.

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

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:
772070	**ASA**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. JULIA GALLAGHER**
Host Institution: School Of Oriental And African Studies Royal Charter, UK

Understanding Statehood through Architecture: a comparative study of Africa's state buildings

The project will develop a new ethnography of statehood through architecture. It goes beyond conventional approaches to statehood, which describe states as an objectively existing set of tools used to run a country, and critical approaches that understand them as discursive constructs. Instead, this research understands statehood as a result of the relationship between functions and symbols, and will read it through an innovative new methodology, namely a study of state architecture.

The study will focus on state buildings in Africa. African statehood, uncertain and often ambiguous, in many cases profoundly shaped by colonial heritages and post-colonial relationships, is reflected in classical-colonial, modernist-nationalist and post-modern or vernacular styles of architecture. African state buildings reveal the complex interplay of ideas, activities and relationships that together constitute an often uncomfortable statehood. They symbolise the state, embodying and projecting ideas of it through their aesthetics; they enable its concrete functions and processes; and they reveal what citizens think about the state in the ways they describe and negotiate them.

The study is comparative, multi-layered and interdisciplinary. It focuses on seven countries (South Africa, Tanzania, DR Congo, Ethiopia, Ghana, Côte d'Ivoire and Guinea Bissau), exploring politics and statehood on domestic, regional and international levels, and drawing on theory and methods from political science, history, sociology, art and architecture theory. It employs innovative ethnographic methods, including the collection and display of photographs in interactive exhibitions staged in Africa to explore the ways citizens think about and use state buildings.

This project will provide an innovative reading of how African statehood is expressed and how it looks and feels to African citizens. In doing this, it will make a distinctive new contribution to understanding how statehood works everywhere.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787258	**InclusivePublicSpace**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. ANNA LAWSON**
Host Institution: University Of Leeds, UK

Inclusive Public Space: Law, Universality and Difference in the Accessibility of Streets

This project considers the accessibility of public space – focusing on pedestrian access to streets. It explores law's engagement with the exclusion which occurs when streets are designed, operated or managed so as to deny access to pedestrians whose bodies, minds or life circumstances do not 'fit'. Such exclusion is damaging both to individuals and communities.

With a view to understanding how states and the EU can more effectively ensure that public space is inclusive, the project aims to deepen understanding of what physical features of streets are experienced as exclusionary in 5 countries and by whom; how effectively law is used to challenge such exclusion in these countries; and how the problem is perceived and politically challenged. It also aims to foster shared concern about this form of exclusion, in the 5 countries and beyond, and to raise awareness of how law can be used to challenge it.

The methodology will be comparative, transdisciplinary and participatory in nature. It will develop innovative videovoice techniques for data gathering. It will also develop groundbreaking awareness-raising tools – such as software to simulate experiences of pedestrian exclusion – as well as digital story telling and legal orientation guides. Theoretical context and framing will be provided by an innovative blending of Martha Fineman's universal vulnerability thesis with the social model of disability.

The project will be the first to bring a multinational sociolegal perspective to bear on this significant social justice problem. It is timely - given concerns about the move in EU countries (often supported by EU funding) toward streets in which space is shared by vehicles and pedestrians; and the ratification (including by the EU) of the UN Convention on the Rights of Persons with Disabilities, which is the first such treaty to include provisions on the accessibility of public space.

Project End Date: **31-DEC-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:
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:
802512	**COSMOLOCALISM**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. VASILEIOS KOSTAKIS**
Host Institution: Tallinna Tehnikaulikool, EE

Design Global, Manufacture Local: Assessing the Practices, Innovation, and Sustainability Potential of an Emerging Mode of Production

COSMOLOCALISM will document, analyse, test, evaluate, and create awareness about an emerging mode of production, based on the confluence of the digital commons (e.g. open knowledge and design) with local manufacturing and automation technologies (from 3D printing and CNC machines to low-tech tools and crafts). This convergence could catalyse the transition to new inclusive and circular productive models, such as the “design global, manufacture local” (DGML) model.

DGML describes the processes through which design is developed as a global digital commons, whereas the manufacturing takes place locally, through shared infrastructures and with local biophysical conditions in mind. DGML seems to form economies of scope that promote sustainability and open innovation while celebrating new ways of cooperation. However, such claims rest on thin conceptual and empirical foundations.
COSMOLOCALISM is a multiphase, pilot-driven investigation of the DGML phenomenon that seeks to understand relevant organisational models, their evolution, and their broader political economy/ecology and policy implications. Through the lens of diverse case studies and participatory action research, the conditions under which the DGML model thrives will be explored.

COSMOLOCALISM has three concurrent streams: practices; innovation; and sustainability. First, DGML practices will be studied, patterns will be reCoGnised and their form, function, cultural values, and governance structure will be determined. Second, the relevant open innovation ecosystems and their potential to reorient design and manufacturing practices will be examined. Third, selected DGML products will be evaluated from an environmental sustainability perspective, involving both qualitative and quantitative methods. The interdisciplinary nature of COSMOLOCALISM will explore new horizons to substantively improve our understanding of how we could do “more” and “better” with less.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
802605	**FIDELIO**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. NIKOLETA JONES**
Host Institution: Anglia Ruskin University Higher Education Corporation, UK

Forecasting social Impacts of bioDiversity consErvation poLicies In EurOpe

Designating Protected Areas (PAs) is the most important policy tool for biodiversity conservation. Over 100 new PAs have been established in the past 36 months in European Union territory. However, effective management of PAs is often obstructed by conflicts mainly associated with the social impacts (SIs) imposed on local communities by their establishment. Despite the importance of these SIs there are certain aspects in this field that remain significantly under-researched. There is now an increasing need to incorporate SI assessments in decision making processes by providing a clear framework explaining how perceptions of these impacts are created and predicting their change in the future. This will support the achievement of international goals for biodiversity conservation and adaptation to climate change as well as better accounting for social justice issues for communities dependent on protected natural resources. The aim of FIDELIO is to develop for the first time a new paradigm in order to understand how perceptions of SIs are formulated taking into consideration the dimensions of space and time. FIDELIO will assist in increasing public engagement and the incorporation of local opinions in decision-making. It will also facilitate the process of policy development and a reduction in conflicts between different stakeholders in PAs. FIDELIO will last 5 years and its research objectives will be explored through the application of a mixed-methods approach including the implementation of two rounds of social surveys in 4 PAs across Europe and the testing of the framework in 15 additional PAs. This is an extremely timely project considering the steady increase of new PAs and the re-designation of current ones. FIDELIO will contribute to the better understanding of SIs and facilitate predictions for their change in the future, while assisting in maximizing social benefits for local communities arising from the designation of a PA.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
803163	**IMAGINE**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. JAN KOMAREK**
Host Institution: Kobenhavns Universitet, DK

EUROPEAN CONSTITUTIONAL IMAGINARIES: UTOPIAS, IDEOLOGIES AND THE OTHER

While scholars have presented and promoted a series of specific theories of EU constitutionalism, no one has yet attempted to analyse their wider intellectual context and the relationship among them – what we call here 'European constitutional imaginaries' (ECIs). In addition, IMAGINE does not limit this general analysis to the mainstream thinkers writing for the audience located at the supranational/transnational level. It includes the perspective of thinkers writing in particular EU member states. IMAGINE seeks to uncover whether there are individuals and ideas that have made important, yet often overlooked, contributions to ECIs. Crucially, IMAGINE puts emphasis on post-communist Europe' experience, hitherto mostly ignored in EU constitutional scholarship.

As a result, IMAGINE will provide the first-ever synthesis and critical evaluation of the core theories of EU constitutionalism, theorizing their mutual relationship and the way in which they have influenced each other.

The overarching objective is to provide a novel account of ECIs: one informed by their intellectual history, which comprises both Old and the post-communist Europe, and which seeks to understand the various problems that lead some people to reject EU constitutionalism and its core values, seeing them as mere utopias or oppressing ideologies.

IMAGINE employs an innovative combination of research methods: empirical surveys, citation network analyses and elite in-depth interviews, together with traditional legal analysis. It will involve experts from particular member states though a number of workshops and a conference organized by the IMAGINE Team.

The PI is uniquely placed to realise IMAGINE: now based as a Professor of EU law at an elite socio-legal research centre iCourts (University of Copenhagen), he has participated in EU constitutional discourse both as a scholar and practitioner in one of the member states of post-communist Europe for more than 10 years.

Project End Date: **31-JAN-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: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

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:
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:
804307	**INTEGRATE**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. DOMINIK HANGARTNER**
Host Institution: Eidgenoessische Technische Hochschule Zurich, CH

Identifying the Impact of Asylum Polices on Refugee Integration and Political Backlash in Host Communities

Confronted with the largest refugee crisis since the Second World War, European governments are struggling with a complex and urgent question: how to best facilitate the integration of increasing numbers of refugees, while mitigating political conflict and native backlash in host communities?

Despite the importance of this question, we lack reliable causal evidence of the impact of the asylum process and the consequences of most integration programs. The goal of INTEGRATE is two-fold. First, to provide systematic evidence that identifies the causal effects of the key parameters of the asylum process on the short and long-term economic, educational, health, political and social integration of refugees, their families, and children in five European countries: Denmark, France, Germany, Sweden and Switzerland. Specifically, INTEGRATE will examine the impact of wait times, labor market access, apprenticeship and training programs, early enrolment in language courses, integration contracts, welfare support, and family reunification policies on integration trajectories. INTEGRATE will achieve this goal by utilizing quasi-experimental research designs and by combining the coverage of high-quality register panel data with comprehensive integration measures from targeted surveys.

Second, INTEGRATE will assess whether effective integration programs alleviate hostility and moderate support for extreme-right parties in host communities by leveraging policy-induced temporal and spatial variation in integration success. In so doing, INTEGRATE endeavours to shed light on the potential of asylum and integration policies to improve social cohesion and lesson refugee-native conflict.

In sum, the goal of INTEGRATE is to use causal research designs and innovative statistical methodology to comprehensively evaluate the asylum process in Europe, establishing an evidence base that can be used to redesign the asylum process to improve outcomes for both refugees and host societies.

Project End Date: **31-OCT-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:
820235	**MOCHA**	**SH2** Institutions, Values, Beliefs and Behaviour

Principal Investigator: **Dr. LORRAINE WHITMARSH**
Host Institution: Cardiff University, UK

Understanding and leveraging 'moments of change' for pro-environmental behaviour shifts

Responding to climate change requires profound changes to individual behaviour. However, much of our behaviour is habitual, which is resistant to change. Habits are cued by stable contexts (i.e., same time, place and/or social group), so when these change, habits are disrupted, providing an opportunity to intervene to foster pro-environmental behaviour. 'Moments of change' are when individual life circumstances shift within a short time frame, and include biographical and exogenous changes (e.g., becoming a parent, travel disruption). The relationship between moments of change and environmental impact is complex, with heterogeneity between individuals, cultures and behaviours. The aim of this proposal is to examine how ambitious lifestyle change might be achieved through understanding and harnessing 'moments of change' in life circumstances. This project integrates insights from several fields (developmental and environmental psychology, sociology, science & technology studies) to bring a much-needed focus on the temporal and socio-technical dimensions of pro-environmental behaviour (change). There are two objectives for the research: (a) To explore and track moments of pro-environmental behaviour change across cultures and life-course; and (b) To examine the efficacy of behavioural interventions targeted to moments of change. Three work packages address these objectives through an ambitious programme of cross-cultural research using secondary and big data analyses, longitudinal qualitative interviews and panel surveys to explore moments of change, and experimental studies to test behaviour change interventions targeted at moments of change (e.g., starting university, retiring, relocating). This project promises a step-change in understanding the dynamics of pro-environmental change across the life course and cultures, and the development of robust habit-disrupting interventions to foster lifestyle change.

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

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: **31-AUG-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
680176	**SCALEFORES**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. FELIX EIGENBROD**
Host Institution: University Of Southampton, UK

SCALEFORES: Scaling Rules For Ecosystem Service Mapping

It is now widely reCoGnized that sustainably managing ecosystem services – the benefits humans obtain from nature – is essential for humanity's prospects in the 21st century and beyond. However, at present there is little data on the distribution of most services in most places.

To date, the discipline of ecosystem service mapping has tried overcome this lack of data by using proxies to map ecosystem services based on our perceived understanding of ecosystem services from small-scale studies. However, the most commonly used proxies have been shown to be inaccurate, particularly for understanding policy-relevant trade-offs and win-wins between ecosystem services. The challenge therefore remains - how do we reliably map such relationships between multiple ES, thereby enabling multifunctional, ES-based management of our landscapes?

In the SCALEFORES project, I will address this challenge head-on by developing and testing a novel methodological framework that enables the use of existing data to produce accurate maps of the relationships between ES in previously unmapped regions. The overarching idea underpinning SCALEFORES is that we can use information on the scale-dependency of relationships between existing social and ecological datasets (e.g. land cover, soil type, human population density) to create maps of trade-offs and win-wins between ecosystem services.

The SCALEFORES project will systematically examine the scale-dependency of relationships between ecosystem services and the social and ecological variables that underpin them. It will then use this knowledge to enable a step change increase in our ability to accurately map both relationships between ES and the distributions of ecosystem services themselves. The methodology developed in SCALEFORES will be validated against existing maps of ecosystem services in Europe, as this is the region with the best data on ecosystem services globally.

Project End Date: **30-JUN-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694767	**ECSAnVis**	**SH3** Environment, Space and Population

Principal Investigator:	**Dr. MUKI HAKLAY**
Host Institution:	University College London, UK

Extreme Citizen Science: Analysis and Visualisation

The challenge of Extreme Citizen Science is to enable any community, regardless of literacy or education, to initiate, run, and use the result of a local citizen science activity, so they can be empowered to address and solve issues that concern them. Citizen Science is understood here as the participation of members of the public in a scientific project, from shaping the question, to collecting the data, analysing it and using the knowledge that emerges from it. Over the past 3 years, under the leadership of Prof. Muki Haklay, the Extreme Citizen Science programme at UCL has demonstrated that non-literate people and those with limited technical literacy can participate in formulating research questions and collecting the data that is important to them. Extreme Citizen Science: Analysis and Visualisation (ECSAnVis) takes the next ambitious step – developing geographical analysis and visualisation tools that can be used, successfully, by people with limited literacy, in a culturally appropriate way. At the core of the proposal is the imperative to see technology as part of socially embedded practices and culture and avoid 'technical fixes'.

The development of novel, socially and culturally accessible Geographic Information System (GIS) interface and underlying algorithms, will provide communities with tools to support them to combine their local environmental knowledge with scientific analysis to improve environmental management. In an exciting collaboration with local indigenous partners on case studies in critically important, yet fragile and menaced ecosystems in the Amazon and the Congo-basin, our network of anthropologists, ecologists, computer scientists, designers and electronic engineers will develop innovative hardware, software and participatory methodologies that will enable any community to use this innovative GIS.

The research will contribute to the fields of geography, geographic information science, anthropology, development, agronomy and conservation.

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

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:
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:
725194	**CRIMTANG**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. HENRIK VIGH**
Host Institution: Kobenhavns Universitet, DK

Criminal Entanglements.
A new ethnographic approach to transnational organised crime.

Linked to terrorism, moral breakdown, and societal decay, Transnational Organised Crime (TOC) has come to embody current global anxieties as a figure of fear and cause of disquiet. Yet despite its central position on the social and political radar, our knowledge of it remains limited and fragmentary. Quantitative analyses may have identified the scale of the problem, but its underlying socio-cultural logic and practices remain under-researched and largely obscure. TOC is on the rise, and we need better insights into how it develops and expands, who engages in it and why, and how it is linked to and embedded in social networks that straddle countries and contexts.

CRIMTANG proposes a unique approach to the study of the social infrastructure of contemporary TOC. It develops a research strategy that is ethnographic and transnational in design and so attuned to the human flows and formations of TOC. The project comprises a trans-disciplinary research team of anthropologists, criminologists and political scientists, and builds on their prior experience of the people, regions and languages under study. It explores the illegal and overlapping flows of migrants and drugs from North-West Africa into Europe, following a key trafficking trajectory stretching from Tangiers to Barcelona, Paris and beyond.

In so doing, CRIMTANG sheds new light on the actual empirical processes in operation at different points along this trafficking route, whilst simultaneously developing new theoretical and methodological apparatuses for apprehending TOC that can be exported and applied in other regions and contexts. It reimagines the idea of social entanglement and proposes new transnational and collective fieldwork strategies. Finally, it will advance and consolidate the European research environment on TOC by creating a research hub for transnational ethnographic criminology at the University of Copenhagen.

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

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:
725961	**EU-FER**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. DANIELE VIGNOLI**
Host Institution: Universita Degli Studi Di Firenze, IT

Economic Uncertainty and Fertility in Europe

EU-FER is a project about Economic Uncertainty and FERtility in EUrope. Economic uncertainty may be interpreted as an individual risk factor, mainly related to the labour market (e.g. unemployment, short-term contract jobs, underemployment, or a combination of these), but it may also be conceptualized as a macro-level phenomenon, reflecting the general uncertainty felt by people in times of economic turbulence. The recent Great Recession, spanning 2007 to 2009 and featuring downturns in both financial and labour market fortunes, has fuelled interest in understanding whether economic uncertainty, which does not appear to be a transient phenomenon, affects fertility.

The economic uncertainty/fertility nexus is far from being clearly understood: theoretical premises are weak and empirical findings send conflicting messages. The goal of this project is to generate new knowledge on if, how, and under what circumstances economic uncertainty matters for fertility in contemporary Europe, adopting a cross-country comparative approach. The use of new data, methodologies, and tools may advance our knowledge on this topic. EU-FER is based on three pillars: a meta-analysis of previous research, a cross-country laboratory experimentation design, and micro-level longitudinal analyses.

EU-FER ensures a strong interdisciplinary perspective, with the following overall goals:

• to advance the understanding of the causal impact of economic uncertainty on fertility addressing this issue in a comprehensive way and from different perspectives, using various measures of uncertainty, and testing aspects that remain unclear from the current body of research;

• to enhance the boundaries of demographic research by illustrating the benefits of a laboratory experimentation design;

• to communicate findings and stimulate the academic and policy debate on how economic uncertainty matters for fertility.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
726141	**GirlsInScience**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. JUDI MESMAN**
Host Institution: Universiteit Leiden, NL

Building an Evidence-Base for Reducing Gender Bias in Educational Pathways

In 2012, the European Commission launched the campaign Science: It's a girl thing!, aimed at encouraging women to choose research careers, as they are sorely underrepresented in science, technology, engineering, and mathematics (STEM). Given that gender disparities in aptitude for specific fields are generally very small, highly gendered skewness in educational choices suggest pathways dictated by stereotypes rather than abilities, leaving valuable STEM talents unused.

Many European countries have invested in boosting girls' participation in STEM through workshops with girl-oriented science topics, contact with female role models, and information packages. However, the vast majority of these initiatives have not been scientifically evaluated. Further, most programs leave untouched one of the key underlying processes keeping girls from STEM that emerge from the research literature, namely daily socialization reinforcing gender stereotypes in the school and family context.

I aim to fill this gap by developing a video-feedback intervention aimed at reducing teachers' (largely unconscious) gendered classroom interactions in primary and secondary schools, testing its effectiveness in reducing gender disparities in STEM in a randomized control trial (RCT), and longitudinally investigating salient family processes from infancy to late adolescence to inform parent education programs.

This approach is innovative because it is the first to apply and rigorously test a video-feedback intervention aimed at reducing gendered interactions in schools. Further, the comprehensive scope of the study design is unique because it includes children and adolescents across development in both the school and the family context.

The insights from this study will provide new avenues for both research and practice regarding gender socialization. The project fits seamlessly with my expertise in gender socialization, and experience with longitudinal and RCT projects in schools and families.

Project End Date: **31-MAY-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:
759681	**BLOCKCHAINSOCIETY**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. BALAZS BODO**
Host Institution: Universiteit Van Amsterdam, NL

The Disrupted Society: mapping the societal effects of blockchain technology diffusion

Recent advances in cryptography yielded the blockchain technology, which enables a radically new and decentralized method to maintain authoritative records, without the need of trusted intermediaries. Bitcoin, a cryptocurrency blockchain application has already demonstrated that it is possible to operate a purely cryptography-based, global, distributed, decentralized, anonymous financial network, independent from central and commercial banks, regulators and the state.

The same technology is now being applied to other social domains (e.g. public registries of ownership and deeds, voting systems, the internet domain name registry). But research on the societal impact of blockchain innovation is scant, and we cannot properly assess its risks and promises. In addition, crucial knowledge is missing on how blockchain technologies can and should be regulated by law.

The BlockchainSociety project focuses on three research questions. (1) What internal factors contribute to the success of a blockchain application? (2) How does society adopt blockchain? (3) How to regulate blockchain? It breaks new ground as it (1) maps the most important blockchain projects, their governance, and assesses their disruptive potential; (2) documents and analyses the social diffusion of the technology, and builds scenarios about the potential impact of blockchain diffusion; and (3) it creates an inventory of emerging policy responses, compares and assesses policy tools in terms of efficiency and impact. The project will (1) build the conceptual and methodological bridges between information law, the study of the self-governance of technological systems via Science and Technology Studies, and the study of collective control efforts of complex socio-technological assemblages via Internet Governance studies; (2) address the most pressing blockchain-specific regulatory challenges via the analysis of emerging policies, and the development of new proposals.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
770839	**PARENTIME**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. ALMUDENA SEVILLA**
Host Institution: University College London, UK

PARENTAL TIME INVESTMENTS AND INTERGENERATIONAL TRANSMISSION OF INEQUALITY

High socio-economic status parents consistently produce high socio-economic status children. The question is how. The objective of PARENTIME is to develop new socio-economic theories that unpack the detailed mechanisms driving the inter-generational transmission of inequality.

Because of data limitations and theoretical traditions, the literature has focused on a narrow conceptualization of parental time (limited to the quantity of time spent with children in different kinds of activities), and a narrow set of child outcomes (limited to educational outcomes and socio-behavioral outcomes during the early years). Thus, while the results from this literature are informative at documenting the phenomenon of inter-generational transmission of human capital, they remain silent about the mechanisms underlying the process. PARENTIME aims to close this gap.

In PARENTIME I will take a theoretically-driven Big Data approach by linking large representative 24-hour diary survey data of parents and children with very comprehensive and detailed information on child outcomes from administrative data to: First, go beyond the quantity of parental time to explore the inter-connections between family members and their role in the child's acquisition of human capital (i.e., the timing and sequence, co-presence, multi-tasking, and instantaneous parental enjoyment). Second, establish long-term effects of parental time investments by looking at a comprehensive set of child human capital measures all the way into the child's adult life. Third, arrive at a well-coordinated scientific approach, starting at the micro-sequential level of parents and children's everyday life and building progressively to a macro understanding of the (re)production of socio-economic inequality.

Project End Date: **31-AUG-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:
785635	**ATTACK**	**SH3** Environment, Space and Population

Principal Investigator:	**Dr. CARSTEN DE DREU**
Host Institution:	Universiteit Leiden, NL

Pressured to Attack: How Carrying-Capacity Stress Creates and Shapes Intergroup Conflict

Throughout history, what has been causing tremendous suffering is groups of people fighting each other. While behavioral science research has advanced our understanding of such intergroup conflict, it has exclusively focused on micro-level processes within and between groups at conflict. Disciplines that employ a more historical perspective like climate studies or political geography report that macro-level pressures due to changes in climate or economic scarcity can go along with social unrest and wars. How do these macro-level pressures relate to micro-level processes? Do they both occur independently, or do macro-level pressures trigger micro-level processes that cause intergroup conflict? And if so, which micro-level processes are triggered, and how?

With unavoidable signs of climate change and increasing resource scarcities, answers to these questions are urgently needed. Here I propose carrying-capacity stress (CCS) as the missing link between macro-level pressures and micro-level processes. A group experiences CCS when its resources do not suffice to maintain its functionality. CCS is a function of macro-level pressures and creates intergroup conflict because it impacts micro-level motivation to contribute to one's group's fighting capacity and shapes the coordination of individual contributions to out-group aggression through emergent norms, communication and leadership.

To test these propositions I develop a parametric model of CCS that is amenable to measurement and experimentation, and use techniques used in my work on conflict and cooperation: Meta-analyses and time-series analysis of macro-level historical data; experiments on intergroup conflict; and measurement of neuro-hormonal correlates of cooperation and conflict. In combination, this project provides novel multi-level conflict theory that integrates macro-level discoveries in climate research and political geography with micro-level processes uncovered in the biobehavioral sciences

Project End Date: **31-JUL-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:
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:
802631	**HEALFAM**	**SH3** Environment, Space and Population

Principal Investigator: **Dr. ANNA BARANOWSKA-RATAJ**
Host Institution: Umea Universitet, SE

The effects of unemployment on health of family members

Previous research has investigated the relationship between unemployment and health from a perspective of an isolated individual. HEALFAM takes a novel approach and examines how transition to unemployment triggers diffusion of ill mental and physical health within families. It investigates how becoming unemployed affects health outcomes of partners, children and elderly parents of the unemployed and whether the magnitudes of these influences differ across families and societies. Thus, instead of viewing the unemployed as functioning in isolation, HEALFAM assesses the consequences of unemployment for family members taking a multi-actor perspective and international comparative approach.

Guided by the life course theoretical framework, which views health and well-being as a process rather than a state and calls for considering interrelatedness of individuals, HEALFAM employs longitudinal data that provide information about multiple members of families. In order to analyse these datasets, HEALFAM uses longitudinal dyadic data analysis techniques as well as multilevel models for longitudinal data.

HEALFAM aims to open a new frontline of research on health and wellbeing from a life course perspective. It benefits from my knowledge on three interrelated social phenomena: (1) the role of labour market career and experiences of unemployment (2) family structure and intra-family resources (3) social antecedents of health and wellbeing among family members. It draws on high quality register and panel survey data as well as the expertise at the interdisciplinary research centres that I am connected to at Umeå University. Through international collaborations, it brings together experts in multiple disciplines carrying out research taking a life course perspective.

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

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:
803239	**CRISP**	**SH3** Environment, Space and Population

Principal Investigator:	**Dr. ANJA LEIST**
Host Institution:	Universite Du Luxembourg, LU

CoGnitive Aging: From Educational Opportunities to Individual Risk Profiles

CoGnitive impairment and dementia have dramatic individual and social consequences, and create high economic costs for societies. In order to delay CoGnitive aging of future generations as long as possible, we need evidence about which contextual factors are most supportive for individuals to reach highest CoGnitive levels relative to their potential. At the same time, for current older generations, we need scalable methods to exactly identify individuals at risk of CoGnitive impairment. The project intends to apply recent methodological and statistical advancements to reach two objectives. Firstly, contextual influences on CoGnitive aging will be comparatively assessed, with a focus on inequalities related to educational opportunities and gender inequalities. This will be done using longitudinal, population-representative, harmonized cross-national aging surveys, merged with contextual information. Secondly, the project will quantify the ability of singular and clustered individual characteristics, such as indicators of CoGnitive reserve and behaviour change, to predict CoGnitive aging and diagnosis of dementia. Project methodology will rely partly on parametric 'traditional' multilevel- or fixed-effects modelling, partly on non-parametric statistical learning approaches, to address objectives both hypothesis- and data-driven. Applying statistical learning techniques in the field of CoGnitive reserve will open new research avenues for efficient handling of large amounts of data, among which most prominently the accurate prediction of health and disease outcomes. Quantifying the role of contextual inequalities related to education and gender will guide policymaking in and beyond the project. Assessing risk profiles of individuals in relation to CoGnitive aging will support efficient and scalable risk screening of individuals. Identifying the value of behaviour change to delay CoGnitive impairment will guide treatment plans for individuals affected by dementia.

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

European Research Council
Executive Agency
Established by the European Commission

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:
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:
646696	**AUDADAPT**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. JONAS OBLESER**
Host Institution: Universitat Zu Lubeck, 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-20**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677601	**NOISYDECISIONS**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. JANNEKE JEHEE**
Host Institution: Stichting Katholieke Universiteit, NL

Neural decisions under uncertainty

Virtually anything we sense, think and do is uncertain. For instance, when driving a car, you often need to determine how close you are to the car in front of you. It is near impossible to estimate this distance with absolute certainty – but it is possible to guess and even to estimate the uncertainty associated with that guess. Accordingly, we reduce speed when driving at night, because we realize perceived distance is more uncertain in the dark than on a sunny, clear day. How do we infer that visual information is less reliable at night? How does the brain represent knowledge of sensory uncertainty? How do we decide to reduce speed? The overall aim of this proposal is to investigate the neural basis of perceptual decision-making under uncertainty. I will concentrate on three major research questions. First, I aim to establish the degree to which sensory uncertainty is represented in human visual cortex. Second, I will examine whether observers are aware of this uncertainty when making decisions. Third, I will investigate the sources of noise that cause the uncertainty in our perceptual decisions. I will address these questions using functional magnetic resonance imaging (fMRI), in combination with a novel analytical method to analyzing fMRI data that I recently developed. This novel approach allows me to characterize, on a trial-by-trial basis, the uncertainty in cortical stimulus representations, and to address unresolved issues regarding the neural mechanisms of human perceptual decision-making. The results from this project will provide important new insights into the neural basis of perceptual decisions, with profound implications for theories of cortical visual function. Given that mechanisms of visual decision-making likely resemble the mechanisms underlying other forms of decisions throughout the brain, the proposed research will also provide a basis for understanding choice under uncertainty in general.

Project End Date: **30-NOV-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
678286	**CONTEXTVISION**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. FLORIS DE LANGE**
Host Institution: Stichting Katholieke Universiteit, NL

Visual perception in Context

Everything occurs in a context. We see a car in the context of a street scene and a stove in the context of a kitchen. Context greatly helps the processing of individual objects. Surprisingly however, context hardly plays a role in most models of visual perception, which treat perception as a largely bottom-up categorization process.

In this research proposal, I will examine how context changes the cortical computations that give rise to visual perception, focusing on contextual modulations in space and time. Moreover, I will translate this research to a clinical condition that is marked by aberrant context modulations in perception.
Firstly, I will examine the influence of spatial context from the surround on cortical processing of individual elements. I aim to uncover the neural mechanisms responsible for the contextual facilitation of features and objects. I hypothesize that spatial context constrains sensory input by changing sensory representations at earlier stages in line with expectations at higher-order stages of perceptual analysis.
Secondly, I will examine the influence of temporal context from past history. I hypothesize that temporal contexts trigger cortical waves of neural 'preplay' activity, setting up time-varying templates of expected incoming visual input.
Thirdly, I will test the clinical significance of this framework to understand perceptual atypicalities in Autism Spectrum Disorder (ASD). I will empirically test the hypothesis that ASD is marked by deficient processing of contextual information, in both the spatial and temporal domain.

This integrative approach has the potential to significantly advance theoretical models of perception, based on underlying neurobiology, and underline the importance of context for understanding perception. Moreover, the knowledge gleaned can have significant societal and clinical impact.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679399	**PERCEPT**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. HELEEN SLAGTER**
Host Institution: Stichting Vu, NL

The mind's eye: How expectation and attention shape perception

Perception is more than meet's the eye; how we see the world is critically shaped by attention (what is relevant) and as a growing body of work indicates, by past experience (what is likely). Overturning the classical notion of perception as a largely bottom-up process, the idea that our brain is a prediction machine, continually trying to predict what is 'out there' based on past experience, is quickly growing in stature and influence. Yet, little is still known about how predictions shape perceptual experience. Moreover, it is completely unknown to what extent predictive processing occurs automatically. Lastly, how the brain ultimately 'decides' on one hypothesis or interpretation of the current sensory state is still unclear. The proposed research program will address these outstanding questions with the ultimate aim to better understand how the brain infers the world and the mechanisms that give rise to perceptual experience. It will do so through an integrated application of psychophysical, neuroimaging, brain stimulation, mathematical modelling, and pharmacological techniques. The research program comprises three projects. The first project will examine how expectations are implemented in the brain and shape stimulus processing, independently from and aided by attention. The second project will reveal if one can teach oneself to be free of expectation and associated habitual responding, through intensive mental training, as cultivated by meditation. The third project will test the idea that the striatum, a subcortical brain region, and its irrigation by the neurotransmitter dopamine play a critical role in updating our internal model about the environment and thereby conscious perception. The proposed research will be critical in elucidating the mechanisms that underlie experience and the extent to which these mechanisms are plastic, and will have important implications for the study of clinical disorders characterized by dysfunctional experience of the world.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682591	**STRESNET**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. ERNO HERMANS**
Host Institution: Stichting Katholieke Universiteit, NL

Stress Resilience and Network-Feedback Training

Acute stress has a profound impact on CoGnitive functioning: it raises alertness for threat, yet it impairs our ability to think clearly. Repeated exposure to stressors is furthermore a critical transdiagnostic factor in etiology, relapse, and chronification in almost all psychiatric disorders. We know from animal work at the cellular level how stressors trigger a neurochemical cascade that alters properties of widespread neuronal populations. A critical gap in our knowledge, however, is how such cellular effects translate to the level of large-scale neural systems which implement higher-order CoGnition. Here, I propose a novel framework for understanding such alterations as shifts in network balance: I hypothesize that acute stress causes dynamic shifts in resource allocation at the level of large-scale networks. First, I will leverage recent advances in network connectivity modeling to characterize the spatiotemporal dynamics of such shifts during acute stress and recovery. Using wearable biosensors and mobile applications, I aim to identify which neural markers predict resilience to stress in real life. Second, I will cross-validate these markers in a patient group characterized by high stress sensitivity. Third, to investigate how rapid network shifts are generated, I will examine the distinct roles of noradrenergic and dopaminergic neuromodulatory systems. Fourth, I will test the hypothesis that CoGnitive functions supported by one network can be disrupted by shifting balance towards another. Finally, I will develop a network-based implementation of functional MRI neurofeedback to train stress-sensitive participants to adaptively reallocate neural resources during acute stress. When successful, this project will yield 1) unprecedented insight into how our brain adapts to acute stress; 2) novel ecologically validated transdiagnostic biomarkers of stress resilience versus sensitivity; and 3) a potentially groundbreaking method for training stress resilience.

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

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:
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:
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:
716321	**FREEMIND**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. JIAXIANG ZHANG**
Host Institution: Cardiff University, UK

FREE the MIND: the neuroCoGnitive determinants of intentional decision

Acting based on intention is a fundamental ability to our lives. Apple or orange, cash or card: we constantly make intentional decisions to fulfil our desires, even when the options have no explicit difference in their rewards. Recently, I and others have offered the first evidence to support that intentional decision and externally guided decision share similar computational principles. However, how the brain implements these principles for intentional decision remains unknown.

This project aims to establish a multilevel understanding of intentional decision, spanning from neurons to brain networks to behaviour, through a powerful combination of novel paradigms, cutting-edge brain imaging, and innovative methods. Central to my approach is formal computational modelling, allowing me to establish a quantitative link between data and theory at multiple levels of abstraction. Subproject 1 will ask which brain regions encode intentional information, when intentional processes occur, and how neurochemical concentration influences intentional decision. Subproject 2 will focus on theoretically predicted changes in intentional decision under behavioural and neural interventions. I will use brain imaging and brain stimulation to test the flexibility of intentional decision within individuals. Subproject 3 will launch the largest study to date on intentional decision. I will characterize individual differences in intentional decision from 2,000 representative samples. I will then investigate, with high statistical power, the contributions of neurochemistry and brain microstructure to individual differences in intentional decision. This project premises to establish the first neurobiological theory of intentional behaviour, and provide mechanistic understanding of its changes within and between individuals. The new theory and innovative methodology will open further research possibilities to explore intentional deficits in diseases, and the neural basis of human volition.

Project End Date: **28-FEB-22**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716931	**GESTIMAGE**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. ADRIEN MEGUERDITCHIAN**
Host Institution: Centre National De La Recherche Scientifique Cnrs, FR

Gestures in nonhuman and human primates, a landmark of language in the brain? Searching for the origins of brain specialization for language

Most of language functions are under the left brain control in both left- and right-handers and involve structural asymmetries between the two hemispheres. While this asymmetry was considered as associated with handedness, such a relation has been recently questioned. Considering the strong language/gesture links in humans and the continuities between the gestural system in apes and monkeys and some language properties, we recently suggested the hypothesis of a continuity between language lateralization and asymmetry of communicative gestures in both human and nonhuman primates. Given the phylogenetical proximity between those species, comparative research on brain specialization between a non-linguistic gestural system (i.e., in monkeys) versus a linguistic gestural systems in humans (i.e., sign language in deaf) might help evaluating the gestural continuities with language lateralization in term of manual asymmetries, structural and functional lateralization of the brain.

To this purpose, a first objective is to evaluate the continuities of manual and brain asymmetries between (1) a linguistic gestural system in humans using MRI in 100 adult native deaf French signers, and (2) a non-linguistic gestural system of adult baboons Papio anubis using 106 MRI brain images.

A second objective is to explore the functional brain lateralization of gestures production in baboons (versus manipulation) using non-invasive wireless Infrared Spectroscopy in 8 trained subjects within interactions with humans.

A last innovative objective is to investigate, through the first non-invasive longitudinal MRI study conducted from birth to sexual maturity in primates, the development and heritability of brain structural asymmetries and their correlates with gesture asymmetries in 30 baboons.

At both evolutionary and developmental levels, the project will thus ultimately contribute to enhance our understanding on the role of gestures in the origins of brain specialization for language.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716974	**Becoming Social**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. KAMI KOLDEWYN**
Host Institution: Bangor University, UK

Social Interaction Perception and the Social Brain Across Typical and Atypical Development

Social interactions are multifaceted and subtle, yet we can almost instantaneously discern if two people are cooperating or competing, flirting or fighting, or helping or hindering each other. Surprisingly, the development and brain basis of this remarkable ability has remained largely unexplored. At the same time, understanding how we develop the ability to process and use social information from other people is widely reCoGnized as a core challenge facing developmental CoGnitive neuroscience. The Becoming Social project meets this challenge by proposing the most complete investigation to date of the development of the behavioural and neurobiological systems that support complex social perception. To achieve this, we first systematically map how the social interactions we observe are coded in the brain by testing typical adults. Next, we investigate developmental change both behaviourally and neurally during a key stage in social development in typically developing children. Finally, we explore whether social interaction perception is clinically relevant by investigating it developmentally in autism spectrum disorder. The Becoming Social project is expected to lead to a novel conception of the neuroCoGnitive architecture supporting the perception of social interactions. In addition, neuroimaging and behavioural tasks measured longitudinally during development will allow us to determine how individual differences in brain and behaviour are causally related to real-world social ability and social learning. The planned studies as well as those generated during the project will enable the Becoming Social team to become a world-leading group bridging social CoGnition, neuroscience and developmental psychology.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
741134	**M and M**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. JEFFREY BOWERS**
Host Institution: University Of Bristol, UK

Generalization in Mind and Machine

Is the human mind a symbolic computational device? This issue was at the core Chomsky's critique of Skinner in the 1960s, and motivated the debates regarding Parallel Distributed Processing models developed in the 1980s. The recent successes of "deep" networks make this issue topical for psychology and neuroscience, and it raises the question of whether symbols are needed for artificial intelligence more generally.

One of the innovations of the current project is to identify simple empirical phenomena that will serve a critical test-bed for both symbolic and non-symbolic neural networks. In order to make substantial progress on this issue a series of empirical and computational investigations are organised as follows. First, studies focus on tasks that, according to proponents of symbolic systems, require symbols for the sake of generalisation. Accordingly, if non-symbolic networks succeed, it would undermine one of the main motivations for symbolic systems. Second, studies focus on generalisation in tasks in which human performance is well characterised. Accordingly, the research will provide important constraints for theories of CoGnition across a range of domains, including vision, memory, and reasoning. Third, studies develop new learning algorithms designed to make symbolic systems biologically plausible. One of the reasons why symbolic networks are often dismissed is the claim that they are not as biologically plausible as non-symbolic models. This last ambition is the most high-risk but also potentially the most important: Introducing new computational principles may fundamentally advance our understanding of how the brain learns and computes, and furthermore, these principles may increase the computational powers of networks in ways that are important for engineering and artificial intelligence.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
742231	**PARTNERS**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. GERGELY CSIBRA**
Host Institution: Kozep-Europai Egyetem, HU

Tracking and evaluating social relations and potential partners in infancy

In order to navigate the social world, children must understand how social interactions unfold in their society. While many recent studies have investigated how children evaluate the roles that people play in everyday interactions and what inferences they draw from their observations, to date there is no unifying account for the conceptual repertoire and computational mechanisms used by infants to analyse their social environment. Taking a new theoretical perspective on this topic, we plan to study whether and how human infants and young children are able to infer the social relations that underlie observed interactions. The theoretical background of this approach is based on the combination of two proposals: (1) that actions are analysed in terms of the costs and benefits they produce to the actors and others affected, and (2) Alan Fiske's theory, according to which human social relations could be classified into basic elementary forms. Using a variety of behavioural and neuroimaging techniques, we intend to investigate whether children infer the specific social relation that the intentional structure and the cost-benefit outcome of an observed interaction could reveal. More specifically, while resource transfer events (e.g., giving, taking) alter the distribution of goods among participants, they may also cue certain types of underlying relations that would ensure that all parties benefit, directly or indirectly, from the exchange on the long run (e.g., by reciprocity). We aim to establish whether drawing inferences to social relations enjoys the priority in the infant mind over attribution of social dispositions, whether infants predict the outcome of new, previously unobserved interactions, what information children use to choose partners for cooperative tasks, and how they track individuals across social contexts. This research will also provide a new perspective on the development of moral psychology by extending its domain from actions to social interactions.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
743035	**ECOLANG**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. GABRIELLA VIGLIOCCO**
Host Institution: University College London, UK

Ecological Language: A multimodal approach to language and the brain

The human brain has evolved the ability to support communication in complex and dynamic environments. In such environments, language is learned, and mostly used in face-to-face contexts in which processing and learning is based on multiple cues: linguistic (such as lexical, syntactic), but also discourse, prosody, face and hands (gestures). Yet, our understanding of how language is learnt and processed, and its associated neural circuitry, comes almost exclusively from reductionist approaches in which the multimodal signal is reduced to speech or text. ECOLANG will pioneer a new way to study language comprehension and learning using a real-world approach in which language is analysed in its rich face-to-face multimodal environment (i.e., language's ecological niche). Experimental rigour is not compromised by the use of innovative technologies (combining automatic, manual and crowdsourcing methods for annotation; creating avatar stimuli for our experiments) and state-of-the-art modelling and data analysis (probabilistic modelling and network-based analyses). ECOLANG studies how the different cues available in face-to-face communication dynamically contribute to processing and learning in adults, children and aphasic patients in contexts representative of everyday conversation. We collect and annotate a corpus of naturalistic language which is then used to derive quantitative informativeness measures for each cue and their combination using computational models, tested and refined on the basis of behavioural and neuroscientific data. We use converging methodologies (behavioural, EEG, fMRI and lesion-symptom mapping) and we investigate different populations (3-4 years old children, healthy and aphasic adults) in order to develop mechanistic accounts of multimodal communication at the CoGnitive as well as neural level that can explain processing and learning (by both children and adults) and can have impact on the rehabilitation of language functions after stroke.

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

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 Cnrs, 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:
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:
769595	**Ctrl-ImpAct**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. FREDERICK VERBRUGGEN**
Host Institution: Universiteit Gent, BE

Control of impulsive action

Adaptive behaviour is typically attributed to an executive-control system that allows people to regulate impulsive actions and to fulfil long-term goals instead. Failures to regulate impulsive actions have been associated with a variety of clinical and behavioural disorders. Therefore, establishing a good understanding of impulse-control mechanisms and how to improve them could be hugely beneficial for both individuals and society at large. Yet many fundamental questions remain unanswered. This stems from a narrow focus on reactive inhibitory control and well-practiced actions. To make significant progress, we need to develop new models that integrate different aspects of impulsive action and executive control. The proposed research program aims to answer five fundamental questions. (1) Can novel impulsive actions arise during task-preparation stages?; (2) What is the role of negative emotions in the origin and control of impulsive actions?; (3) How does learning modulate impulsive behaviour?; (4) When are impulsive actions (dys)functional?; and (5) How is variation in state impulsivity associated with trait impulsivity?

To answer these questions, we will use carefully designed behavioural paradigms, CoGnitive neuroscience techniques (TMS & EEG), physiological measures (e.g. facial EMG), and mathematical modelling of decision-making to specify the origin and control of impulsive actions. Our ultimate goal is to transform the impulsive action field by replacing the currently dominant 'inhibitory control' models of impulsive action with detailed multifaceted models that can explain impulsivity and control across time and space. Developing a new behavioural model of impulsive action will also contribute to a better understanding of the causes of individual differences in impulsivity and the many disorders associated with impulse-control deficits.

Project End Date: **31-MAY-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:
772000	**TURNTAKING**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. SIMONE PIKA**
Host Institution: Universitaet Osnabrueck, DE

Taking turns: The 'missing' link in language evolution?

Language — the most distinctive human trait — remains a 'mystery'1 or even a 'problem'2 for evolutionary theory. It is underpinned by cooperative turn-taking3, which has been implicated with highly sophisticated CoGnitive skills such as mindreading4. Some have claimed that this turn-taking system is uniquely human5,6, but others argue that it provides the evolutionary 'missing link' between animal and human communication7. This debate has been constrained by a lack of comparative data, methodological confounds that often prevent meaningful comparisons, and a lack of information on key components of social relationships8,9 that might strongly impact upon turn-taking propensities.

Objectives. TURNTAKING will quantify turn-taking production and comprehension in human children, chimpanzees, and two distantly related species — geladas and common marmosets. It will apply a powerful combination of systematic behavioral observations, eye-tracking paradigms, and established measures from Conversational Analysis3,10 and Primatology9 that allow the same type of data to be collected and analyzed in directly comparable ways across species. This will provide the first rigorous test of whether cooperative turn-taking is uniquely human, ancestral in the primate lineage, or evolved independently in different species. TURNTAKING will identify which hallmarks of human turn-taking are shared across different primate species, and which key components of relationship quality8,9 act upon turn-taking skills.

Outcomes. This project will found the field of comparative turn-taking, and provide pioneering insights into the behavioral flexibility underlying different turn-taking systems. It will go beyond the state of the art by exposing whether cooperative turn-taking is the evolutionary 'missing link' between our species and our inarticulate primate cousins, and whether pro-social behaviors drove its emergence.

Project End Date: **31-DEC-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:
787929	**SPAGAD**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. MANFRED KRIFKA**
Host Institution: Geisteswissenschaftliche Zentren Berlin Ev, DE

Speech Acts in Grammar and Discourse

The SPAGAD project will investigate speech acts, the basic linguistic units with communicative function. It is made possible by recent breakthroughs in our understanding of speech acts as devices to change the world by establishing new commitments and constrain the future development of a conversation.

The project will propose a formal model for speech acts. In the light of this model it will investigate the role of speech acts in three areas. It will elucidate their role in grammar in typologically diverse languages: how they are expressed by morphological, syntactic and prosodic means, how expressions like adverbials and clause-embedding verbs can operate on them, and how they can be integrated in a formal model of the syntax/semantics interface. It will investigate speech acts in discourse: how they are used to enrich the common ground, how they can be employed to negotiate conflicts in the development of conversation, how questions, contrastive topics and discourse particles are devices that restrict the development a discourse can take, and how the choice of one speech act out of set of alternatives creates pragmatic effects like bias in questions or politeness in commands. And it will explore speech acts in communication: What are the societal norms of different speech acts, like the prohibition against asserting falsehoods, which strategies can increase or decrease the commitments of speakers, how does the context influence the type of commitments, how do social groups within one language community differ, what are the difference across language communities, how are the societal norms that come with speech acts acquired?

The SPAGAD project will have a major impact on linguistic semantics and pragmatics; it will reconceive them by a model theory based on commitments, rather than truth. Due to the pivotal role of speech acts, it will offer new perspectives for syntax, discourse studies, psycholinguistics, sociolinguistics and the philosophy of language.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
787981	**FOUNDCoG**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. RHODRI CUSACK**
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

Curiosity and the Development of the Hidden Foundations of CoGnition

How do human infants develop complex CoGnition? We propose that artificial intelligence (AI) provides crucial insight into human curiosity-driven learning and the development of infant CoGnition. Deep learning—a technology that has revolutionised AI—involves the acquisition of informative internal representations through pre-training, as a critical precursory step to learning any specific task. We propose that, similarly, curiosity guides human infants to develop 'hidden' mature mental representations through pre-training well before the manifestation of behaviour. To test this proposal, for the first time we will use neuroimaging to measure the hidden changes in representations during infancy and compare these to predictions from deep learning in machines. Research Question 1 will ask how infants guide pre-training through directed curiosity, by testing quantitative models of curiosity adapted from developmental robotics. We will also test the hypothesis from pilot data that the fronto-parietal brain network guides curiosity from the start. Research Question 2 will further test the parallel with deep learning by characterising the developing infant's mental representations within the visual system using the powerful neuroimaging technique of representational similarity analysis. Research Question 3 will investigate how individual differences in curiosity affect later CoGnitive performance, and test the prediction from deep learning that the effects of early experience during pre-training grow rather than shrink with subsequent experience. Finally, Research Question 4 will test the novel prediction from deep learning that, following perinatal brain injury, pre-training creates resilience provided that curiosity is intact. The investigations will answer the overarching question of how pre-training learning lays the foundations for CoGnition and pioneer the new field of Computational Developmental CoGnitive Neuroscience.

Project End Date: **31-DEC-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:
802482	**VarPL**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. CASPAR SCHWIEDRZIK**
Host Institution: Universitaetsmedizin Goettingen - Georg-August-Universitaet Goettingen - Stiftung Oeffentlichen Rechts, DE

Specificity or generalization? Neural mechanisms for perceptual learning with variability

The visual system is equipped with a powerful plasticity mechanism, perceptual learning, which serves to improve perception of consistent inputs. However, the signals it receives are extremely variable. How variability affects perceptual learning is unclear. Here, I ask how the visual system tackles the challenge of variability for learning: variability could impair perceptual learning, or, like in language and motor learning, result in the ability to generalize from trained to new materials. To create effective training programs, e.g., for clinical applications, it is crucial to know how to reap the benefits of variability, or, conversely, to overcome the challenges variability poses. Yet, the neural mechanisms by which the visual system copes with variability are unknown, hampering this endeavor. To close this gap, I propose a new theory, derived from the architecture of cortex: I hypothesize that perceptual learning is not limited to early visual areas, but flexibly occurs at a 'sweet spot' along the visual hierarchy whose functional properties match the variability in the given environment. To test this theory, I build on a multimodal, multispecies approach I have previously developed to study learning: I will identify general principles by which variability affects perceptual learning in behavior, dissect the critical neural circuits in macaque monkeys and humans with neuroimaging, determine the functional characteristics of neurons contributing to learning by electrophysiology, and establish their causal relevance using electrical stimulation. This unique combination of species and techniques is ideally suited to unravel the neural mechanism for coping with variability in perceptual learning. By elucidating the computations and mechanisms by which the visual system handles one of the most characteristic aspects of its inputs, I aim to provide the basis for neuroscience-based training paradigms that help alleviate vision deficits.

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

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:
802905	**INFOSAMPLE**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. KONSTANTINOS TSETSOS**
Host Institution: Universitaetsklinikum Hamburg-Eppendorf, DE

Information Sampling in Multiattribute Choice

Do we prefer a small flat with a short commute or a large house with a long commute? Many real-life decisions require combining information across different attributes. It has been shown that during such multiattribute decisions people serially attend to (or sample) a subset of the available information. The way this process takes place largely influences the final choice: for example, if the "commute" attribute is considered for longer, then the small flat will tend to appear better.
Up to date, information sampling has been studied within the social sciences using eye-tracking techniques. However, in the context of choice tasks, the way eye fixations influence the upcoming choice is not precisely known and, thus, this line of research has not yielded any definitive mechanistic conclusions. Recently, theorists have proposed different mechanisms of information sampling but these proposals were not constrained by relevant data.

I propose to fill this gap in a data-driven fashion by harnessing tools from sensory neuroscience. Using magnetoencephalography (MEG) we will simultaneously track the locus of attention and the tendency to choose one alternative over the other, during the entire time-course of a single multiattribute decision. This approach will enable us to unravel the computational and neural mechanisms that guide attention towards different aspects of a multiattribute choice problem.

This project will yield a neurophysiologically detailed theory of multiattribute choice–from the level of neurotransmitters, to large-scale brain networks, to behaviour– that will ultimately shed light on century-long questions, such as why humans reverse their preferences irrationally, when irrelevant alternatives are added to the choice-set. The emerging framework will be useful to policy makers and practitioners, interested in a descriptively enriched model of choice; and to clinicians aiming to understand how information sampling goes awry in neuropsychiatric disorders.

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

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 Cnrs, 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:
803370	**CRACK**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. RADOSLAW MARTIN CICHY**
Host Institution: Freie Universitaet Berlin, DE

Cracking the neural code of human object vision

At each blink of our eyes, our brain rapidly transforms the stream of photons hitting the retina into a conscious percept of the world as consisting of meaningful objects that guide our actions to ensure survival. Yet, in spite of intense research three interrelated, fundamental, long-standing and open questions about how neural dynamics mediate object reCoGnition remain unanswered: How exactly do the core cortical regions active during vision represent objects? How and what do those regions communicate? How does the observed activity mediate adaptive behavior? The overall goal of the program CRACK is to crack the neural code of object vision by addressing those three fundamental questions. For this, CRACK will integrate in an unprecedented manner cutting-edge, non-invasive brain imaging methods, advanced multivariate analysis techniques and state-of-the-art computational modelling in an ambitious three-step interdisciplinary work program. Each step is marked by innovation that breaks new ground and opens new horizons at the next step. First, CRACK will unravel the unique representational format of each core cortical region using an unprecedented brain mapping approach that combines brain imaging with artificial deep neural networks (DNNs). Second, it will clarify the flow of information between visual regions that creates these representations with unseen spatiotemporal precision by resolving neural activity in both cortical layers and frequency channels using a combination of functional MRI (fMRI) and electroencephalography (EEG). Third, it will use advanced multivariate methods linking brain activity and behavior to reveal which aspects of the newly described neural dynamics drive human choice behavior. By breaking down current knowledge boundaries, CRACK will provide the empirical evidence for a new theory of the neural dynamics underlying human visual object reCoGnition, and transform the way we think about and investigate sensory processing.

Project End Date: **30-APR-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:
817492	**SAMPLING**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. ADAM SANBORN**
Host Institution: The University Of Warwick, UK

Searching for the Approximation Method used to Perform rationaL inference by INdividuals and Groups

Over the past two decades, a wave of Bayesian explanations has swept through CoGnitive science, explaining behaviour in domains from intuitive physics and causal learning, to perception, motor control and language. Yet people produce stunningly incorrect answers in response to even the simplest questions about probabilities. How can a supposedly Bayesian brain paradoxically reason so poorly with probabilities? Perhaps Bayesian brains do not represent or calculate probabilities at all and are, indeed, poorly adapted to do so. Instead the brain could be approximating Bayesian inference through sampling: drawing samples from its distribution over likely hypotheses over time.

This work aims to put meat on the bones of this hypothesis by identifying the kinds of algorithms used by the brain to draw samples. Previous proposals of simple sampling algorithms both do not match human data, nor scale well to more complex probability distributions and hypothesis spaces. In our first work programme, we will investigate advanced algorithms that have been developed in computer science and statistics, to see which one is employed by the brain to draw samples.

A catalog of reasoning errors has been used to argue against a Bayesian brain, but only with infinite samples does a Bayesian sampler conform to the laws of probability. In our second work programme, we will show how with finite samples the sampling algorithm we identify systematically generates classic probabilistic reasoning errors in individuals, upending the longstanding consensus on these effects. In our third work programme, we will apply the algorithm to group decision making, investigating how the sampling algorithm provides a new perspective on group decision making biases and errors in financial decision making, and harness the algorithm to produce novel and effective ways for human and artificial experts to collaborate.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
818633	**GROUNDS**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. ROBERT WILLIAMS**
Host Institution: University Of Leeds, UK

GRoup thinking: new fOUNDationS

This project builds new foundations for collective attitudes and representational states: group belief and group desire. The platform is the PI's recent advances in the metaphysics of representation for individual representational states, where he develops and defends a substantive, realist interpretationism: (i) what it is to believe/desire that p is for the selected interpretation to attribute that belief/desire to them; (ii) the selected interpretation is that which makes the subject most reason-responsive, given the way they act and the evidence available to them. This project leverages this work to construct a common structure for the metaphysics of group representation and individual representation, isolating parameters that differentiate the cases and theorizing the distinctive ingredients of the group case. The first phase of the work places group representation in context, studying the theoretical deployments of group attitudes, and dependencies between accounts of individual representation, group representation and linguistic representation. The second phase lays the basis on which interpretations of individuals and groups are selected---individual and joint action, and individual and joint evidence. An account of such facts must be given prior to and independent of belief and desire, on pain of circularity in the overall account. The third phase examines the relation between foundations of representation and metaphysics of persistence---required if the basis for interpretation is to be modally and temporally extended. The fourth shows how key issues in the theory of normative reasons will impact the metaphysics of content, given appeal to reasons responsiveness at the heart of the account. The fifth phase identifies the boundaries between realist and anti-realist accounts of group thought.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
820185	**NewSense**	**SH4** The Human Mind and Its Complexity

Principal Investigator: **Dr. MARKO NARDINI**
Host Institution: University Of Durham, UK

Perception with New Sensory Signals

Advances in wearable displays and networked devices lead to the exciting possibility that humans can transcend the senses they were born with and learn to 'see' the world in radically new ways. Genuinely incorporating new signals in our sensory repertoire would transform our everyday experience, from social encounters to surgery, and advance us towards a technologically-enhanced 'transhuman' state. In contrast, current additions to sensory streams such as navigating with GPS are far from being incorporated into our natural perception: we interpret them effortfully, like words from a foreign menu, rather than feeling them directly. In this project, we use a ground-breaking new approach to test how new sensory signals can be incorporated into the fundamental human experience. We train participants using new immersive virtual-reality paradigms developed in our lab, which give us unprecedented speed, control and flexibility. We test what is learned by comparing different mathematical model predictions with perceptual performance. This model-based approach uniquely shows when new signals are integrated into standard sensory processing. We compare neuroimaging data with model predictions to detect integration of newly-learned signals within brain circuits processing familiar signals. We test predictions that short-term changes to normal visual input can improve adult plasticity, and measure age-changes in plasticity by testing 8- to 12-year-old children and (in another new approach, learning via wearable devices) infants. In a wide-ranging design allowing for domain-general conclusions, we work across modalities (visual, auditory, tactile) and across two fundamental perceptual problems: judging spatial layout ('where' objects are) and material properties ('what' they are made of). The work will provide fundamental insights into computational and brain mechanisms underlying sensory learning, and a platform for transcending the limits of human perception.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
669190	**MALMECC**	**SH5** Cultures and Cultural Production

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

Music and Late Medieval European Court Cultures: Towards a Trans-Disciplinary and Post-National Cultural Poetics of the Performative Arts

Late medieval European court cultures have traditionally been studied from a mono-disciplinary and national(ist) perspective. This focus has obscured much of the interplay of cultural performances that informed “courtly life”. Recent research has begun to reverse this, focusing on issues such as the tensions between orality, writing, and performance; the sociocultural dimensions of making and owning manuscripts (musical and otherwise); the interstices between musical, literary and visual texts and political, social and religious rituals; and the impact of gender, kinship, and social status on the genesis and transmission of culture and music. These “new medievalist” studies have significantly enhanced our understanding of the cultural meanings of singing, listening, and sound in late medieval times.

Taking a decisive step further, MALMECC will, for the first time, systematically explore late medieval (c. 1280-1450) court cultures and their music synoptically across Europe. England, the Low Countries, Avignon, Bohemia, south-eastern Germany/Salzburg, Savoy, and Cyprus have been selected for study as each was a vibrant site of cultural production but has been relatively neglected due to prevailing discursive formations favouring “centres” like Paris and Florence. Linking these courts in a large-scale comparative study focused on the role of music in courtly life but embedded within a multidisciplinary framework encompassing all the arts as well as politics and religion will reveal the complex ecology of late medieval performances of noblesse in unheard-of depth while at the same time throwing the unique qualities of each court into distinct relief. The project will apply an innovative research paradigm that develops a trans-disciplinary and post-national(ist), “relational” approach to the study of music in late-medieval court cultures. In doing so it will integrate all late medieval arts and re-constitute the fullness of their potential meanings.

Project End Date: **31-DEC-20**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677638	**ACO**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. PETER RIEDLBERGER**
Host Institution: Otto-Friedrich-Universitaet Bamberg, DE

The Proceedings of the Ecumenical Councils from Oral Utterance to Manuscript Edition as Evidence for Late Antique Persuasion and Self-Representation Techniques

The Acts of the Ecumenical Councils of Late Antiquity include (purportedly) verbatim minutes of the proceedings, a formal framework and copies of relevant documents which were either (allegedly) read out during the proceedings or which were later attached to the Acts proper. Despite this unusual wealth of documentary evidence, the daunting nature of the Acts demanding multidisciplinary competency, their complex structure with a matryoshka-like nesting of proceedings from different dates, and the stereotype that their contents bear only on Christological niceties have deterred generations of historians from studying them. Only in recent years have their fortunes begun to improve, but this recent research has not always been based on sound principles: the recorded proceedings of the sessions are still often accepted as verbatim minutes. Yet even a superficial reading quickly reveals widespread editorial interference. We must accept that in many cases the Acts will teach us less about the actual debates than about the editors who shaped their presentation. This does not depreciate the Acts' evidence: on the contrary, they are first-rate material for the rhetoric of persuasion and self-representation. It is possible, in fact, to take the investigation to a deeper level and examine in what manner the oral proceedings were put into writing: several passages in the Acts comment upon the process of note-taking and the work of the shorthand writers. Thus, the main objective of the proposed research project could be described as an attempt to trace the destinies of the Acts' texts, from the oral utterance to the manuscript texts we have today. This will include the fullest study on ancient transcript techniques to date; a structural analysis of the Acts' texts with the aim of highlighting edited passages; and a careful comparison of the various editions of the Acts, which survive in Greek, Latin, Syriac and Coptic, in order to detect traces of editorial interference.

Project End Date: **30-APR-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677758	**CREWS**	**SH5** Cultures and Cultural Production

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

Contexts of and Relations between Early Writing Systems

Contexts of and Relations between Early Writing Systems
This project takes an innovative and interdisciplinary approach to the history of writing, redressing lingering problems that have hampered previous research and developing new methodologies for studying scripts and their social context. The staff on the project will work on specific case studies relating to inscriptions of the ancient Aegean, Eastern Mediterranean and Levant (c.2000-600 BC), developing a new and much deeper understanding of writing, literacy and social and cultural interrelations in the area than has ever been possible via the often out-dated traditional methods usually applied to these data. The focus will be on enriching our understanding of both linguistic and social aspects of the borrowing and propagation of writing. This planned research has the potential to change the way we think about writing systems, their societal context and the ways in which ideas were exchanged in early civilisations. Published and publicised through multiple outputs and media, the results will be of importance not only to the specific chronological period and geographical area under close consideration but also to the diachronic study of relationships between population groups and the significance of such relationships for the wider field of cultural history.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677955	**DigitalMemories**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. SILVANA MANDOLESSI**
Host Institution: Katholieke Universiteit Leuven, BE

We are all Ayotzinapa: The role of Digital Media in the Shaping of Transnational Memories on Disappearance

The project seeks to study the role of digital media in the shaping of transnational memories on disappearance. It investigates a novel case that is in process of shaping: the disappearance of 43 students in Mexico in September 2014. The role of the new media in getting citizens' attention and in marking a "turning point" was crucial to the upsurge of a counter-movement against the Mexican government and qualifies the event as significant for the transnational arena.
The groundbreaking aspect of the project consists in proposing a double approach:

a) a theoretical approach in which "disappearance" is considered as a particular crime that becomes a model for analyzing digital memory. Disappearance is a technology that produces a subject with a new ontological status: the disappeared are non-beings, because they are neither alive nor dead. This ontological status transgresses the clear boundaries separating life and death, past, present and future, materiality and immateriality, personal and collective spheres. "Digital memory", i.e. a memory mediated by digital technology, is also determined by the transgression of the boundaries of given categories

b) a multidisciplinary approach situating Mexico´s case in a long transnational history of disappearance in the Hispanic World, including Argentina and Spain. This longer history seeks to compare disappearance as a mnemonic object developed in the global sphere –in social network sites as blogs, Facebook, Twitter and YouTube– in Mexico and the social performances and artistic representations –literature, photo exhibitions, and films– developed in Spain and Argentina.
The Mexican case represents a paradigm for the redefinition of the relationship between media and memory. The main output of the project will consist in constructing a theoretical model for analyzing digital mnemonic objects in the rise of networked social movements with a transnational scope.

Project End Date: **30-JUN-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679083	**HUNAYNNET**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. GRIGORY KESSEL**
Host Institution: Oesterreichische Akademie Der Wissenschaften, AT

Transmission of Classical Scientific and Philosophical Literature from Greek into Syriac and Arabic

It is often taken for granted that the Greek-Arabic translation movement (8th-10th c.) that made the whole bulk of Classical Greek scientific and philosophical literature available in Arabic (and that was later handed over to Europe in Latin translations) owes much to the preceding period in the history of transmission of this scientific and philosophical literature, namely translations into the Syriac language that were implemented by Aramaic-speaking Syriac Christians. The problem of continuity between the two periods however has not been tackled thoroughly in scholarship and thus the actual impact of the Syriac translations on later methods of translation has so far not been measured and assessed. One feasible solution to this problem in our understanding of the background to the Greek-Arabic translation movement is to implement a comprehensive comparison of Syriac and Arabic translations by means of lexiCoGraphical analysis. This project offers a research tool capable of allowing this comparison. It will combine methods of online lexiCoGraphy and of corpus linguistics with the aim of presenting in a systematic and rationalized way the lexical data from the entire corpus of Syriac scientific and philosophical translations, comparing and analyzing its terminology and translation techniques, first, with the extant Greek originals and, secondly, with Arabic versions. The lexiCoGraphic database will be an effective instrument providing definite data for the study of Syriac and Arabic translations and their close connections. It will reveal how the Syriac translations along with underlying methods and tools that were put to use for the first time ever by Syriac Christians eventually determined the prosperity of the Islamic sciences. Fully endorsing a principle of open access the database creates a new instrument for a study of the history of the transmission of Greek scientific literature in Antiquity and the Middle Ages.

Project End Date: **30-APR-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679586	**BUMP**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. ELSELIJN KINGMA**
Host Institution: University Of Southampton, UK

BETTER UNDERSTANDING the METAPHYSICS of PREGNANCY

Every single human is the product of a pregnancy: an approximately nine-month period during which a foetus develops within its mother's body. Yet pregnancy has not been a traditional focus in philosophy. That is remarkable, for two reasons:
First, because pregnancy presents fascinating philosophical problems: what, during the pregnancy, is the nature of the relationship between the foetus and the maternal organism? What is the relationship between the pregnant organism and the later baby? And when does one person or organism become two?
Second, because so many topics immediately adjacent to or involved in pregnancy have taken centre stage in philosophical enquiry. Examples include questions about personhood, foetuses, personal identity and the self.

This project launches the metaphysics of pregnancy as an important and fundamental area of philosophical research.

The core aims of the project are:
(1) to develop a philosophically sophisticated account of human pregnancy and birth, and the entities involved in this, that is attentive to our best empirical understanding of human reproductive biology;
(2) to articulate the metaphysics of organisms, persons and selves in a way that acknowledges the details of how we come into existence; and
(3) to start the process of rewriting the legal, social and moral language we use to classify ourselves and our actions, so that it is compatible with and can accommodate the nature of pregnancy.

The project will investigate these questions in the context of a range of philosophical sub disciplines, including analytic metaphysics, philosophy of biology and feminist philosophy, and in close dialogue with our best empirical understanding of the life sciences – most notably physiology.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681269	**DECOR**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. ANNETTE HAUG**
Host Institution: Christian-Albrechts-Universitaet Zu Kiel, DE

Decorative Principles in late Republican and early Imperial Italy

This project will provide a comprehensive analysis of the decorative principles employed between the late Republic and the end of the early Imperial period, i.e. the 2nd century BC and the end of the 1st century AD. It will be the first research programme to move away from analyses of single decorative elements in isolation and to focus on their correlation and interaction. This comprehensive approach will be adopted for varying spatial contexts such as houses, sanctuaries and main streets, enabling analyses of the changes decorative principles underwent according to spatial and functional contexts. Within this framework, the project will address four core research questions:

(1) How can the interplay of different decorative elements be analysed for architecturally closed and open urban spaces? A key question here is how forms of decor interact on a formal level, as well as in terms of content and meaning, in order to create specific atmospheres.

(2) What methods allow a scientific assessment of the interplay between decor and the use of space?

(3) Is there a social significance to decorative principles? Do specific social groups or specific spatial contexts favour or exclusively employ specific forms of decor?

(4) How can decorative ensembles be identified as artistic expressions typical for certain periods?

This approach will enable analyses of forms of decor and their dependencies on respective functional contexts in spatial, chronological and social terms.

The project is a pilot project for advancing new methods in substantial analyses of decorated spaces. At the same time, it provides a fundamental advancement of our understanding of the visual culture from the late Republic to the early Roman Empire.

Project End Date: **30-SEP-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681814	**EURO-EXPERT**	**SH5** Cultures and Cultural Production

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

Cultural Expertise in Europe: What is it useful for?

Respect for diversity has been at the forefront of political accession to the European Union since 1993 and socio-legal scholarship has developed articulated reflections on the accommodation of ethnic and religious minorities in Europe. Country-experts have been instructed with increasing frequency in judicial and pre-judicial proceedings involving members of diasporic communities. In some common law countries the role of the expert witness has expanded to systematically assist the judge when litigants belong to minorities; in most civil law countries, similar roles are played by translators and cultural mediators, including notaries and lawyers. Cultural expertise is sometimes used in order to avoid excessive judicialisation. Notwithstanding, disbelief is developing around cultural expertise; and, excalations of violence and counter-violence signal that European majority and the so-called minorities are drifting apart. Hence our question: Cultural Expertise in Europe: What is it useful for? A comprehensive assessment of cultural expertise was entrenched by its narrow technical definition. This project develops around a new integrated concept of cultural expertise to empirically investigate its use and impact in fourteen European countries. In-context data will be collected through ethnographic fieldwork conducted by a modular team allowing real time analysis and immediate use of results by the stakeholders. The objectives will be to: 1) map the terms, condition, and costs of cultural expertise in private and public law; 2) create a toolkit for measuring the impact of cultural expertise; 3) establish an open access searchable data base for the consultation of cases and solution including cultural expertise; 4) design a teaching and learning module using the cultural expertise impact toolkit; and 5) formulate policy-making guidelines which include tested solutions for a sustainable inclusiveness in Europe.

Project End Date: **30-SEP-21**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682022	**MEDIATE**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. ALICIA MONTOYA**
Host Institution: Stichting Katholieke Universiteit, NL

Middlebrow Enlightenment: Disseminating Ideas, Authors, and Texts in 18th-century Europe

Intellectual history has long focused on a small number of authors and conceptual frameworks in studying societal change during the Enlightenment. Historians of the book have similarly restricted their vision, tending to privilege radical, subversive or forbidden texts. Yet ever since Daniel Mornet launched the history of the book approach a century ago, historians have reCoGnized that it was authors who were not radical or subversive who produced the best-selling texts of the 18th century. This project will push Enlightenment studies in a new direction by moving beyond the present, narrow corpus of texts and models that dominate the field, and propose a new conceptual framework that takes as its starting-point the heuristic concept of middlebrow culture. Developing a state-of-the-art database, it will, firstly, identify not the 'high' Enlightenment texts studied by the history of ideas, and not the 'low', forbidden texts of book history, but the real best-sellers of the 18th century. These were the texts that, to readers on the ground, represented the most visible face of the Enlightenment, but have hitherto never really been studied. Secondly, it will elaborate a typology of this corpus describing its generic traits, intended readers, relation to major political-religious debates, and how readers in different parts of Europe appropriated these texts through translations, reworkings and other uses. Finally, it examines how historiography came to define the Enlightenment as the work of an intellectual elite, downplaying the impact of middlebrow texts and readers. The project thus brings an ambitious, bottom-up approach to intellectual history, using book history data and innovative digital tools to argue that the Enlightenment was fashioned not only by the progressive intellectuals we know today, but just as importantly, also by a large mass of forgotten, middlebrow best-sellers that need to be adequately studied if we are to truly understand how we 'became modern'

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682467	**MoralisingMisfortune**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. ERIK BÄHRE**
Host Institution: Universiteit Leiden, NL

Moralising Misfortune: A comparative anthropology of commercial insurance

This is a study of the morality of commercial life insurance. What moral issues are raised when commercial companies define responsibilities for misfortune and the appropriateness of entitlements? What are the concerns about the financialization of life and intimacy?

First, this study examines the morality of bureaucratic classifications produced by the insurance industry. Classifications reveal particular perspectives on the world and are at the heart of defining the risks covered by life insurance policies, as well as defining exclusionary clauses and who is allowed to take which policies; in addition, they are central to the exploration of consumer markets. What are the moral implications of classification and its associated bureaucratic procedures?

Second, the study explores the questions life insurance raises about the value of life. Life insurance literally prices death. How much is a life worth? What lives can be compensated and who can receive compensation? Moral obligations and the allocation of blame may depend on whether financial support is given by commercial companies, kinship, or voluntary associations. This project examines the morality of the integration of life insurance into wider financial systems.

The objective of the research is to gain insight into:

1. Public discourses on the role of commercial life insurance in everyday life;
2. The ways in which life insurance gives rise to particular notions of responsibility and compensation.
3. The ways in which the morality of commercial life insurance is intertwined with explaining misfortune, and with organizing care through kinship and voluntary associations.

The study will be carried out in five countries: France and the Netherlands – two of the world's wealthiest countries, with a long history of life insurance; India and Brazil – two of the world's fastest expanding economies, with a growing insurance market; and the USA – where innovations create new moral concerns.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682779	**ETI**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. JARI KAUKUA**
Host Institution: Jyvaskylan Yliopisto, FI

Epistemic Transitions in Islamic Philosophy, Theology and Science: From the 12th to the 19th Century

Not very long ago, it was still common to hold that little of interest took place in Islamic philosophy, theology and science after the death of the Peripatetic commentator Averroes in 1198. Recent research has produced increasing evidence against this view, and experts now commonly agree that texts from the so-called post-classical period merit serious analysis. That evidence, however, is still fragmentary, and we lack a clear understanding of the large scale and long run development in the various fields of Islamic intellectual culture after the twelfth century.

This project will investigate debates concerning the nature and methods of knowledge in four of the most ambitious strands of Islamic theoretical thought, that is, philosophy, theology, natural science, and philosophically inclined Sufism. Its temporal scope extends from the end of the twelfth century to the beginning of the colonial era, and it focuses on foundational epistemological questions (how knowledge is defined, what criteria are used to distinguish it from less secure epistemic attitudes, what methods are identified as valid in the acquisition of knowledge) as well as questions concerning knowledge as the goal of our existence (in particular, whether perceptual experience is inherently valuable).

Our study of the four strands is based on the hypothesis that the post-classical period is witness to a sophisticated discussion of knowledge, in which epistemic realism, intuitionism, phenomenalism, and subjectivism are pitted against each other in a nuanced manner. Hence, the project will result in a well-founded reassessment of the common view according to which post-classical Islamic intellectual culture is authoritarian and stuck to an epistemic paradigm that stifles insight and creativity. Thereby it will provide new ingredients for projects of endogenous reform and reorientation in Islam, and corroborate the view that our future histories of philosophy should incorporate the Islamic tradition.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694482	**CROSSLOCATIONS**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. SARAH GREEN**
Host Institution: Helsingin Yliopisto, FI

Crosslocations in the Mediterranean: rethinking the socio-cultural dynamics of relative positioning

The Mediterranean, a key socio-cultural, economic and political crossroads, has shifted its relative position recently, with profound effects for relations between the peoples associated with its diverse parts. Crosslocations is a groundbreaking theoretical approach that goes beyond current borders research to analyse the significance of the changes in relations between places and peoples that this involves. It does this through explaining shifts in the relative positioning of the Mediterranean's many locations – i.e. the changing values of where people are rather than who they are. Approaches focusing on people's identities, statecraft or networks do not provide a way to research how the relative value of 'being somewhere in particular' is changing and diversifying.

The approach builds on the idea that in socio-cultural terms, location is a form of political, social, economic, and technical relative positioning, involving diverse scales that calibrate relative values (here called 'locating regimes'). This means locations are both multiple and historically variable, so different types of location may overlap in the same geographical space, particularly in crossroads regions such as the Mediterranean. The dynamics between them alter relations between places, significantly affecting people's daily lives, including their life chances, wellbeing, environmental, social and political conditions and status.

The project will first research the locating regimes crossing the Mediterranean region (border regimes, infrastructures; digital technologies; fiscal, financial and trading systems; environmental policies; and social and religious structures); then intensively ethnographically study the socio-cultural dynamics of relative positioning that these regimes generate in selected parts of the Mediterranean region. Through explaining the dynamics of relative location, Crosslocations will transform our understanding of trans-local, socio-cultural relations and separations.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695245	**LAWALISI**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. ROBERT GLEAVE**
Host Institution: The University Of Exeter, UK

Law, Authority and Learning in Imami Shi'ite Islam

The academic study of Islamic law has, so far, almost exclusively focused on Sunni legal thought. The legal thought and practice of Shi'ite (and other) traditions has been neglected, and this has created a rather skewed account of the history of Islamic law. This project aims to rectify this inadequacy by producing a body of research in which the Imami Shi'ite contribution to Islamic legal history is described, analysed and evaluated. Imami Shi'ites, sometimes termed Twelvers, are the largest branch of Shi'ism today. Imamis form a majority in Iran and Iraq where the major Shi'i centres of legal learning are located.

In the project, we aim to examine the theories and methods used by scholars in the study of Islamic law, derived mainly from Sunni sources, and test them against the Shi'ite legal literature. The project aims to demonstrate that a non-Sunni tradition of Islamic legal thought, in this case Imami Shi'i law, can illuminate and enrich the general history of Islamic law. At times, Shi'ite law shares features with other legal schools; at other times it provides an alternative account, challenging long held assumptions concerning Islam's legal development. The project will do this through 5 independent, but linked, Research Themes, in which research fellows and visiting professors will carry out detailed programmes of research. These will cover Imami law and doctrine, the dynamics of legal authority, the relationship between legal theory and doctrine and the influence of law on political theory. The project will facilitate opportunities to test the researchers' research findings with both international experts in the field, and scholars from within the Imami legal tradition.

The Principal Investigator, Robert Gleave, has made a major contribution to this area in his research, publications and other activities for 20 years, and this project extends and expands this interest, aiming to make a lasting impact on the field of Islamic legal studies in the future.

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

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:
716181	**HOM**	**SH5** Cultures and Cultural Production

Principal Investigator:	**Dr. NIDESH LAWTOO**
Host Institution:	Katholieke Universiteit Leuven, BE

Homo Mimeticus: Theory and Criticism

Mimesis is one of the most influential concepts in Western thought. Originally invoked to define humans as the "most imitative" creatures in classical antiquity, mimesis (imitation) has recently been at the centre of theoretical debates in the humanities, social sciences, and the neurosciences concerning the role of "mimicry," "identification," "contagion," and "mirror neurons" in the formation of subjectivity. And yet, despite the growing confirmations that imitation is constitutive of human behaviour, mimesis still tends to be confined to the sphere of realistic representation. The HOM project combines approaches that are usually split in different areas of disciplinary specialization to provide a correction to this tendency.

Conceived as a trilogy situated at the crossroads between literary criticism, cinema studies, and critical theory, HOM's outcomes will result in two monographs and accompanying articles that explore the aesthetic, affective, and conceptual implications of the mimetic faculty. The first, radically reframes a major proponent of anti-mimetic aesthetics in modern literature, Oscar Wilde, by looking back to the classical foundations of theatrical mimesis that inform his corpus; the second considers the material effects of virtual simulation by looking ahead to new digital media via contemporary science-fiction films; and the third establishes an interdisciplinary dialogue between philosophical accounts of mimesis and recent discoveries in the neurosciences. Together, these new perspectives on homo mimeticus reconsider the aesthetic foundations of a major literary author, open up a new line of inquiry in film studies, and steer philosophical debates on mimesis in new interdisciplinary directions.

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

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:
757291	**CALLIOPE**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. JOSEPHINE HOEGAERTS**
Host Institution: Helsingin Yliopisto, FI

voCAL articuLations Of Parliamentary Identity and Empire

What did politicians sound like before they were on the radio and television? The fascination with politicians' vocal characteristics and quirks is often connected to the rise of audio-visual media. But in the age of the printed press, political representatives also had to 'speak well' – without recourse to amplification.

Historians and linguists have provided sophisticated understandings of the discursive and aesthetic aspects of politicians' language, but have largely ignored the importance of the acoustic character of their speech. CALLIOPE studies how vocal performances in parliament have influenced the course of political careers and political decision making in the 19th century. It shows how politicians' voices helped to define the diverse identities they articulated. In viewing parliament through the lens of audibility, the project offers a new perspective on political representation by reframing how authority was embodied (through performances that were heard, rather than seen). It does so for the Second Chamber in Britain and France, and in dialogue with 'colonial' modes of speech in Kolkata and Algiers, which, we argue, exerted considerable influence on European vocal culture.

The project devises an innovative methodological approach to include the sound of the human voice in studies of the past that precede acoustic recording. Adapting methods developed in sound studies and combining them with the tools of political history, the project proposes a new way to analyse parliamentary reporting, while also drawing on a variety of sources that are rarely connected to the history of politics.

The main source material for the study comprise transcripts of parliamentary speech (official reports and renditions by journalists). However, the project also mobilizes educational, satirical and fictional sources to elucidate the convoluted processes that led to the cultivation, exertion, reception and evaluation of a voice 'fit' for nineteenth-century politics.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
757299	**PALaC**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. FEDERICO GIUSFREDI**
Host Institution: Universita Degli Studi Di Verona, IT

Pre-Classical Anatolian Languages in Contact

The aim of the PALaC project is to provide a systematic and complete study of language-contact in pre-classical Anatolia, from the XVIII century BCE up the Anatolian and Syro-Anatolian cultures of the Iron ages. Language contact is a specific phenomenon present in all phases of modern and historical languages, and requires to be investigated using the language-internal methodologies of contact-linguistics. The project will provide a rigorous and complete description of the linguistic interactions in ancient Anatolia, a unique historical and geographical gateway where Indo-European, Semitic and isolated languages interacted with each other, on the ideal boundary between the East and the West. PALaC will deal with the analysis of the textual data from the different Ancient Anatolian corpora, that will be assessed both from a linguistic and from philological perspective. The final results will also be integrated in the general framework of historical and cultural contact in the Ancient Mediterranean world by a dedicated work-package. The project will take advantage of the methodological expertise of a team of researchers who are well trained both in the philological study of the Ancient Near Eastern texts and in the linguistic study of languages in contact.

Project End Date: **31-JAN-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:
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:
771383	**Global Horizons**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. BEATE FRICKE**
Host Institution: Universitaet Bern, CH

Global Horizons in Pre-Modern Art

The horizon is the line that seems to separate earth from sky, the line that divides all visible categories into two categories: those that intersect the earth's surface and those that do not. The horizon is key to the experience of space; it defines our perspective on the visible world. The GLOBAL HORIZONS project will investigate the historical meanings and functions of the horizon in visual and intellectual cultures of the pre-Modern world on a global scale. Examining how pre-Modern cultures conceived of the horizon opens a crucial line of inquiry into understanding the many different ways in which humans have conceived of the relationship between an invisible cosmos and the visible world.

Non-western art history is rarely taught at European institutions although countless important works of Non-Western art are kept in museum collections all across Europe. Including non-western concepts of pictorial space is key to the project, however, for Eurocentric models of art history have generally privileged the rise of the linear perspective. This framing has limited our understanding of the horizon's complex rhetorical, visual and epistemological roles.

The project's specific question connects a variety of objects and epistemological categories, such as panel painting, manuscript illumination, profane und religious objects, cartography, travel accounts, and cosmological treaties. The applied methodological approaches will range from art history, visual studies and cultural anthropology. They will also draw upon interdisciplinary expertise, such as technologies of art production, history of science and philosophy. The project thus makes an important contribution to global art history, a highly innovative area in which only very few pre-modern topics have been addressed. It is the ultimate goal of GLOBAL HORIZONS is to suggest a new history of representation in Western medieval art.

Project End Date: **31-AUG-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:
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:
772762	**MiMus**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. ANNA ALBERNI**
Host Institution: Universitat De Barcelona, ES

Ioculator seu mimus. Performing Music and Poetry in medieval Iberia

What was the role played by courtly musicians and poets in fostering a performative dimension of cultural life in the late Middle Ages? How did this contribute to the social value of the poet and musician as an artist? In the late medieval period the Crown of Aragon was a political and cultural crossroads, a coveted destination for artists of various kinds who attended the refined court of the Catalan kings. Musicians and performing entertainers with skills in the verbal and non-verbal domains were among the most sought after. This project will review and expand the corpus of documentary evidence informing us about musical activity and performing artists at the court of Aragon in the late medieval period, with the aim to analyse what this tells us about similar activity at other European courts. Thus, it will examine the professional profiles, cultural backgrounds and networks of patronage behind the minstrels who thrived in the Catalan court between 1235 and 1435. The main source of information will be the Archive of the Crown of Aragon in Barcelona and the Archive of Valencia. The project will also consider the debt of Catalan poetry to foreign musicians, with the aim to establish whether any intertextuality exists between Catalan poetry and the poetry produced in the regions adjacent to the territories of the Crown of Aragon that was specifically mediated by the presence of foreign musicians at the Catalan court. Specific objectives of the project will be: 1) to establish whether the ideas of minstrelsy passed down to us by literature and scholarship fit the real profiles of minstrels provided by medieval documents; 2) to evaluate the impact, where appropriate, of contacts between religious and ethnic communities in the profession of minstrelsy in late medieval Iberia; 3) to assess the role of queenship in musical and poetic patronage; 4) to clarify the influence of foreign musical traditions on Catalan poetry.

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:
788205	**HisTochText**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. GEORGES PINAULT**
Host Institution: Ecole Pratique Des Hautes Etudes, FR

History of the Tocharian Texts of the Pelliot Collection

HisTochText addresses written Buddhist culture of the northern Silk Road in an innovative and path-breaking way, by going beyond the frontier of disciplines which have been cultivated separately: philology, digital humanities and in-depth analysis of materials, edition of Tocharian texts and comparative Buddhist literature, Sanskrit poetics and narratology, texts and social contexts.

The flourishing Buddhist culture of the northern Silk Road during the 1st millennium CE in the Tarim Basin in present-day Xinjiang (NW China) is known by archaeological findings, artifacts and manuscripts in various languages. Since Buddhism was introduced from India, Sanskrit was the dominant religious language. By contrast, Tocharian belongs to the few local languages that are known to us thanks to Buddhist written culture. The two closely related Tocharian languages (Tocharian A and Tocharian B) were deciphered in 1908 on the basis of manuscripts discovered at the beginning of the past century in Buddhist sites of this region, together with Sanskrit manuscripts.

The collection of the Bibliothèque nationale de France issued from the Pelliot expedition is a major collection of Tocharian manuscripts, counting around 2,000 fragments, second only to the Berlin collection, but in comparison hardly investigated, despite its containing numerous unique masterpieces and the broadest cross-section of manuscript and document styles and types. Only one fourth has been edited, mostly in a provisional manner, without translation nor commentary. Many texts of the Pelliot collection, literary and non-literary, are of the utmost importance because they have no match in any other collection of Tocharian manuscripts, nor in Buddhist corpora in other languages. As most Pelliot manuscripts in Sanskrit and in Tocharian were found in Buddhist sites of the Kucha region, the comprehensive edition and analysis of the texts will provide precious information about an important centre of Central Asian Buddhism.

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

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
789270	**RESPONSIBILITY**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. JOHN HYMAN**
Host Institution: University College London, UK

The Roots of Responsibility: Metaphysics, Humanity, and Society

Philosophical research on responsibility today stems from early modern debates about causal necessity and freedom of the will, and ultimately from the Stoic problem of reconciling ethics with physics. It is therefore mainly focused on scepticism about the existence of free will and on the question whether moral responsibility is compatible with physical determinism. The main premises of this project are that this focus is too narrow, and that the traditional problems can only be solved with a deeper understanding of the network of human capacities responsibility involves and the social and interpersonal context in which questions about responsibility arise. This in turn depends on a wide range of philosophical and scientific research that has been neglected in debates about determinism, responsibility and free will, in particular, legal theory, where the literature on the relationships between responsibility, liability and culpability is more sophisticated and more nuanced than it is in philosophy; biological systems theory, which has shown how the activity of more complex systems can harness stochasticity in the activity of the less complex systems of which they are composed; and the philosophy of action, in which the physical, psychological, ethical and intellectual dimensions of human agency are now more clearly articulated and better understood. The Roots of Responsibility will draw on all of these resources, in order to develop a comprehensive theory of responsibility, which cuts across traditional boundaries between metaphysics, epistemology, ethics, and philosophy of law. It will foster collaborative research in these branches of philosophy, and include expertise in psychology and theoretical biology at the relevant stages.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
801653	**NaturalPhilosophy**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. ANDREA SANGIACOMO**
Host Institution: Rijksuniversiteit Groningen, NL

The normalisation of natural philosophy: how teaching practices shaped the evolution of early modern science

Early modern natural philosophy underwent dramatic transformations that completely reshaped its conceptual framework and set of practices. The main contention of my ERC project is that teaching practices had a decisive and 'normalising' impact on the progressive dissemination, adaptation and selection of rival conceptions of natural philosophy. Normalisation occurs when historical actors collectively present certain tenets as crucial for the study of a discipline, and thus prescribe them as a necessary subject for teaching and learning.

The overall aim of this ERC project is to determine and explain how the process of normalisation embedded in teaching practices shaped the evolution of early modern natural philosophy. To study normalisation, it is necessary to operate a systematic comparative investigation of hundreds of works through which natural philosophy was taught, learned and reshaped, both within and outside universities. The size of this corpus defies the traditional method of close reading used by historians of philosophy and science.

I will meet this challenge by organically integrating close reading with digital 'distant reading'. I will digitally transcribe a corpus of approximately 500 early modern works on natural philosophy, published in Britain, France and the Dutch Republic. Using digital tools to investigate how the networks of authors and concepts of natural philosophy co-evolved over time will allow me to identify textual excerpts that are representative of historical trends. By analysing these excerpts with close reading and assessing them against the digital results, I will determine and explain how normalisation shaped the evolution of natural philosophy.

This project will boost the integration of digital approaches in the history of philosophy and science by producing a newly digitised corpus, tools customized for analysing early modern texts, and methodological reflections on their implementation.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
801861	**JEWTACT**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. IRIS IDELSON-SHEIN**
Host Institution: Ben-Gurion University Of The Negev, IL

Jewish Translation and Cultural Transfer in Early Modern Europe

Contemporary scholarship has often envisioned modernity as a kind of immense cultural earthquake, originating somewhere in western or central Europe, and then gradually propagating throughout the continent. This massive upheaval is said to have shaken the very foundations of every culture it frequented, subsequently eliminating the world which once was, to make way for a new age. This project offers a new understanding of modernization, not as a radical break with tradition, but as the careful importation of new ideas by often timid, almost inadvertent innovators. The project focuses on the rich corpus of translations of non-Jewish texts into Jewish languages, which developed during the early modern period. Largely neglected by modern scholars, these translations played a pivotal role in fashioning Jewish culture from the sixteenth century into modern times.

Jewish translators were never merely passive recipients of their non-Jewish sources; they mistranslated both deliberately and accidentally, added and omitted, and harnessed their sources to meet their own unique agendas. Throughout the process of translation then, a new corpus was created, one that was distinctly Jewish in character, but closely corresponded with the surrounding majority culture.

JEWTACT offers the first comprehensive study of the entire gamut of these early modern Jewish translations, exposing a hitherto unexplored terrain of surprising intercultural encounters which took place upon the advent of modernity—between East and West, tradition and innovation, Christians and Jews. The project posits translation as the primary and most ubiquitous mechanism of Christian-Jewish cultural transfer in early modern Europe. In so doing, I wish to revolutionize our understanding of the so-called early modern "Jewish book," revealing its intensely porous, collaborative and innovative nature, and to offer a new paradigm of Jewish modernization and cultural exchange.

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

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:
805436	**WINK**	**SH5** Cultures and Cultural Production

Principal Investigator: **Dr. CARME FONT PAZ**
Host Institution: Universitat 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:
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:
648535	**ArtEmpire**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. BETHANY ARAM**
Host Institution: Universidad Pablo De Olavide, ES

An ARTery of EMPIRE. Conquest, Commerce, Crisis, Culture and the Panamanian Junction (1513-1671)

European incursions onto the narrow isthmian pass that divided and connected the Atlantic and Pacific oceans made it a strategic node of the Spanish Empire and a crucial site for early modern globalization. On the front lines of the convergence of four continents, Old Panama offers an unusual opportunity for examining the diverse, often asymmetrical impacts of cultural and commercial contacts. The role of Italian, Portuguese, British, Dutch, and French interests in the area, as well as an influx of African slaves and Asian merchandise, have left a unique material legacy that requires an integrated, interdisciplinary approach to its varied sources. Bones, teeth and artifacts on this artery of Empire offer the possibility of new insights into the cultural and biological impact of early globalization. They also invite an interdisciplinary approach to different groups' tactics for survival, including possible dietary changes, and the pursuit of profit. Such strategies may have led the diverse peoples inhabiting this junction, from indigenous allies to African and Asian bandits to European corsairs, to develop and to favor local production and Pacific trade networks at the expense of commerce with the metropolis.

This project applies historical, archaeological and archaeometric methodologies to evidence of encounters between peoples and goods from Europe, America, Africa and Asia that took place on the Isthmus of Panama during the sixteenth and seventeenth centuries. Forging an interdisciplinary approach to early globalization, it challenges both Euro-centric and Hispano-phobic interpretations of the impact of the conquest of America, traditionally seen as a demographic catastrophe that reached its nadir in the so-called seventeenth-century crisis. Rather than applying quantitative methods to incomplete source material, researchers will adopt a contextualized, inter-disciplinary, qualitative approach to diverse agents involved in cultural and commercial exchange.

Project End Date: **31-DEC-20**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
669461	**NorFish**	**SH6** The Study of the Human Past

Principal Investigator:	**Dr. POUL HOLM**
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

North Atlantic Fisheries: An Environmental History, 1400-1700

NorFish aims to understand the restructuring of the North Atlantic fisheries, fish markets and fishery-dependent communities in the late medieval and early modern world. The project exploits a multi-disciplinary, humanities-led approach to marine environmental history, assessing and synthesizing the dynamics and significance of the North Atlantic fish revolution, equipped by methodological advances in which the PI has been to the fore in delivering. It establishes a robust quantitative framework of extractions, supplies and prices, while also charting the qualitative preferences and politics that motivated actors of the fish revolution across the North Atlantic.

Fish contributed to environmental and societal change in the North Atlantic for over 300 years, shifting from being a high-priced, limited resource in the late Middle Ages to a low-priced, abundant one by early modern times. Conditioned by market forces, the 'fish revolution' of the 1500s and 1600s reshaped alignments in economic power, demography, and politics. With acute consequences in peripheral Atlantic settlements from Newfoundland to Scandinavia, it held strategic importance to all the major western European powers. While the fish revolution catalysed the globalization of the Atlantic world, we lack adequate baselines and trajectories for key questions of natural abundance, supply and demand, cultural preferences, marketing technologies, plus national and regional strategies.

In short, the core questions are what were the natural and economic causes of the fish revolution, how did marginal societies adapt to changing international trade and consumption patterns around the North Atlantic, and how did economic and political actors respond? The answers will help explain the historic role of environment and climate change, how markets impacted marginal communities, and how humans perceived long-term change.

Project End Date: **31-DEC-20**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
678901	**FoodTransforms**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. PHILIPP STOCKHAMMER**
Host Institution: Ludwig-Maximilians-Universitaet Muenchen, DE

Transformations of Food in the Eastern Mediterranean Late Bronze Age

Mediterranean cuisine has long been perceived as a timeless constant, already linking the different societies around the sea by the 2nd mill. BC. The geographic frame was considered to be essential, whereas intercultural entanglements as transformative factors were neglected. By integrating archaeological, textual and scientific research, we will shed new light on the transformative power of cultural encounters arising from the intense connectivity between local communities in the Eastern Mediterranean Late Bronze Age and the simultaneous introduction of food of South and East Asian origin (e.g. pepper, nutmeg, cinnamon). We intend to achieve this goal by analysing human remains and pottery vessels from selected sites between the Aegean and Egypt from the 15th to the 12th cent. BC to trace spatial and temporal dynamics. Organic residue analyses of the pottery will shed light on the preparation and consumption of food (e.g. oils, wine, spices). We will include vessels with their contents labelled on them and then link so-far hardly understood Egyptian textual evidence to the contents, which enables a new understanding of these texts for the study of food. We combine the results from residue analyses with a cutting-edge approach to the study of human dental calculus, the potential of which has just been reCoGnized for the understanding of human nutrition: we will analyse DNA from food traces and bacteria as well as proteins, lipids and microremains in dental calculus. This will give unique insight into individual consumption of different oils (olive, sesame etc.), kinds of milk (cow, sheep, goat) and related products (cheese, kefir) and of plants (spices, cereals), which goes far beyond what has been achieved to date. The linkage of food residues in vessels and calculus will allow us to trace processes of homogenization and diversification as consequences of early globalization and better understand food circulation in present and future globalization processes.

Project End Date: **30-JUN-21**

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: **30-SEP-21**

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: **31-AUG-21**

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:
715069	**FINDER**	**SH6** The Study of the Human Past

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

Fossil Fingerprinting and Identification of New Denisovan remains from Pleistocene Asia

Ancient genomics have transformed our knowledge of archaic hominins present in Eurasia prior to the expansion of modern humans (AMH) from Africa. In 2010, a finger bone discovered in Siberia was assigned using DNA to a new, previously unknown human group, the Denisovans. The Denisovans interbred with both Asian Neanderthals and AMH over the past 100,000 years; their geographic distribution is now thought to have stretched from the Siberian steppes to the tropical forests of SE Asia and Oceania.

Despite their broad spatio-temporal range, the Denisovans are only known from 4 tiny bones, all from a single Siberian cave. This patchy knowledge of an entire human population significantly limits our ability to test hypotheses and interpretative models concerning major issues in human evolution, such as the routes and timing of people movements across Asia, the nature and frequency of interaction between indigenous groups and migratory AMH, the mechanisms leading to the demise of archaic lineages and eventual sole dominance of our species on Earth.

This project aims to rectify the dearth of Denisovan fossils by applying a novel combination of cutting-edge scientific methods (collagen fingerprinting, radiocarbon dating and ancient DNA) designed to identify, date and genetically characterize new human fossils, with a particular emphasis on the discovery of Denisovan remains. Instead of only focusing on the few morphologically identifiable human bones, a groundbreaking high-throughput approach will target bulk collections of unidentified bone fragments (30,000) from ~20 Asian sites dating to between 100,000-10,000 years.

Ultimately, the goal is to expand our understanding of the Denisovans, reveal their geographic range, age, genetic variation and archaeological signature. In addition to solving the puzzles of ancient population history, this research has the potential to decode the patchwork that makes modern humans who we are today, physically, behaviourally and genetically.

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:
724114	**HealthScaping**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. GUY GELTNER**
Host Institution: Universiteit Van Amsterdam, NL

Healthscaping Urban Europe: Bio-Power, Space and Society, 1200-1500

Medieval public health is mired in modern myth: without centralized governments, democratic values and advanced medicine, promoting health at the population level was purportedly either unthinkable or simply impractical. Offering a radically different view, HealthScaping will document, analyze and disseminate knowledge about preventative public healthcare between 1200-1500, an era of accelerated urbanization followed by massive demographic decline, with the onset of Black Death (1347-51). This long-term and comparative perspective will fundamentally revise the narrative of European public health by tracing the development and impact of pertinent government policies, medical discourses and social and religious action in the continent's two most urbanized and richly documented regions, Italy and the Low Countries. The project taps numerous written, material and visual sources and archaeological data from several sites, and examines them also by critically engaging the insights of governmentality studies, cultural-spatial analysis and actor-network theory. A multidisciplinary team, working in a Geographical Information Systems environment and generating innovative urban health maps, will recover earlier societies' struggles with domestic and industrial waste, travel and labor hazards, food quality, and social and religious behaviors considered harmful or dangerous. As such, the project's implications will be broad and profound, for it will 1) dislodge bio-power from its accustomed place in modernity; 2) historicize the concept of the public sphere from a health perspective; and 3) challenge the privileged role given to epidemic disease as a catalyst for environmental interventions in premodernity. It will also 4) generate new insights for public health scholars and practitioners working today around the globe, by rethinking the feasibility of preventative interventions under highly diverse forms of government, culture and topography.

Project End Date: **31-OCT-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:
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:
757873	**BETWEEN THE TIMES**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. LIISI KEEDUS**
Host Institution: Tallinn University, EE

"Between the Times": Embattled Temporalities and Political Imagination in Interwar Europe

The proposed project offers a new, pan-European intellectual history of the political imagination in the interwar period that places the demise of historicism and progressivism – and the emerging anti-teleological visions of time – at the center of some of its most innovative ethical, political and methodological pursuits. It argues that only a distinctively cross-disciplinary and European narrative can capture the full ramifications and legacies of a fundamental rupture in thought conventionally, yet inadequately confined to the German cultural space and termed "anti-historicism". It innovates narratively by exploring politically and theoretically interlaced reinventions of temporality across and between different disciplines (theology, jurisprudence, classical studies, literary theory, linguistics, sociology, philosophy), as well as other creative fields. It experiments methodologically by reconstructing the dynamics of political thought prosopographically, through intellectual groupings at the forefront of the scholarly and political debates of the period. It challenges the sufficiency of the standard focus in interwar intellectual history on one or two, at most three (usually "Western" European) national contexts by following out the interactions of these groupings in France, Britain, Germany, Russia, Czechoslovakia, and Romania – groupings whose members frequently moved across national contexts. What were the political languages encoded in the reinventions of time, and vice versa – how were political aims translated into and advanced through theoretical innovation? How did these differ in different national contexts, and why? What are the fragmented legacies of this rupture, disbursed in and through the philosophical, methodological and political dicta and dogmas that rooted themselves in post-1945 thought? This project provides the first comprehensive answer to these fundamental questions about the intellectual identity of Europe and its historicities.

Project End Date: **31-MAY-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: Oesterreichische Akademie Der Wissenschaften, 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:
759829	**DISCOMPOSE**	**SH6** The Study of the Human Past

Principal Investigator:	**Dr. DOMENICO CECERE**
Host Institution:	Universita Degli Studi Di Napoli Federico Ii., IT

Disasters, Communication and Politics in South-Western Europe: the Making of Emergency Response Policies in the Early Modern Age

The connections between the circulation of news of extreme events, the making of influential narratives of collective traumas and the development of emergency response policies lie at the heart of this research proposal, which focuses on four Southern European areas: Catalonia, Naples, Sicily and Valencia, from the 16th to the 18th century. How did accounts and individual memories of extreme events amount to authoritative interpretations? In which ways, and to what extent, did the latter orient collective behaviours and the recovery process, in both the short and the long term?
Starting from the assumption that human relations are enhanced by the increased levels of socialisation that commonly occur in the aftermath of shocking events, which trigger the sharing of information, opinions and memories; and that the emotional impact of such events is likely to create a public opinion that draws attention to government's action; the research proposal aims to contribute new insights into these issues by adopting an original methodology, developed across a variety of disciplines, including Cultural and Social History, Textual Criticism, Philology and Anthropology. Moreover, it will adopt a transnational perspective: since the selected regions belonged to the Spanish Monarchy, the development of practices and polices aimed to respond to disruption depended not only on the specific social and cultural features of local societies, but also on the circulation of political and technical staff, as well as on the sharing of knowledge, experiences and policy models, among the various areas of the Empire and its colonies. Studying the information exchange in the aftermath of disasters and the formation of an imagery of extraordinary events, will allow a comprehensive perspective on the policies and practices adopted by early modern societies to manage uncertainty, and on the potential impact that such narratives could have on the renegotiation of political and social relations.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
759926	**UMMA**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. ARTUR OBLUSKI**
Host Institution: Uniwersytet Warszawski, PL

Urban Metamorphosis of the community of a Medieval African capital city

UMMA (Arab. أمة - community) is a multidisciplinary project aimed as the first study of the liminal phases of a Christian African community inhabiting Dongola, the capital city of of Makuria (modern Sudan). It will concern the twilight of Christian Dongola and the metamorphosis of its urban community into a new entity organised along different social and religious paradigms.
The project will investigate the impact between the weakening of the central authority and migrations of Islamic Arab tribes on the kingdom's capital city and its community. The notion that the project intends to investigate is that a complete breakdown of this urban organism and its hinterland was avoided thanks to cooperation established between the remaining local community and migrant population groups arriving in the period under consideration. The project will seek to identify strategies of interaction between the local community and the newcomers, as well as patterns of survival of the old traditions on household level.
UMMA will lay foundations for further enquiries into evolution of precolonial African communities and provoke a general discussion on social changes in urban environments. It will unfold a whole new research perspective on the period from the gradual decline of the kingdom of Makuria (14th-15th cent. CE) to the Egyptian invasion in 1820, which is virtually absent from scholarly enquiry to date.

UMMA brings together specialists from several disciplines to carry out an exemplary archaeological project to set the standards for future archaeological research on late medieval and early modern Sudan. The project will combine methods of inquiry used in disciplines like history, archaeology, geophysics, chemistry and physics to obtain a multifaceted, cross-disciplinary perspective on the social phenomenon of liminal periods in urbanism.

Project End Date: **31-MAY-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: **31-DEC-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:
772390	**NEOGENE**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. MEHMET SOMEL**
Host Institution: Middle East Technical University, TR

Archaeogenomic analysis of genetic and cultural interactions in Neolithic Anatolian societies

The Neolithic Transition in the Near East (c.10,000-6,000 BC) was a period of singular sociocultural change, when societies adopted sedentary life and agriculture for the first time in human history. This project will jointly use genomic and quantitative cultural data to explore Transition societies' organisation, interactions, and their social and demographic evolution in time. (1) We will start by dissecting social structures within Neolithic communities in Anatolia, studying the role of kinship, postmarital residence customs, and endogamy. For this end, we will produce genotype data for c.250 individuals interred within five Pre-Pottery and Pottery Neolithic villages in South East and Central Anatolia, and analyse genomic relatedness patterns in the context of bioarchaeological similarity (e.g. by measuring genetic relatedness among Çatalhöyük individuals buried within the same house over generations). (2) We will study the means of cultural interaction among Near Eastern Neolithic societies by documenting which cultural traits -from skull removal customs to pottery- were most likely propagated through emulation and acculturation, and which ones by gene flow, when and where. Here we will produce whole genome data, compile genomic and material culture similarity matrices for >30 Near Eastern pre-Neolithic and Neolithic populations, and develop frameworks for integrated analysis of quantitative material culture and genomic similarity among populations (also including obsidian and sheep exchange connections as factors). The data will be analysed on multiple levels: within regions, interregional, and diachronic. (3) The work will conclude by examining the evolution of social organisation and population interaction patterns through the Neolithic Transition. While enriching and revising current Transition models, the project will set precedents for employing archaeogenomics to study social structures and for systematic co-analysis of genomic and archaeological data.

Project End Date: **31-MAY-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:
788476	**ENPMUC**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. CHRISTIAN HENRIOT**
Host Institution: Universite D'Aix Marseille, FR

Elites, networks, and power in modern urban China (1830-1949).

This project proposes a step-change in the study of modern China reliant upon scalable data-rich history. It will deliver precise historical information at an unprecedented scale from heretofore untapped sources - as well as reshaping the analysis of existing sources - to create a new dimension in the study of the transformation of elites in modern China. It will deploy an array of cutting-edge digital methods — including data mining, sampling, and analysis within an integrated virtual research environment. To establish the validity of this approach, the project focuses on the three urban areas (Shanghai, Beijing/Tianjin, Canton/Hong Kong) that had the most profound impact on the course of modern Chinese history. Starting from the mid-19th century, the narrow elite of Confucian-trained scholar-officials that had ruled the country for a millenium was finally swept away. Power and social prestige shifted to socially more diversified groups of Chinese and foreigners who operated within interlocked transnational networks. The project will challenge the China-centered and group-based approach dominant in the historical literature of the past two decades. The project envisions elites in urban China as actors whose status, position, and practices were shaped by the power configurations that developed over time and whose actions through institutions and informal/formal networks in turn were a determining factor in redrawing social and political boundaries. The project will place the emphasis on the networks through which information, capital, and individuals circulated. It will investigate the transnationalization of elites as a process that overstepped the limits of institutions and nation states. The key issue that the project will address is breaking through existing limits of access to historical information that is embedded in complex sources and its transformation into refined, re-usable and sustainable data for contemporary and future study of modern China.

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

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
788616	**YMPACT**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. VOLKER HEYD**
Host Institution: Helsingin Yliopisto, FI

The Yamnaya Impact on Prehistoric Europe

Dramatic migrations in the third millennium BC re-shaped Europe, modifying its economy, society, ethnicity and ideological structure for ever. The best incentive proxy are populations that moved from the steppes of Russia, spreading as far west as Hungary, implanting a pastoral economy with widespread innovations. These dynamic people covered thousands of kilometres within a few centuries, and organised direct physical relations over the steppes for the first time. This synchronism is promoted by a society organised to fit to this lifestyle, with new herding techniques, likely use of wagons and domesticated horses, and a protein-rich diet, whose adaptive advantages are evident from the physical record in human skeletons and territorial extensions. This is the Yamnaya complex, whose impact remains visible today in the European gene pool and apparently the propagation of Indo-European languages. This international and interdisciplinary project examines the data from 320 excavated burial mounds and c.1350 burials to calibrate these changes, also against a control sample of supposedly local and neighbouring populations. The archaeological, biological and environmental information allows large, new datasets to be built, whose systematic interrogation and modelling should reveal the formative processes behind these changes. Assessing funeral archaeology, material culture, and exchange pattern defines their culture and impact. Scientific analyses of skeletons expose relations of origin, degrees of consanguinity, diet, and histories of individual mobility over single lifetimes with new precision and replicability. They should also act as proxy datasets for environmental changes using further analytical techniques in a context of landscape evolution. Diachronic patterns within these sets should link with aspects of the internal social dynamics, such as the creation of new status positions, visible later in the Pan-European Corded Ware and Bell Beaker groups.

Project End Date: **31-DEC-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:
804151	**AncientAdhesives**	**SH6** The Study of the Human Past

Principal Investigator: **Dr. GEESKE LANGEJANS**
Host Institution: Technische Universiteit Delft, NL

Ancient Adhesives - A window on prehistoric technological complexity

AncientAdhesives addresses the most crucial problem in Palaeolithic archaeology: How to reliably infer CoGnitively complex behaviour in the deep past. To study the evolution of Neandertal and modern human CoGnitive capacities, certain find categories are taken to reflect behavioural and thus CoGnitive complexitye.g. Among these are art objects, personal ornaments and complex technology. Of these technology is best-suited to trace changing behavioural complexity, because 1) it is the least vulnerable to differential preservation, and 2) technological behaviours are present throughout the history of our genus. Adhesives are the oldest examples of highly complex technology. They are also known earlier from Neandertal than from modern human contexts. Understanding their technological complexity is thus essential to resolve debates on differences in CoGnitive complexity of both species. However, currently, there is no agreed-upon method to measure technological complexity.

The aim of AncientAdhesives is to create the first reliable method to compare the complexity of Neandertal and modern human technologies. This is achieved through three main objectives:

1. Collate the first comprehensive body of knowledge on adhesives, including ethnography, archaeology and (experimental) material properties (e.g. preservation, production).
2. Develop a new archaeological methodology by modifying industrial process modelling for archaeological applications.
3. Evaluate the development of adhesive technological complexity through time and across species using a range of explicit complexity measures.

By analysing adhesives, it is possible to measure technological complexity, to identify idiosyncratic behaviours and to track adoption and loss of complex technological know-how. This represents a step-change in debates about the development of behavioural complexity and differences/similarities between Neanderthals and modern humans.

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

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:
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:
810131	**PLAMORF**	**SYG** Synergy

Principal Investigator: **Dr. JULIA KEHR**
Host Institution: University of Hamburg, DE

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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:
810131	**PLAMORF**	**SYG** Synergy

Principal Investigator: **Dr. RICHARD MORRIS**
Host Institution: John Innes Centre, UK

Plant Mobile RNAs: Function, Transport and Features

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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:
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:
810186	**BacterialCORE**	**SYG** Synergy

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

Widespread Bacterial CORE Complex Executes Intra- and Inter-Kingdom Cytoplasmic Molecular Trade

The enormous versatility of bacteria enables the formation of multi-species communities that colonize nearly every niche on earth, making them the dominant life form and a major component of the biomass. Exchange of molecular information among neighboring bacteria in such communities, as well as between bacteria and proximal eukaryotic cells, is key for bacterial success. Yet, the principles controlling these multicellular interactions are poorly defined. Here we describe the identification of a bacterial protein complex, herein termed CORE, whose function is to traffic cytoplasmic molecules among different bacterial species, and between pathogenic bacteria and their human host cells. The CORE is composed of five membrane proteins, highly conserved across the entire bacterial kingdom, providing a ubiquitous platform that facilitates both intra- and inter-kingdom crosstalk. Our preliminary data support the idea that the CORE acts as a shared module for the assembly of larger apparatuses, executing this universal molecular flow among organisms. We propose to elucidate components, structure and biogenesis of the CORE machinery, operating during bacteria-bacteria and pathogen-host interactions. We further aim to provide an unbiased-global view of the extent and identity of cytoplasmic molecules traded via CORE including metabolites, proteins and RNA, and to reveal the criteria determining the specificity of the transported cargo. Furthermore, we intend to decipher the impact of CORE-mediated molecular exchange on bacterial physiology and virulence, and devise anti-CORE compounds to combat pathogenic bacteria. This study is expected to transform the way we currently view bacterial communities and host-pathogen interactions. We anticipate these findings to lead to the development of creative strategies to modulate, predict and even design bacterial communities, and lay the foundation for new and innovative approaches to fight bacterial diseases.

Project End Date: **31-MAR-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:
810316	**4-D nanoSCOPE**	**SYG** Synergy

Principal Investigator: **Dr. SILKE CHRISTIANSEN**
Host Institution: Helmholtz Zentrum Berlin, DE

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