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2017

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Project ID:	Project Acronym:	Evaluation Panel:
335855	**PicoStructure**	**LS1 - Molecular and Structural Biology and Biochemistry**

Principal Investigator:	**Dr. Pavel Plevka** pavel.plevka@ceitec.muni.cz
Host Institution:	Masarykova Univerzita, CZ

Structural studies of human picornaviruses

Many picornaviruses are human pathogens that cause diseases varying in symptoms from common cold to life-threatening encephalitis. Currently there are no anti-picornavirus drugs approved for human use. We propose to study molecular structures of picornaviruses and their life cycle intermediates in order to identify new targets for anti-viral inhibitors and to lay the foundations for structure-based development of drugs against previously structurally uncharacterized picornaviruses. We will use X-ray crystallography to determine virion structures of representative viruses from Parechovirus, Kobuvirus, Cardiovirus, and Cosavirus genera and Human Rhinovirus-C species. We will use cryo-electron microscopy to study picornavirus replication complexes in order to explain the mechanism of copy-choice recombination of picornavirus RNA genomes that leads to creation of new picornavirus species. We will determine whether picornavirus virions assemble from capsid protein protomers around the condensed genome or if the genome is packaged into a pre-formed empty capsid. Furthermore, we will investigate how picornaviruses initiate infection by analyzing genome release from virions and its translocation across lipid membrane.

A major innovation in our approach will be the use of focused ion beam micromachining for sample preparation that will allow us to study macromolecular complexes within infected mammalian cells by cryo-electron tomography. Our analysis of virion structure, cell entry, genome replication, and particle assembly will identify molecular details and mechanism of function of critical picornavirus life-cycle intermediates.

Project End Date: **2/28/2019**

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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** mariusz.nowacki@izb.unibe.ch
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: **4/30/2021**

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Project ID:	Project Acronym:	Evaluation Panel:
640283	**VIDOCK**	**LS1 - Molecular and Structural Biology and Biochemistry**

Principal Investigator:	**Dr. Matthieu Montes** matthieu.montes@cnam.fr
Host Institution:	Conservatoire National Des Arts Et Metiers, FR

2D Conformal mapping of protein surfaces: applications to VIsualization and DOCKing software

The goals of structural biology include developing a comprehensive understanding of the molecular shapes and forms embraced by biological macromolecules and extending this knowledge to understand how different molecular architectures are used to perform the chemical reactions that are central to life. Since the first resolution of protein structures by X-ray crystallography and NMR, structural biology seeks to provide this picture of biological phenomena at the molecular and atomic level by analyzing 3D structures. In the present proposal, we propose to change this paradigm by changing the mode of representation of protein surfaces to 2D maps. That will open new avenues for 1. the development of innovative high-throughput computation of protein interactions and relationships and 2. the emergence of new forms of visualization and analysis of protein structures and properties. We will apply this powerful tool of conformal mapping to structural biology by representing protein surfaces that are complex 3D surfaces in 2D conformal maps that we will call positive conformal maps. We will extend this representation by also generating the 2D conformal maps of the negatives of the 3D surface of the proteins. These positive and negative 2D conformal maps of the surface of proteins will constitute a new representation of the protein surfaces that will be the basis for innovative high-throughput and/or interactive simulation methods, visualization methods and more generally that will give an other insight on the structure of proteins. The major impact of this proposal lies in the fact that it will at last open the gates of the long awaited proteome docking. Using a simplified representation of protein surfaces will allow to perform faster complete cross docking calculations and create a new classification of the protein structures based on their surficial similarity.

Project End Date: **6/30/2020**

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Project ID:	Project Acronym:	Evaluation Panel:
681630	**HRMECH**	**LS1 - Molecular and Structural Biology and Biochemistry**

Principal Investigator:	**Dr. Petr Cejka** petr.cejka@irb.usi.ch
Host Institution:	Fondazione Per L'Istituto Di Ricerc A In Biomedicina, CH

Nucleases in homologous recombination: from basic principles to genome editing

Homologous recombination plays a crucial role to repair DNA strand breaks that may occur spontaneously upon replication fork collapse, during the course of radio- or chemotherapy or in a programmed manner during meiosis. Understanding the molecular mechanisms of re-combinational repair is thus very important not only from a basic research viewpoint, but it is also highly relevant for human health. Here, we will define the function of nucleases in homol-ogous recombination. First, we will study the initial steps in this pathway. We could show previously that the S. cerevisiae Sae2 protein promotes the endonuclease activity of the Mre11-Rad50-Xrs2 (MRX) complex near protein blocked DNA ends. This initiates nucleolytic resection of DNA breaks and activates homologous recombination. Our biochemical setup will be instrumental to define how is the activity of Sae2 regulated by phosphorylation on a mech-anistic level and how physiological protein blocks direct the Mre11 endonuclease. We will ex-tend the study to the human system, and attempt to apply the gained knowledge to improve the efficiency of genome editing by activating recombination in conjunction with the CRISPR-Cas9 nuclease system. Second, we will study how homologous recombination promotes gen-eration of genetic diversity during sexual reproduction. DNA strand breaks are introduced in-tentionally during the prophase of the first meiotic division. They are then processed by the recombination machinery into Holliday junction intermediates. These joint molecules are preferentially converted into crossovers in meiosis, resulting in exchange of genetic infor-mation between the maternal and paternal DNA molecules. This is dependent on the Mlh1-Mlh3 nuclease through a yet unknown mechanism. We will study how Mlh1-Mlh3 in complex with other proteins guarantee crossover outcome to promote diversity of the progeny.

Project End Date: **9/30/2021**

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Project ID:	Project Acronym:	Evaluation Panel:
614552	**TORCH**	**LS1 - Molecular and Structural Biology and Biochemistry**

Principal Investigator:	**Dr. Robbie Loewith** Robbie.loewith@unige.ch
Host Institution:	Universite De Geneve, CH

TOR and Cellular Homeostasis

The Target Of Rapamycin (TOR) proteins are ser/thr kinases conserved in Eukarya. They nucleate two distinct multiprotein complexes, named TORC1 and TORC2, which regulate many, widely varying, aspects of cell and organism physiology. TOR inhibitors, such as rapamycin and derivatives, are used clinically to treat cancer, cardio-vasculature disease and to prevent organ rejection. We recently reported that both TORC1/2 are wired in feedback loops, where their downstream cellular effectors are at the same time upstream regulators. It is this feedback loop that ultimately mediates the intrinsic role of TORC1/2 in cellular homeostasis: TORC1/2 detects deviations from a steady-state condition and by means of these feedback loops returns the cell to its homeostatic situation. We propose to systematically identify the TORC1/2 homeostatic signalling loops. Subsequent characterization will focus on the signalling networks controlling intermediary metabolism. Our ultimate goal is to comprehensively unravel the TORC1/2-dependent metabolic networks composed of regulatory feedback loops which will reveal the fundamental role of the TOR Complexes as molecular devices to achieve cellular homeostasis.

Project End Date: **3/31/2019**

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Project ID:	Project Acronym:	Evaluation Panel:
670578	**ABCvolume**	**LS1 - Molecular and Structural Biology and Biochemistry**

Principal Investigator:	**Dr. Bert Poolman** b.poolman@rug.nl
Host Institution:	Rijksuniversiteit Groningen, NL

The ABC of Cell Volume Regulation

Cell volume regulation is crucial for any living cell because changes in volume determine the metabolic activity through e.g. changes in ionic strength, pH, macromolecular crowding and membrane tension. These physical chemical parameters influence interaction rates and affinities of biomolecules, folding rates, and fold stabilities in vivo. Understanding of the underlying volume regulatory mechanisms has immediate application in biotechnology and health, yet these factors are generally ignored in systems analyses of cellular functions.My team has uncovered a number of mechanisms and insights of cell volume regulation. The next step forward is to elucidate how the components of a cell volume regulatory circuit work together and control the physicochemical conditions of the cell.I propose construction of a synthetic cell in which an osmoregulatory transporter and mechanosensitive channel form a minimal volume regulatory network. My group has developed the technology to reconstitute membrane proteins into lipid vesicles (synthetic cells). One of the challenges is to incorporate into the vesicles an efficient pathway for ATP production and maintain energy homeostasis while the load on the system varies. We aim to control the transmembrane flux of osmolytes, which requires elucidation of the molecular mechanism of gating of the osmoregulatory transporter. We will focus on the glycine betaine ABC importer, which is one of the most complex transporters known to date with ten distinct protein domains, transiently interacting with each other. The proposed synthetic metabolic circuit constitutes a fascinating out-of-equilibrium system, allowing us to understand cell volume regulatory mechanisms in a context and at a level of complexity minimally needed for life. Analysis of this circuit will address many outstanding questions and eventually allow us to design more sophisticated vesicular systems with applications, for example as compartmentalized reaction networks.

Project End Date: **6/30/2020**

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

Principal Investigator:	**Dr. Lori Passmore** passmore@mrc-lmb.cam.ac.uk
Host Institution:	Medical Research Council, UK

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

Gene expression is tightly regulated to allow rapid responses to cellular stimuli. In eukaryotes, the 3′ polyA tail of mRNAs plays key roles in post-transcriptional control. The Cleavage and Polyadenylation Factor (CPF), Ccr4–Not and Pan2–Pan3 multiprotein complexes add or remove polyA tails to regulate mRNA stability and efficiency of translation. They control expression of genes in the inflammatory response, miRNA-targeted gene silencing and expression of maternal mRNAs in oocyte development. These processes are deregulated in disease, including cancer and neurological disorders. Although the proteins that add and remove polyA tails are known, their mechanisms are poorly understood. My lab recently established methods to reconstitute the polyA machinery. This led to new insights into the link between transcription and polyadenylation, new understanding of the molecular mechanisms of deadenylation, and details of RNA recruitment. In this proposal, my objective is to understand the molecular basis for polyadenylation and deadenylation of specific mRNAs. This is now possible because of our novel methodological and biological advances. We will determine high-resolution structures of the polyA machinery using electron cryo-microscopy (cryo-EM), reconstitute their biochemical activities in vitro and study their in vivo functional roles. We use this integrated approach to study intact multiprotein complexes, not individual subunits or domains. This involves considerable technical challenges and an investment in developing high quality purifications and new structural methods. I will determine how the four enzymatic activities of CPF are coupled, the mechanisms by which Ccr4–Not targets specific RNAs, and the molecular basis for RNA recognition by Pan2–Pan3. Together, this will provide new biological and technological insights, leading to understanding of fundamental processes in gene expression and the role of polyA tails in disease.

Project End Date: **3/31/2022**

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

Principal Investigator:	**Dr. Gustav Berggren** gustav.berggren@kemi.uu.se
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: **1/31/2022**

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Project ID:	Project Acronym:	Evaluation Panel:
695013	**pre-FAB**	**LS1 - Molecular and Structural Biology and Biochemistry**

Principal Investigator:	**Dr. David Leys** david.leys@manchester.ac.uk
Host Institution:	The University Of Manchester, UK

Prenylated-flavins: Application and Biochemistry

Our group has recently discovered a new type of cofactor: a prenylated-flavin that has azomethine ylide properties. This cofactor is an integral part of the widespread ubiD/ubiX system. The latter is implicated in the non-oxidative reversible decarboxylation of aromatic substrates, and plays a pivotal role in bacterial ubiquinone biosynthesis or microbial biodegradation of aromatic compounds. We established UbiX acts as a novel flavin prenyltransferase, linking a dimethylallyl moiety to the flavin N5 and C6 atoms. Formation of the holo-UbiD enzyme involves oxidative maturation of the new cofactor, creating the novel azomethine ylide moiety. The dipolarophile substrate binds directly above the azomethine ylide group, and our data strongly suggests 1,3-dipolar cycloaddition chemistry supports reversible decarboxylation in these enzymes. While 1,3-dipolar cycloaddition is commonly used in organic chemistry, this presents the first example of an enzymatic 1,3-dipolar cycloaddition reaction. Our model for UbiD catalysis hints at new routes in alkene hydrocarbon production or aryl (de)carboxylation. The current application builds ambitiously on these results and takes the project altogether to another level: we seek to investigate structure/function of relationships of the wider UbiD family, ultimately including the multi-subunit enzymes that couple ATP-hydrolysis to benzene or naphthalene carboxylation. Furthermore, we will explore and harness the unusual properties of the prenylated flavin, through targeted evolution of (monoxygenase) flavoenzymes to create artificial prFMN-dependent self-sufficient monoxygenases. Our approach seeks to harness both the UbiD and the artificial prFMN-dependent enzymes in novel green routes to commodity chemicals.

Project End Date: **8/31/2021**

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Project ID:	Project Acronym:	Evaluation Panel:
670146	**MASCP**	**LS1 - Molecular and Structural Biology and Biochemistry**

Principal Investigator:	**Dr. Juan Valcarcel** juan.valcarcel@crg.eu
Host Institution:	Fundacio Centre De Regulacio Genomica, ES

Mechanisms of alternative pre-mRNA splicing regulation in cancer and pluripotent cells

Alternative splicing of messenger RNA precursors is a prevalent form of gene regulation that greatly expands the coding capacity and regulatory opportunities of higher eukaryotic genomes. It contributes to cell differentiation and pluripotency and its deregulation promotes cancer progression, as evidenced by the frequent occurrence of cancer-associated mutations in splicing factors, which are also targets of anti-tumor drugs. Despite its prevalence and relevance, the underlying mechanisms of regulation remain poorly understood. This proposal aims to develop and apply systematic approaches that can allow us to carry out the equivalent of genetic analysis of splicing regulation in cancer and pluripotent cells. These technologies can help to unweave the complex network of functional interactions within the spliceosome and of the spliceosome with regulatory factors, exhaustively map the contribution of regulatory sequences and be used to investigate, with unprecedented detail, mechanisms of regulation for essentially any regulator or alternative splicing event operating in a particular cell line. Such approaches can offer a unique opportunity to address key unresolved mechanistic questions, including the molecular basis for positional effects of splicing regulatory factors (RNA Maps), the regulatory potential of the core spliceosome and the integration of alternative splicing with other cell regulatory programs. We will combine these approaches with biochemical and cellular assays to investigate detailed mechanisms of regulation relevant for the control of cell proliferation and/or pluripotency in cancer and induced pluripotent stem (iPS) cells. Progress in this area can contribute to reveal the molecular logic governing a key layer of gene regulation and has the potential to discover novel factors and regulatory circuits that trigger or modulate cell growth, differentiation and cancer progression.

Project End Date: **9/30/2020**

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Project ID:	Project Acronym:	Evaluation Panel:
679239	**SELFORGANICELL**	**LS1 - Molecular and Structural Biology and Biochemistry**

Principal Investigator:	**Dr. Martin Loose** mloose@ist.ac.at
Host Institution:	Institute Of Science And Technology Austria, AT

Self-Organization of the Bacterial Cell

One of the most remarkable features of biological systems is their ability to self-organize in space and time. Even a relatively simple cell like the bacterium Escherichia coli has a precisely regulated cellular anatomy, which emerges from dynamic interactions between proteins and the cell membrane. Self-organization allows the cell to perform extremely challenging tasks. For example, for cell division, more than ten different proteins assemble into a complex, yet highly dynamic machine, which controls the invagination of the cell while constantly remodeling itself. Although the individual components involved have been largely identified, how they act together to accomplish this challenge is not understood. It has become clear that sophisticated biochemical networks give rise to intracellular organization, but we have yet to uncover the underlying mechanistic principles.

In this research proposal, I aim to develop a detailed mechanistic understanding of the self-organizing, emergent properties of the cell. To this end, my research group will develop novel in vitro reconstitution experiments combined with high-resolution fluorescence microscopy and theoretical modeling. Following this “bottom-up” approach, we will quantitatively analyze collective protein dynamics and emergent mechanochemical properties of the bacterial cell division machinery. I aim to answer the following fundamental questions:

1) What is the biochemical network giving rise to the dynamic assembly of the divisome?
2) How do the components of the divisome interact to generate force?
3) How do peptidoglycan synthases build the cell wall?

By comparing protein dynamics in vitro with those measured in vivo, we will provide a link between molecular properties and the processes found in the living cell. This project will not only improve our understanding of the bacterial cell, but also open new research avenues for eukaryotic cell biology, synthetic biology and biophysics.

Project End Date: **3/31/2021**

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Project ID:	Project Acronym:	Evaluation Panel:
340081	**PRIME**	**LS1 - Molecular and Structural Biology and Biochemistry**

Principal Investigator:	**Dr. Neil Brockdorff** neil.brockdorff@bioch.ox.ac.uk
Host Institution:	The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Polycomb repressor interactions in relation to the mammalian epigenome.

In mammals Polycomb group (PcG) repressors play a central role in maintaining cell type specific gene expression patterns in stem cells and through differentiation and development. Accordingly, deficiencies in the Polycomb system are important in disease, notably in several types of cancer. Although it is established that the effector function of PcG proteins is in large part attributable to intrinsic histone modification activities, the mechanisms that target PcG proteins to defined loci remain poorly understood. A number of different models have been proposed in order to account for PcG targeting to CpG islands at the promoters of target genes, the inactive X chromosome, and in defined circumstances, to pericentric constitutive heterochromatin. Our recent studies, and those of others, have highlighted that underlying chromatin state and DNA methylation play an important role, and based on this we have developed a general model that can account for PcG localisation at all target loci. The central aim of this proposal is to test the general model and to determine the mechanisms by which underlying chromatin states dictate PcG factor binding. In a series of integrated experiments we will define chromatin modifications on mononucleosomes purified from PcG target loci, determine the activity of major PcG complexes in vitro using nucleosome templates assembled with recombinant histones/histone variants bearing specific chromatin modifications, and, using a novel photo-cross-linking strategy, define, at the atomic level, interactions of PcG complexes with chromatin templates in vitro. Finally, based on our findings we will establish de novo PcG target sites in cells and/or disrupt preexisting PcG target sites. These studies will help to define the fundamental mechanisms that determine PcG protein targeting, and in addition will provide insight into misregulation of PcG proteins in disease.

Project End Date: **1/31/2019**

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Project ID:	Project Acronym:	Evaluation Panel:
639905	**ProPlantStress**	**LS1 - Molecular and Structural Biology and Biochemistry**

Principal Investigator:	**Dr. Pitter Huesgen** p.huesgen@fz-juelich.de
Host Institution:	Forschungszentrum Julich Gmbh, DE

Proteolytic processing in plant stress signal transduction and responses to abiotic stress and pathogen attack

Site-specific proteolytic processing is an irreversible post-translational protein modification that generates distinct protein species with new functions, interactions and subcellular locations. In plants, proteolytic processing regulates hormonal and stress signaling leading to adaptation of metabolic pathways and is implicated in plant-pathogen interactions. Despite their importance, proteolytic processes have largely been identified serendipitously, specific cleavage sites have rarely been identified and only a few of the hundreds of proteases encoded in plant genomes (>800 in Arabidopsis) have been linked to any substrates.Positional proteomics enables system-wide identification of proteolytic processing and protease substrate repertoires through quantitative determination of protein N- or C-termini. ProPlantStress will employ these approaches, which I co-developed during my postdoctoral research, to two linked abiotic and biotic stress conditions: i) Time-resolved mapping of chloroplast protein processing induced by high intensity light will reveal novel mechanisms of retrograde signal transduction, stress response and acclimation; ii) Profiling of protein processing triggered by pathogen recognition, combined with substrate identification for selected host and bacterial pathogen effector proteases will identify proteins with novel functions in plant immune responses and systemic signaling.Importantly, ProPlantStress will not merely catalogue termini and substrates: Mapping of cleavage sites to the protein domains and correlation with other modifications, such as phosphorylation, generates testable hypotheses on the function of processed protein species that will be examined in detail.ProPlantStress will thereby provide fundamental insights into proteolytic mechanisms underlying plant stress responses that are unattainable by other means. In the long term such knowledge is needed to develop new strategies for crop protection and mitigation of harvest loss.

Project End Date: **5/31/2020**

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Project ID:	Project Acronym:	Evaluation Panel:
338252	**miRLIFE**	**LS1 - Molecular and Structural Biology and Biochemistry**

Principal Investigator:	**Dr. Stefan Ameres** stefan.ameres@imba.oeaw.ac.at
Host Institution:	Institut Fuer Molekulare Biotechnologie Gmbh, AT

Molecular Characterization of the microRNA Life-Cycle

Small silencing RNAs regulate gene expression in nearly all eukaryotes and have enormous biotechnological and therapeutic potential. MicroRNAs belong to the larges family of trans-acting gene regulatory molecules in multicellular organisms. In flies and mammals, they control more than half of the protein-coding transcriptome, and act as key regulators of organismal development, physiology, and disease.

Here, we propose to study the molecular mechanisms that regulate microRNA homeostasis. We aim to understand how distinct small RNA profiles are established and maintained to coordinate the expression of more than half of all protein coding genes in flies and mammals. Our studies will provide insight into the processes that regulate the function of miRNAs, determine possible causes for aberrant miRNA levels, that have been associated with human diseases, and provide guidelines how to efficiently inhibit miRNA function for analytical and therapeutic purposes.

We aim to identify and characterize the molecular determinants of microRNA stability, to dissect the pathways that promote the sequence-specific degradation of microRNAs, and to understand the biological consequences and therapeutic potential of small RNA decay. We will develop novel tools to obtain a view on the intracellular dynamics of RNA silencing pathways, in order to determine the molecular features associated with small RNA biogenesis and decay.

Because of its genetic and biochemical tools, we will use Drosophila melanogaster as a model organism. We will employ a combination of bioinformatics, cell-free biochemical experiments, cell culture methods, and in vivo genetics. What we learn in flies we will test in vitro in mammalian cell extracts, in cultured human cell lines and in vivo in mice to identify where these processes are conserved and where they diverge.

Overall, our goal is to determine fundamental biological mechanisms of RNA silencing, a phenomenon with enormous biological and biomedical impact.

Project End Date: **1/31/2019**

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Project ID:	Project Acronym:	Evaluation Panel:
647784	**Chap4Resp**	**LS1 - Molecular and Structural Biology and Biochemistry**

Principal Investigator: **Dr. Irina Gutsche**
irina.gutsche@ibs.fr

Host Institution: Centre National De La Recherche Scientifique, FR

Catching in action a novel bacterial chaperone for respiratory complexes

Cellular respiration provides energy to power essential processes of life. Respiratory complexes are macromolecular batteries coupling electron flow through a wire of metal clusters and cofactors with proton transfer across the inner membrane of mitochondria and bacteria. Waste products of these cellular factories are reactive oxygen species causing ageing and diseases. Assembly and maturation mechanisms of respiratory complexes remain enigmatic because of their membrane location, multisubunit composition and cofactor insertion. E. coli Complex I, one of the largest membrane proteins, composed of 14 conserved subunits with 9 Fe/S clusters and a flavin, is a minimal model for its 45-subunit human homologue. When proton pumping by respiratory complexes is affected, bacteria become resistant to antibiotics requiring proton gradient for uptake. Based on the latest genetic data, we realize that the huge E. coli macromolecular cage, the structure of which we recently solved by cryo-electron microscopy (cryoEM), in conjunction with a novel protein cofactor, is a specific chaperone for Fe/S cluster biogenesis and assembly of respiratory complexes. This integrated multidisciplinary project combines cryoEM and other structural, biophysical and spectroscopic techniques, to uncover the functional mechanism of this emerging chaperone. The structural plasticity of the chaperone fuelled by ATP hydrolysis, and its interaction with Fe/S cluster biogenesis systems and the main respiratory complexes as a function of stresses, will be scrutinized to gain quasiatomic insights into the way the chaperone operates on its substrates. A novel technology for synergetic in situ investigation of protein complexes in the bacterial cytoplasm by optical imaging, state-of-the-art cryogenic correlative light and electron microscopy, and subtomogram analysis, will be developed and used to obtain snapshots of the chaperone-substrate interactions in the cellular context.

Project End Date: **9/30/2020**

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Project ID:	Project Acronym:	Evaluation Panel:
677500	**MAIN**	**LS1 - Molecular and Structural Biology and Biochemistry**

Principal Investigator:	**Dr. Bert Janssen** b.j.c.janssen@uu.nl
Host Institution:	Universiteit Utrecht, NL

Molecular Adhesion and Interactions in the Nervous system

Surface-attached proteins establish cell-to-cell contacts and generate signals to control development and function of tissues. It is not clear how protein structure and interactions organize into intercellular assemblies to regulate signalling and adhesion. Using a hybrid approach and focusing on two cell-signalling systems critical for nervous system function, I will determine how protein conformation, interaction and spatial arrangement form cis and trans assemblies to control intercellular adhesion and signalling. In the mammalian nervous system where intricate intercellular connections are highly abundant, two protein interaction systems play essential roles and have been studied extensively on a cellular and in vivo level:

1. Notch receptors with Jagged and Delta-like ligands in neurogenesis and neuronal plasticity
2. Contactins with Casprs, Neurofascin and Amyloid Precursor Protein in formation and maintenance of the nervous system.

In addition, Notch signalling triggered by Contactins promotes cell maturation and interlinks these two signalling systems. The detailed molecular-level structures and interactions, however, remain largely unresolved and, consequently, our understanding of how Notch and Contactin conformational and oligomeric changes trigger cell signalling and adhesion is limited. The overall aim is to resolve the extracellular interactions of adhesion and the molecular mechanisms underlying signalling in the Notch and Contactin systems. I will combine X-ray crystallography and cryo-EM to determine structures of proteins, complexes and higher-order assemblies in the pre- and post-intercellular state, and use biophysical and cellular methods to probe cis and trans multivalent interactions. This will provide the molecular basis of intercellular communication and a stepping stone for the development of therapeutics to treat Notch and Contactin associated neurological disorders and cancers.

Project End Date: **2/28/2021**

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Project ID:	Project Acronym:	Evaluation Panel:
614944	**SysPharmAD**	**LS2 - Genetics, Genomics, Bioinformatics and Systems Biology**

Principal Investigator:	**Dr. Patrick Aloy** patrick.aloy@irbbarcelona.org
Host Institution:	Fundacio Institut De Recerca Biomedica (Irb Barcelona), ES

A systems pharmacology approach to the discovery of novel therapeutics in Alzheimer´s disease

Alzheimer´s disease (AD) is the most common form of dementia, with over 35 million people suffering from it worldwide, and it constitutes a personal and societal tragedy of immense proportions. Fifty years of intense research have revealed many key elements of the biology of this neurodegenerative disorder. However, our understanding of the molecular bases of the disease is still very limited, and the available medical treatments for AD are purely symptomatic and hardly effective. It is now clear that the modulation of a single target is unlikely to yield the desired outcome, and we should move from gene-centric to network-centric therapeutic strategies. In addition, we should focus on early (asymptomatic) phases of AD, before the brain damage is irreversible, and the identification of molecular biomarkers to monitor the response of patients is paramount. Accordingly, the main objective of our proposal is the identification of novel biomarkers in AD to monitor the onset and progression of the pathology from very early stages, and to discover combinations of drug targets and chemical compounds able to modify the biology of the disease. We will first run proteomics and transcriptomics experiments, in AD mouse models, to reveal the organization of proteins and genes that are up- or down-regulated at different ages and AD stages, and their potential translocation into/out of mitochondria. We will then construct the AD-associated network, incorporating clinical data, which we will use as a framework for the integration and analyses of the –omics data collected. We will transform the static data snapshots, corresponding to the different AD stages, into a dynamic model able to explain the progression of the disease, providing hints as to the best strategies to monitor and modulate AD evolution. We will finally design and validate a systems pharmacology strategy, based on concerted multi-target perturbations with small molecules, to modify the biology of the disease.

Project End Date: **3/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647403	**D-FENS**	**LS2 - Genetics, Genomics, Bioinformatics and Systems Biology**

Principal Investigator:	**Dr. Petr Svoboda** svobodap@img.cas.cz
Host Institution:	Ustav Molekularni Genetiky Akademie Ved Ceske Republiky Verejna Vyzkumna Instituce, CZ

Dicer-Dependent Defense in Mammals

Viral infection or retrotransposon expansion in the genome often result in production of double-stranded RNA (dsRNA). dsRNA can be intercepted by RNase III Dicer acting in the RNA interference (RNAi) pathway, an ancient eukaryotic defense mechanism. Notably, endogenous mammalian RNAi appears dormant while its common and unique physiological roles remain poorly understood. A factor underlying mammalian RNAi dormancy is inefficient processing of dsRNA by the full-length Dicer. Yet, a simple truncation of Dicer leads to hyperactive RNAi, which is naturally present in mouse oocytes.The D-FENS project will use genetic animal models to define common, cell-specific and species-specific roles of mammalian RNAi. D-FENS has three complementary and synergizing objectives:(1) Explore consequences of hyperactive RNAi in vivo. A mouse expressing a truncated Dicer will reveal at the organismal level any negative effect of hyperactive RNAi, the relationship between RNAi and mammalian immune system, and potential of RNAi to suppress viral infections in mammals.(2) Define common and species-specific features of RNAi in the oocyte. Functional and bioinformatics analyses in mouse, bovine, and hamster oocytes will define rules and exceptions concerning endogenous RNAi roles, including RNAi contribution to maternal mRNA degradation and co-existence with the miRNA pathway.(3) Uncover relationship between RNAi and piRNA pathways in suppression of retrotransposons. We hypothesize that hyperactive RNAi in mouse oocytes functionally complements the piRNA pathway, a Dicer-independent pathway suppressing retrotransposons in the germline. Using genetic models, we will explore unique and redundant roles of both pathways in the germline.D-FENS will uncover physiological significance of the N-terminal part of Dicer, fundamentally improve understanding RNAi function in the germline, and provide a critical in vivo assessment of antiviral activity of RNAi with implications for human therapy.

Project End Date: **6/30/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
670881	**SYSMET**	**LS2 - Genetics, Genomics, Bioinformatics and Systems Biology**

Principal Investigator:	**Dr. Maria Antonietta De Matteis** dematteis@tigem.it
Host Institution:	Fondazione Telethon, IT

Systems Biology of Membrane Trafficking

Membrane trafficking is fundamental for homeostasis of the internal membrane system and transport to and from the extracellular medium. Although we have gained detailed knowledge on the molecular organization of membrane trafficking machineries a global view of its function and regulation is lacking. To date membrane trafficking is often regarded as a constitutive process with a high degree of functional redundancy. However, the fact that mutations of single trafficking genes with ubiquitous expression give rise to tissue-specific human diseases and discrete sets of trafficking genes have differential effects on tissue development challenge this view.Here, using a combination of state-of the-art technologies, we will apply a systems biology approach in specialized cell types to establish a physiological and functional spatiotemporal map of membrane trafficking genes and proteins (membrane trafficking modules; MTMs). To this end we have curated a list of 1,187 genes representing ER, Golgi, Endosomes and Lysosomes (EGEL) around which we develop independent but interconnected approaches: (i) RNA-seq and antibody microarrays to identify co-regulated MTMs; (ii) high-content siRNA screening to define functional MTMs; (iii) epistatic functional analysis between EGEL genes and five membrane trafficking disease genes (TRAPPC2 in chondrocytes, Sec23A in osteoblasts, OCRL and CLCN5 in proximal tubular epithelial kidney cells, and VAPB in neuronal cells); and (iv) studies of protein-protein interactions to generate functional and physical networks centered on the disease genes.SYSMET will generate a unique resource by defining the impact and interplay of the different regulatory layers of the entire membrane trafficking system with important implications for human health.

Project End Date: **12/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679146	**EpigenomeProgramming**	**LS2 - Genetics, Genomics, Bioinformatics and Systems Biology**

Principal Investigator:	**Dr. Christoph Bock** cbock@cemm.oeaw.ac.at
Host Institution:	Cemm - Forschungszentrum Fuer Molekulare Medizin Gmbh, AT

An experimental and bioinformatic toolbox for functional epigenomics and its application to epigenetically making and breaking a cancer cell

Epigenetic alterations can be detected in all cancers and in essentially every patient. Despite their prevalence, the concrete functional roles of these alterations are not well understood, for two reasons: First, cancer samples tend to carry many correlated epigenetic alterations, making it difficult to statistically distinguish relevant driver events from those that co-occur for other reasons. Second, we lack tools for targeted epigenome editing that could be used to validate biological function in perturbation and rescue experiments. The proposed project strives to overcome these limitations through experimental and bioinformatic methods development, with the ambition of making and breaking cancer cells in vitro by introducing defined sets of epigenetic alterations. We will focus on leukemia as our “model cancer” (given its low mutation rate, frequent defects in epigenetic regulators, and availability of excellent functional assays), but the concepts and methods are general. In Aim 1, we will generate epigenome profiles for a human knockout cell collection comprising 100 epigenetic regulators and use the data to functionally annotate thousands of epigenetic alterations observed in large cancer datasets. In Aim 2, we will develop an experimental toolbox for epigenome programming using epigenetic drugs, CRISPR-assisted recruitment of epigenetic modifiers for locus-specific editing, and cell-derived guide RNA libraries for epigenome copying. Finally, in Aim 3 we will explore epigenome programming (methods from Aim 2) of candidate driver events (predictions from Aim 1) with the ultimate goal of converting cancer cells into non-cancer cells and vice versa. In summary, this project will establish a broadly applicable methodology and toolbox for dissecting the functional roles of epigenetic alterations in cancer. Moreover, successful creation of a cancer that is driven purely by epigenetic alterations could challenge our understanding of cancer as a genetic disease.

Project End Date: **11/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681396	**Extinction Genomics**	**LS2 - Genetics, Genomics, Bioinformatics and Systems Biology**

Principal Investigator:	**Dr. Marcus Thomas Gilbert** tgilbert@snm.ku.dk
Host Institution:	Københavns Universitet, DK

Exploring and exploiting the potential of extinct genome sequencing

Palaeogenomics is the nascent discipline concerned with sequencing and analysis of genome-scale information from historic, ancient, and even extinct samples. While once inconceivable due to the challenges of DNA damage, contamination, and the technical limitations of PCR-based Sanger sequencing, following the dawn of the second-generation sequencing revolution, it has rapidly become a reality. Indeed, so much so, that popular perception has moved away from if extinct species' genomes can be sequenced, to when it will happen - and even, when will the first extinct animals be regenerated. Unfortunately this view is naïve, and does not account for the financial and technical challenges that face such attempts. I propose an exploration of exactly what the limits on genome reconstruction from extinct or otherwise historic/ancient material are. This will be achieved through new laboratory and bioinformatic developments aimed at decreasing the cost, while concomitantly increasing the quality of genome reconstruction from poor quality materials. In doing so I aim to build a scientifically-grounded framework against which the possibilities and limitations of extinct genome reconstruction can be assessed. Subsequently genomic information will be generated from a range of extinct and near-extinct avian and mammalian species, in order to showcase the potential of reconstructed genomes across research questions spanning at least three different streams of research: De-extinction, Evolutionary Genomics, and Conservation Genomics. Ultimately, achievement of these goals requires formation of a dedicated, closely knit team, focusing on both the methodological challenges as well as their bigger picture application to high-risk high-gain ventures. With ERC funding this can become a reality, and enable palaeogenomics to be pushed to the limits possible under modern technology.

Project End Date: **3/31/2021**

European Research Council
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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** yifat.merbl@weizmann.ac.il
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: **4/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
678624	**CHROMTOPOLOGY**	**LS2 - Genetics, Genomics, Bioinformatics and Systems Biology**

Principal Investigator:	**Dr. Thomas Sexton** sexton@igbmc.fr
Host Institution:	Centre Europeen De Recherche En Biologie Et Medecine, FR

Understanding and manipulating the dynamics of chromosome topologies in transcriptional control

Transcriptional regulation of genes in eukaryotic cells requires a complex and highly regulated interplay of chromatin environment, epigenetic status of target sequences and several different transcription factors. Eukaryotic genomes are tightly packaged within nuclei, yet must be accessible for transcription, replication and repair. A striking correlation exists between chromatin topology and underlying gene activity. According to the textbook view, chromatin loops bring genes into direct contact with distal regulatory elements, such as enhancers. Moreover, we and others have shown that genomes are organized into discretely folded megabase-sized regions, denoted as topologically associated domains (TADs), which seem to correlate well with transcription activity and histone modifications. However, it is unknown whether chromosome folding is a cause or consequence of underlying gene function.

To better understand the role of genome organization in transcription regulation, I will address the following questions: (i) How are chromatin configurations altered during transcriptional changes accompanying development?

(ii) What are the real-time kinetics and cell-to-cell variabilities of chromatin interactions and TAD architectures?

(iii) Can chromatin loops be engineered de novo, and do they influence gene expression?

(iv) What genetic elements and trans-acting factors are required to organize TADs? To address these fundamental questions, I will use a combination of novel technologies and approaches, such as Hi-C, CRISPR knock-ins, ANCHOR tagging of DNA loci, high- and super-resolution single-cell imaging, genome-wide screens and optogenetics, in order to both study and engineer chromatin architectures.

These studies will give groundbreaking insight into if and how chromatin topology regulates transcription. Thus, I anticipate that the results of this project will have a major impact on the field and will lead to a new paradigm for metazoan transcription control.

Project End Date: **5/31/2021**

European Research Council
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Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716344	**TREATCilia**	**LS2 - Genetics, Genomics, Bioinformatics and Systems Biology**

Principal Investigator:	**Dr. Miriam Schmidts** miriam.schmidts@radboudumc.nl
Host Institution:	Stichting Katholieke Universiteit, NL

Novel Therapeutic Avenues for dynein-related Ciliopathies

Background: Cilia are hair-like, microtubule-based organelles protruding from most quiescent mammalian cells. They play essential roles in cell signalling (primary cilia) as well as movement of fluid (motile cilia). Although individually rare, cilia dysfunction affects up to 1 in 500 people in Europe, significantly reducing quality of life and lifespan due to dysfunction of multiple organs, including the kidneys, liver, heart, brain, retina, airways and the skeleton. To date, treatment is purely symptomatic. Aim and Approach: TREATCilia aims to decipher novel treatment avenues and improve clinical management for dynein-related ciliopathies. Next-generation sequencing based gene identification for dynein-related ciliopathies (ciliary chondrodysplasias and Primary Ciliary Dyskinesia, PCD) is employed to dissect the molecular basis and identify new therapeutic targets. Revealing genotype-phenotype mechanisms and their underlying cell signalling defects provides further insight into potential treatment options. Novel innovative curative approaches include high-throughput substance screening in model organisms such as the green algae Chlamydomonas and mammalian cells specially adapted for this purpose. Impact: Identification of novel ciliopathy genes will not only improve the biological understanding, but also reveal new treatment candidates. Furthermore, scrutinizing the molecular mechanisms of disease yields pharmacological entry points. TREATCilia develops a pre-clinical pipeline towards gene and mutation-specific treatments for hereditary conditions resulting from dynein-related ciliary dysfunction.

Project End Date: **1/31/2022**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
682009	**YEASTMEMORY**	**LS2 - Genetics, Genomics, Bioinformatics and Systems Biology**

Principal Investigator:	**Dr. Kevin Verstrepen** kevin.verstrepen@kuleuven.vib.be
Host Institution:	Vib, BE

Memory in biological regulatory circuits

The emergence of intelligence –the ability to remember and analyze data to make decisions– was a milestone in evolution. Intelligence and memory are usually associated with plastic neuronal connections in higher organisms. However, new discoveries hint that a rudimentary form of intelligence is rooted in networks that regulate gene expression in a wide range of organisms, including bacteria and yeasts. Specifically, we and others have shown that microbes show plastic behavioral responses to past experiences, such as previously available nutrients or stresses. This implies that information about the past is somehow retained and passed to next generations, where it influences cellular regulation. The goal of this project is to use a simple eukaryotic regulatory circuit as a model to obtain a comprehensive picture of the different genes and molecular mechanisms underlying history-dependence (hysteresis) in cellular regulation. Specifically, we will study maltose (MAL) regulation in budding yeast, because this signaling pathway serves as a model for gene regulation circuits in other organisms, including humans. We will use a combination of genetic screens, live-cell microscopy in custom-built microfluidic devices, and mathematical modeling to pursue four aims: 1. To provide a comprehensive quantitative analysis of hysteresis in MAL regulation

2. To unravel the molecular mechanisms contributing to hysteresis

3. To unravel the epigenetic mechanisms allowing hysteresis to extend over several generations

4. To characterize the ecological relevance of hysteresis This project will establish an innovative model for hysteresis and generate a genome-wide, systems-level view of how past influences can be stored in regulatory cascades to influence cellular decision-making. The results will contribute to a paradigm shift in our view of biological regulation and memory, with possible applications in fields as diverse as industrial microbiology, synthetic biology and medicine.

Project End Date: **9/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
340560	**EVOCAN**	**LS2 - Genetics, Genomics, Bioinformatics and Systems Biology**

Principal Investigator:	**Dr. Ian Tomlinson** iant@well.ox.ac.uk
Host Institution:	The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Why do cancers occur where they do? A genetic and evolutionary approach.

Tumorigenesis is a form of somatic evolution, a topical subject given the advent of cancer genome sequencing. However, we contend that some features of Darwinian evolution have been neglected when cancer is studied, as have some aspects of evolution that are special to cancers. For example, tumours comprise an expanding population of cells, cancers must occur within a normal human lifespan, and genotypes detrimental to growth of the tumour as a whole may be selected. These factors may render invalid the classical model in which successive mutations with large advantages arise and spread through the tumour in selective sweeps. To incorporate these neglected features and to test how tumorigenesis depends on factors such as mutation rate, selection and size constraints, we shall set up a comprehensive model of tumour growth incorporating cell birth, death, division and mutation parameters. We shall examine specific aspects of cancer-as-evolution in mice. By marking mutant clones using fluorescent proteins, we can track them and see how they persist, spread and die. We shall also determine the mutation profiles and genetic diversity of mutant clones and whole tumours in mice and humans using next-generation sequencing. Specific experiments will determine: (i) the fate of new advantageous clones arising in an existing tumour; (ii) whether new disadvantageous clones can persist in tumours; (iii) whether apparently maladaptive traits for tumour growth, such as suppressing the growth of competitors, can be selected; (iv) why do housekeeper gene mutations cause cancer in specific sites; (v) can cancer cells have too much genomic instability; and (vi) whether all cancers develop owing to driver mutations with big effects, or are there “mini-drivers” of tumorigenesis? There will be continual cross-talk between the experimental and modelling work. The results of the project will enhance our basic understanding of tumorigenesis and suggest strategies for anticancer therapy.

Project End Date: **8/31/2019**

European Research Council
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Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
338904	**PHAGORISC**	**LS3 - Cellular and Developmental Biology**

Principal Investigator:	**Dr. Pascal Genschik** pascal.genschik@ibmp-cnrs.unistra.fr
Host Institution:	Centre National De La Recherche Scientifique, FR

Connecting RNA and protein degradation machineries

RNA silencing has become a major focus of molecular research around the world with important implications in biotechnology and medicine. RNA silencing involves processing of dsRNA by the enzyme Dicer, into small RNAs, 21-to-25 nucleotides in length. One of the two RNA strands is then incorporated into a protein complex called RISC (RNA induced silencing complex) that invariably contains a member of the highly conserved ARGONAUTE protein family. The incorporated small RNA then guides the complex to silence partly or fully complementary RNA. RNA silencing is important for the regulation of development in animals and plants, but plays also an antiviral role in plants and invertebrates (including worms and flies). In light of the apparent importance of RNA silencing in most eukaryotes, it is surprising that molecular mechanisms regulating ARGONAUTE proteins (and RISC) turnover have received so little attention. For instance, it is unknown whether ARGONAUTE proteins remain very stable when incorporated in RISC and how many times they can operate on different mRNA targets while loaded with the same siRNA/miRNA. More importantly, intriguing questions concern ARGONAUTE protein turnover under stress conditions. For instance, it is unknown whether ARGONAUTE proteins (and RISC) are degraded during stress, a situation where siRNA/miRNA populations quickly change and RISC re-programming is expected. My research project aims to answer to these questions. The content of this program is multidisciplinary combining molecular and cell biology, genetics, biochemistry and structural biology. Based on its approaches and already pioneering data recently obtained in my lab, I believe that this ERC research project has the potential to go substantially beyond the current state of the art in this field by providing deep insights into the regulatory mechanisms that control and mediate ARGONAUTE proteins turnover, in particular during stress responses.

Project End Date: **2/28/2019**

European Research Council
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Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647186	**MolCellTissMech**	**LS3 - Cellular and Developmental Biology**

Principal Investigator:	**Dr. Guillaume Charras** g.charras@ucl.ac.uk
Host Institution:	University College London, UK

Molecular and cellular determinants of cell monolayer mechanics

Epithelial monolayers are amongst the simplest tissues in the body, yet they play fundamental roles in adult organisms where they separate the internal environment from the external environment and in development when the intrinsic forces generated by cells within the monolayer drive tissue morphogenesis. The mechanics of these simple tissues is dictated by the cytoskeletal and adhesive proteins that interface the constituent cells into a tissue-scale mechanical syncitium. Mutations in these proteins lead to diseases with fragilised epithelia. However, a quantitative understanding of how subcellular structures govern monolayer mechanics, how cells sense their mechanical environment and what mechanical forces participate in tissue morphogenesis is lacking.To overcome these challenges, my lab devised a new technique to study the mechanics of load-bearing monolayers under well-controlled mechanical conditions while allowing imaging at subcellular, cellular and tissue resolutions. Using this instrument, my proposal aims to understand the molecular determinants of monolayer mechanics as well as the cellular behaviours that drive tissue morphogenesis. I will focus on four objectives: 1) discover the molecular determinants of monolayer mechanics, 2) characterise monolayer mechanics, 3) dissect how tension is sensed by monolayers, and 4) investigate the biophysics of individual cell behaviours participating in tissue morphogenesis.Together these studies will enable us to understand how monolayer mechanics is affected by changes in single cell behaviour, subcellular organisation, and molecular turnover. This multi-scale characterisation of monolayer mechanics will set the stage for new theoretical descriptions of living tissues involving both molecular-scale phenomena (cytoskeletal turnover, contractility, and protein unfolding) operating on short time-scales and rearrangements due to cell-scale phenomena (cell intercalation, cell division) acting on longer times.

Project End Date: **8/31/2020**

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Project ID:	Project Acronym:	Evaluation Panel:
616499	**PROTEODYNAMICS**	**LS3 - Cellular and Developmental Biology**

Principal Investigator:	**Dr. Thorsten Hoppe** thorsten.hoppe@uni-koeln.de
Host Institution:	Universitaet Zu Koeln, DE

Global Dynamics of Proteolytic Quality Control Networks in Stress Response and Aging

Accumulation of damaged and aggregated proteins is associated with age-related neurodegeneration in Alzheimer's and Parkinson's patients. The ubiquitin/proteasome system (UPS) is a major proteolytic route functioning in a cellular network that maintains the proteome during stress and aging. Degradation of damaged proteins is mediated by the 26S proteasome upon attachment of ubiquitin (Ub) proteins (ubiquitylation). Another proteolytic system supporting protein homeostasis (proteostasis) is the autophagy-lysosome pathway that degrades proteins inside activated autophagosomes. An age-related impairment of either of these systems causes enhanced protein aggregation and affects lifespan, suggesting functional overlap and cooperation between UPS and autophagy in stress and aging. Despite the progress made in searching for key substrates that are destined for degradation, the major challenge in the field is to understand how these proteolytic systems are mechanistically coordinated to overcome age-related proteotoxicity. The ultimate goal of the proposed research is to assemble a global picture of stress-induced proteolytic networks critical for aging of multicellular organisms. The tissue-specific regulation of protein degradation pathways will be addressed using the powerful genetic model of Caenorhabditis elegans. The suggested project will systematically analyze: inducible protein degradation pathways (Aim 1), the regulation of UPS and autophagy by microRNAs (miRNAs) (Aim 2), and tissue-specific adaptation of proteolytic networks (Aim 3) in stress response and aging. To this end, comprehensive transcriptome analysis, large-scale genetic screenings combined with deep-sequencing technology, and candidate approaches based on in vivo imaging and degradation assays will be performed. Together, we propose a highly complementary research plan that aims to break new grounds in the understanding of proteolytic networks in aging and disease.

Project End Date: **5/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
671083	**ACTOMYOSIN RING**	**LS3 - Cellular and Developmental Biology**

Principal Investigator: **Dr. MOHAN BALASUBRAMANIAN**
M.K.BALASUBRAMANIAN@WARWICK.AC.UK

Host Institution: The University Of Warwick, UK

Understanding Cytokinetic Actomyosin Ring Assembly Through Genetic Code Expansion, Click Chemistry, DNA origami, and in vitro Reconstitution

The mechanism of cell division is conserved in many eukaryotes, from yeast to man. A contractile ring of filamentous actin and myosin II motors generates the force to bisect a mother cell into two daughters. The actomyosin ring is among the most complex cellular machines, comprising over 150 proteins. Understanding how these proteins organize themselves into a functional ring with appropriate contractile properties remains one of the great challenges in cell biology. Efforts to generate a comprehensive understanding of the mechanism of actomyosin ring assembly have been hampered by the lack of structural information on the arrangement of actin, myosin II, and actin modulators in the ring in its native state. Fundamental questions such as how actin filaments are assembled and organized into a ring remain actively debated. This project will investigate key issues pertaining to cytokinesis in the fission yeast Schizosaccharomyces pombe, which divides employing an actomyosin based contractile ring, using the methods of genetics, biochemistry, cellular imaging, DNA origami, genetic code expansion, and click chemistry. Specifically, we will (1) attempt to visualize actin filament assembly in live cells expressing fluorescent actin generated through synthetic biological approaches, including genetic code expansion and click chemistry (2) decipher actin filament polarity in the actomyosin ring using total internal reflection fluorescence microscopy of labelled dimeric and multimeric myosins V and VI generated through DNA origami approaches (3) address when, where, and how actin filaments for cytokinesis are assembled and organized into a ring and (4) reconstitute actin filament and functional actomyosin ring assembly in permeabilized spheroplasts and in supported bilayers. Success in the project will provide major insight into the mechanism of actomyosin ring assembly and illuminate principles behind cytoskeletal self-organization.

Project End Date: **10/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
683258	**CentrioleBirthDeath**	**LS3 - Cellular and Developmental Biology**

Principal Investigator:	**Dr. Monica Bettencourt-Dias** mdias@igc.gulbenkian.pt
Host Institution:	Fundacao Calouste Gulbenkian, PT

Mechanism of centriole inheritance and maintenance

Centrioles assemble centrosomes and cilia/flagella, critical structures for cell division, polarity, motility and signalling, which are often deregulated in human disease. Centriole inheritance, in particular the preservation of their copy number and position in the cell is critical in many eukaryotes. I propose to investigate, in an integrative and quantitative way, how centrioles are formed in the right numbers at the right time and place, and how they are maintained to ensure their function and inheritance. We first ask how centrioles guide their own assembly position and centriole copy number. Our recent work highlighted several properties of the system, including positive and negative feedbacks and spatial cues. We explore critical hypotheses through a combination of biochemistry, quantitative live cell microscopy and computational modelling. We then ask how the centrosome and the cell cycle are both coordinated. We recently identified the triggering event in centriole biogenesis and how its regulation is akin to cell cycle control of DNA replication and centromere assembly. We will explore new hypotheses to understand how assembly time is coupled to the cell cycle. Lastly, we ask how centriole maintenance is regulated. By studying centriole disappearance in the female germline we uncovered that centrioles need to be actively maintained by their surrounding matrix. We propose to investigate how that matrix provides stability to the centrioles, whether this is differently regulated in different cell types and the possible consequences of its misregulation for the organism (infertility and ciliopathy-like symptoms). We will take advantage of several experimental systems (in silico, ex-vivo, flies and human cells), tailoring the assay to the question and allowing for comparisons across experimental systems to provide a deeper understanding of the process and its regulation.

Project End Date: **12/31/2021**

European Research Council
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Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679140	**CentSatRegFunc**	**LS3 - Cellular and Developmental Biology**

Principal Investigator: **Dr. Elif Nur Firat-Karalar**
ekaralar@ku.edu.tr

Host Institution: Koc University, TR

Dissecting the function and regulation of centriolar satellites: key regulators of the centrosome/cilium complex

Centrosomes are the main microtubule-organizing centers of animal cells. They influence the morphology of the microtubule cytoskeleton and function as the base of primary cilium, a nexus for important signaling pathways. Structural and functional defects in centrosome/cilium complex cause a variety of human diseases including cancer, ciliopathies and microcephaly. To understand the relationship between human diseases and centrosome/cilium abnormalities, it is essential to elucidate the biogenesis of centrosome/cilium complex and the control mechanisms that regulate their structure and function. To tackle these fundamental problems, we will dissect the function and regulation of centriolar satellites, the array of granules that localize around the centrosome/cilium complex in mammalian cells. Only recently interest in the satellites has grown because mutations affecting satellite components were shown to cause ciliopathies, microcephaly and schizophrenia.
Remarkably, many centrosome/cilium proteins localize to these structures and we lack understanding of when, why and how these proteins localize to satellites. The central hypothesis of this grant is that satellites ensure proper centrosome/cilium complex structure and function by acting as transit paths for modification, assembly, storage, stability and trafficking of centrosome/cilium proteins. In Aim 1, we will identify the nature of regulatory and molecular relationship between satellites and the centrosome/cilium complex. In Aim 2, we will elucidate the role of satellites in proteostasis of centrosome/cilium proteins. In Aim 3, we will investigate the functional significance of satellite-localization of centrosome/cilium proteins during processes that go awry in human disease. Using a multidisciplinary approach, the proposed research will expand our knowledge of the spatiotemporal regulation of the centrosome/cilium complex and provide new insights into pathogenesis of ciliopathies and primary microcephaly.

Project End Date: **5/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
340260	**PalmERa**	**LS3 - Cellular and Developmental Biology**

Principal Investigator: **Dr. Gisou van der Goot**
gisou.vandergoot@epfl.ch

Host Institution: Ecole Polytechnique Federale De Lausanne, CH

Roles of Palmitoylation networks in ER architecture and functions

The endoplasmic reticulum (ER) is the largest intracellular organelle of mammalian cells. It fulfills major functions such as folding and quality control of membrane proteins, lipid biosynthesis, calcium storage, and modulation of apoptosis. This diversity of functions is accompanied by a complex 3D architecture, the maintenance of which is essential, since alterations lead to disease. How this architecture is generated, how proteins localize to specific subdomains and how structure and functions are coordinated is poorly understood. Our unpublished observations show that many ER membrane proteins, involved in key functions or in organelle shaping, are lipid modified, by the same palmitoyltransferases, and in a switch-like manner. We hypothesize that palmitoyltransferases act as regulators of the mammalian ER, controlling the function of a network of key proteins through reversible acylation, analogous to the control of signaling networks by phosphorylation. To establish the role of palmitoylation in coordinating ER structure/function, we propose a program integrating biochemical, functional and modeling approaches. We will determine the ER palmitome and investigate the impact of acylation on the function of individual proteins, on ER architecture and on the ER lipidome. We will analyze the interplay between and ubiquitination in controlling ER functions. Since we found that the DHHC6 palmitoytransferase is essential in mice and palmitoylates key ER proteins, we will study this enzyme in depth in terms of structure, function, target specific and regulation. Finally, we will combine the information emanating from these studies into a mathematical model of the ER palmitoylation network.

Project End Date: **1/31/2019**

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**
beryb@psb.vib-ugent.be

Host Institution: Vib, BE

Understanding the molecular mechanisms controlling the orientation of plant cell divisions

Due to the presence of a rigid cell wall, plant cells are fixed within their tissue context and cannot move relative to each other during development. Plants thus need to rely on directed cell elongation and cell division to generate a full three-dimensional (3D) structure. Controlling cell division orientations relative to the tissue axis is therefore the fundamental basis for 3D growth. In the root, plant cells are organised in cell files and undergo two main types of cell division to allow directional growth: anticlinal cell divisions (AD, adding cells within a cell file) and periclinal cell divisions (PD, creating new cell files, organs and tissues). Understanding the mechanisms that control cell division orientation is a key question in developmental biology and the main focus of this application.

PDs are challenging to study as they only occur sporadically and typically in the most inner tissues of the root. I recently constructed a powerful system to induce strong, fast and homogenous PDs in any tissue type. I therefore now have the perfect tool at hands to tackle the fundamental question of how plants control the orientation of its cell divisions by: 1. Understanding the cellular events that occur prior to PD using a set of complementary techniques.

2. Identifying novel downstream components that translate the known genetic triggers for PD into changes in cell division orientation by performing an unbiased genetic screen.

3. Determining the developmental specificity and convergence of the known genetic pathways capable of inducing PD through studying their transcriptional targets in an ectopic tissue context.

4. Establishing a cell-culture based system for genetic and high throughput chemical perturbation studies of cell division orientation. I thus aim to perform a global and comprehensive study of cell division orientation, a process crucial for 3D growth in general and vascular development in specific.

Project End Date: **1/31/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
309966	**APOQUANT**	**LS3 - Cellular and Developmental Biology**

Principal Investigator: **Dr. Ana J. Garcia-Saez**
ana.garcia@uni-tuebingen.de

Host Institution: Eberhard Karls Universitaet Tuebingen, DE

The quantitative Bcl-2 interactome in apoptosis: decoding how cancer cells escape death

The proteins of the Bcl-2 family function as key regulators of apoptosis by controlling the permeabilization of the mitochondrial outer membrane. They form an intricate, fine-tuned interaction network which is altered in cancer cells to avoid cell death. Currently, we do not understand how signaling within this network, which combines events in cytosol and membranes, is orchestrated to decide the cell fate. The main goal of this proposal is to unravel how apoptosis signaling is integrated by the Bcl-2 network by determining the quantitative Bcl-2 interactome and building with it a mathematical model that identifies which interactions determine the overall outcome. To this aim, we have established a reconstituted system for the quantification of the interactions between Bcl-2 proteins not only in solution but also in membranes at the single molecule level by fluorescence correlation spectroscopy (FCS).

(1) This project aims to quantify the relative affinities between an reconstituted Bcl-2 network by FCS.

(2) This will be combined with quantitative studies in living cells, which include the signaling pathway in its entirety. To this aim, we will develop new FCS methods for mitochondria.

(3) The structural and dynamic aspects of the Bcl-2 network will be studied by super resolution and live cell microscopy.

(4) The acquired knowledge will be used to build a mathematical model that uncovers how the multiple interactions within the Bcl-2 network are integrated and identifies critical steps in apoptosis regulation.

These studies are expected to broaden the general knowledge about the design principles of cellular signaling as well as how cancer cells alter the Bcl-2 network to escape cell death. This systems analysis will allow us to predict which perturbations in the Bcl-2 network of cancer cells can switch signaling towards cell death. Ultimately it could be translated into clinical applications for anticancer therapy.

Project End Date: **3/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
335672	**MINICELL**	**LS3 - Cellular and Developmental Biology**

Principal Investigator:	**Dr. Gijsje Koenderink** gkoenderink@amolf.nl
Host Institution:	Stichting Voor Fundamenteel Onderzoek Der Materie - Fom, NL

Building minimal cells to understand active cell shape control

Understanding how cells control their shape is an important scientific goal, since cells in our body constantly need to undergo shape changes to perform vital tasks such as growth and division. Conversely, abnormal cell shape changes contribute to life-threatening diseases such as cancer and developmental disorders. I propose to resolve the physical basis of active cell shape control by studying minimal cells built from purified cellular components. The main determinant of cell shape in animals is the actin cortex beneath the cell membrane, which contains molecular motors that actively generate forces. There is growing evidence that cells tightly balance these active forces with passive forces arising from cortex-membrane adhesion and elasticity. However, it is unclear how these forces are generated and controlled on the molecular level given the enormous complexity of cells. To circumvent this complexity, we will reconstitute cell-free actin networks and couple them to model biomembranes with the essential cellular linker protein septin. Using various advanced microscopy techniques, we will study (1) how active cortical networks and lipid bilayers influence each other's spatial organization; (2) how active cortical networks control membrane shape; and (3) how spatial gradients in cortex contractility can cause cell shape polarization. My long-term ambition is to bridge the gap between the physical properties of cell-free model systems and biological functions in living cells. Thanks to recent breakthroughs in our understanding of the biophysical properties of contractile actin networks, we can now build more relevant cell-free model systems that can mimic active cell shape changes. To test the biological relevance of our findings, we will confront our results with live cell observations in fly embryos, together with a developmental biology group. Ultimately, the model cells developed here will enable a wide range of further studies of cellular (mal)functions.

Project End Date: **11/30/2018**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
340227	**CENFOR**	**LS3 - Cellular and Developmental Biology**

Principal Investigator:	**Dr. Pierre Gönczy** pierre.gonczy@epfl.ch
Host Institution:	Ecole Polytechnique Federale De Lausanne, CH

Dissecting the mechanisms governing centriole formation

Centrioles are critical for the formation of cilia, flagella and centrosomes, as well as for human health. The mechanisms governing centriole formation constitute a long-standing question in cell biology. We will pursue an innovative multidisciplinary research program to gain further insight into these mechanisms, using human cells, C. elegans and Trichonympha as model systems. This program is expected to also have a major impact by contributing a novel cell free assay to the field, thus paving the way towards making synthetic centrioles. Six specific aims will be pursued:

1) Deciphering HsSAS-6/STIL distribution and dynamics. We will use super-resolution microscopy, molecular counting, photoconversion and FCS to further characterize these two key components required for centriole formation in human cells.

2) The SAS-6 ring model as a tool to redirect centriole organization. Utilizing predictions from the SAS-6 ring model, we will assay the consequences for centrioles and cilia of altering the diameter and symmetry of the structure.

3) Determining the architecture of C. elegans centrioles. We will conduct molecular counting and cryo-ET of purified C. elegans centrioles to determine if they contain a spiral or a cartwheel, as well as identify SAS-6-interacting components.

4) Comprehensive 3D map and proteomics of Trichonympha centriole. We will obtain a ~35 Å 3D map of the complete T. agilis centriole, perform proteomic analysis to identify its constituents and test their function using RNAi.

5) Regulation of cartwheel height and centriole length. We will explore whether cartwheel height is set by SAS-6 proteins and perform screens in human cells to identify novel components regulating cartwheel height and centriole length.

6) Novel cell free assay for cartwheel assembly and centriole formation. Using SAS-6 proteins on a lipid monolayer as starting point, we will develop and utilize a cell-free assay to reconstitute cartwheel assembly and centriole format

Project End Date: **3/31/2019**

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** didier.stainier@mpi-bn.mpg.de
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: **9/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
639478	**AuxinER**	**LS3 - Cellular and Developmental Biology**

Principal Investigator:	**Dr. Jürgen Kleine-Vehn** juergen.kleine-vehn@boku.ac.at
Host Institution:	Universitaet Fuer Bodenkultur Wien, AT

Mechanisms of Auxin-dependent Signaling in the Endoplasmic Reticulum

The phytohormone auxin has profound importance for plant development. The extracellular AUXIN BINDING PROTEIN1 (ABP1) and the nuclear AUXIN F-BOX PROTEINs (TIR1/AFBs) auxin receptors perceive fast, non-genomic and slow, genomic auxin responses, respectively. Despite the fact that ABP1 mainly localizes to the endoplasmic reticulum (ER), until now it has been proposed to be active only in the extracellular matrix (reviewed in Sauer and Kleine-Vehn, 2011). Just recently, ABP1 function was also linked to genomic responses, modulating TIR1/AFB-dependent processes (Tromas et al., 2013). Intriguingly, the genomic effect of ABP1 appears to be at least partially independent of the endogenous auxin indole 3-acetic acid (IAA) (Paque et al., 2014). In this proposal my main research objective is to unravel the importance of the ER for genomic auxin responses. The PIN-LIKES (PILS) putative carriers for auxinic compounds also localize to the ER and determine the cellular sensitivity to auxin. PILS5 gain-of-function reduces canonical auxin signaling (Barbez et al., 2012) and phenocopies abp1 knock down lines (Barbez et al., 2012, Paque et al., 2014). Accordingly, a PILS-dependent substrate could be a negative regulator of ABP1 function in the ER. Based on our unpublished data, an IAA metabolite could play a role in ABP1-dependent processes in the ER, possibly providing feedback on the canonical nuclear IAA-signaling. I hypothesize that the genomic auxin response may be an integration of auxin- and auxin-metabolite-dependent nuclear and ER localized signaling, respectively. This proposed project aims to characterize a novel auxin-signaling paradigm in plants. We will employ state of the art interdisciplinary (biochemical, biophysical, computational modeling, molecular, and genetic) methods to assess the projected research. The identification of the proposed auxin conjugate-dependent signal could have far reaching plant developmental and biotechnological importance.

Project End Date: **5/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681443	**CODECHECK**	**LS3 - Cellular and Developmental Biology**

Principal Investigator: **Dr. Helder Maiato**
maiato@i3s.up.pt

Host Institution: Instituto De Biologia Molecular E Celular-Ibmc, PT

CRACKING THE CODE BEHIND MITOTIC FIDELITY: the roles of tubulin post-translational modifications and a chromosome separation checkpoint

During the human lifetime 10000 trillion cell divisions take place to ensure tissue homeostasis and several vital functions in the organism. Mitosis is the process that ensures that dividing cells preserve the chromosome number of their progenitors, while deviation from this, a condition known as aneuploidy, represents the most common feature in human cancers. Here we will test two original concepts with strong implications for chromosome segregation fidelity. The first concept is based on the "tubulin code" hypothesis, which predicts that molecular motors "read" tubulin post-translational modifications on spindle microtubules. Our proof-of-concept experiments demonstrate that tubulin detyrosination works as a navigation system that guides chromosomes towards the cell equator. Thus, in addition to regulating the motors required for chromosome motion, the cell might regulate the tracks in which they move on. We will combine proteomic, super-resolution and live-cell microscopy, with in vitro reconstitutions, to perform a comprehensive survey of the tubulin code and the respective implications for motors involved in chromosome motion, mitotic spindle assembly and correction of kinetochore-microtubule attachments. The second concept is centered on the recently uncovered chromosome separation checkpoint mediated by a midzone-associated Aurora B gradient, which delays nuclear envelope reformation in response to incompletely separated chromosomes. We aim to identify Aurora B targets involved in the spatiotemporal regulation of the anaphase-telophase transition. We will establish powerful live-cell microscopy assays and a novel mammalian model system to dissect how this checkpoint allows the detection and correction of lagging/long chromosomes and DNA bridges that would otherwise contribute to genomic instability. Overall, this work will establish a paradigm shift in our understanding of how spatial information is conveyed to faithfully segregate chromosomes during mitosis.

Project End Date: **6/30/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
340784	**TiMORPH**	**LS3 - Cellular and Developmental Biology**

Principal Investigator:	**Dr. yohanns bellaiche** yohanns.bellaiche@curie.Fr
Host Institution:	Institut Curie, FR

Morphogenesis of proliferative epithelial tissue

Shape is a conspicuous and fundamental property of living multicellular organisms. Questions related to embryo shape or morphogenesis have naturally haunted developmental biologists for decades. Recent advances have highlighted that the understanding of the morphogenesis of proliferative tissue will require (i) the dissection of how subcellular cytoskeleton dynamics controls cellular processes such as cell division orientation and adherens junction formation; (ii) the study of the interplay between biochemical and mechanical processes regulating collective cell behaviours and thus tissue movements. In addition, whole tissue imaging has revealed that distinct local cell dynamics account for tissue shape regulation. Yet, it remains poorly explored how gene expression patterns specify distinct local cell dynamics within a proliferative epithelium. To decipher the mechanisms of Drosophila epithelial tissue morphogenesis, we aim to apply a series of complementary, state of the art methods (quantitative measurement of cell and tissue morphogenesis, mechanical stress inference, opto-genetics, computer simulation and advanced statistics) in order to:

1. Dissect the molecular and mechanical mechanisms regulating cytoskeleton and cell dynamics by focusing on mitotic spindle orientation and de novo adherens junction formation during cell division and cell rearrangement.
2. Link cytoskeleton organization, cell dynamics and mechanics to the regulation of large-scale tissue deformation.
3. Introduce a ‘morphogenomics’ approach to understand how combinatory gene expression patterns can account for distinct cell dynamics observed in the different regions of a tissue.

By exploring the mechanisms of tissue morphogenesis at different time-scales and length-scales, as well as by focusing both on its genetic and mechanical regulation, these complementary aims should advance the understanding of morphogenesis in animals.

Project End Date: **2/28/2019**

European Research Council
Executive Agency
Established by the European Commission

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

Principal Investigator:	**Dr. Kevin Myant** kevin.myant@igmm.ed.ac.uk
Host Institution:	The University Of Edinburgh, UK

Defining novel mechanisms critical for colorectal tumourigenesis

Cancer genome sequencing has led to a paradigm shift in our understanding of oncogenesis. It has identified thousands of genetic alterations that segregate into two groups, a small number of frequently mutated genes and a much larger number of infrequently mutated genes. The causative role of frequently mutated genes is often clear and are the focus of concerted therapeutic development efforts. The role of those infrequently mutated is often unclear and can be difficult to separate from 'mutational noise'. Determining the relevance of low frequency mutations is important for providing a full understanding of processes driving tumourigenesis and if functionally relevant may have broader implications on the applicability of targeted therapies. This project aims to begin addressing this by defining the function of all genes mutated in colorectal cancer (CRC) in the earliest stages of tumour formation. I have performed a whole genome screen in a 3D organoid CRC initiation model identifying several potentially important mediators of this process. Crucially, some of these genes are mutated in CRC at low frequency but not described as cancer driver genes. Thus, I hypothesize that rather than 'mutational noise' infrequently mutated genes contribute to CRC initiation. I will test this by addressing two aims: 1) Determine the role of genes mutated in CRC during tumour initiation

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

Project End Date: **4/30/2022**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
337479	**ProlongBileSignaling**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Konstantijn (Stan) Van de Graaf** k.f.vandegraaf@amc.uva.nl
Host Institution:	Academisch Medisch Centrum Bij De Universiteit Van Amsterdam, NL

Improving Metabolism via Prolonged Bile Acid Signalling
targeting hepatic bile acid uptake to fight metabolic diseases

Bile acids play a pivotal role in energy supply as they facilitate the solubilization and absorption of fat in the intestine. Furthermore, bile acids are recently identified as important signalling molecules regulating glucose metabolism, inflammation and energy expenditure. Targeting bile acid signalling is, therefore, appealing to treat metabolic diseases such as diabetes and atherosclerosis. These disorders are potentially affecting >1 billion individuals worldwide and current options to treat them remain insufficient. I postulate that the hepatic bile acid uptake transporter NTCP (gene name SLC10A1) provides an excellent novel target to improve human health as it determines the duration of bile acid signalling by controlling how fast bile acids are removed from serum after a meal. In this proposal I will elucidate the contribution of bile acid dynamics to energy homeostasis and metabolism and identify the molecular mechanisms that regulate NTCP. My aim is to generate novel strategies to reduce hepatic bile acid uptake to prolong bile-acid signalling and increase energy expenditure, improve glucose handling and reduce atherosclerosis. My key objectives are:

1. to determine the consequence of NTCP modulation on systemic bile acid dynamics, glucose and energy metabolism in animal models. To this end, I will perform careful metabolic analysis of a unique Slc10a1 knockout model in combination with diet-induced and genetic models for atherosclerosis and diabetes.
2. to identify novel means to inhibit NTCP-mediated bile acid uptake. To this end, I will make use of a FRET-based bile acid sensor that I recently developed to characterize the molecular regulation of hepatic bile acid uptake and to identify FDA-approved drugs that inhibit NTCP-mediated bile acid uptake. This will establish my new research line on serum bile acid dynamics and ultimately provide new ways to treat metabolic diseases related to disturbed bile acid, lipid, glucose and energy homeostasis.

Project End Date: **11/30/2018**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
646663	**DeFiNER**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Georgios Garinis** garinis@imbb.forth.gr
Host Institution:	Foundation For Research And Technology Hellas, GR

Nucleotide Excision Repair: Decoding its Functional Role in Mammals

Genome maintenance, chromatin remodelling and transcription are tightly linked biological processes that are currently poorly understood and vastly unexplored. Nucleotide excision repair (NER) is a major DNA repair pathway that mammalian cells employ to maintain their genome intact and faithfully transmit it into their progeny. Besides cancer and aging, however, defects in NER give rise to developmental disorders whose clinical heterogeneity and varying severity can only insufficiently be explained by the DNA repair defect. Recent work reveals that NER factors play a role, in addition to DNA repair, in transcription and the three-dimensional organization of our genome. Indeed, NER factors are now known to function in the regulation of gene expression, the transcriptional reprogramming of pluripotent stem cells and the fine-tuning of growth hormones during mammalian development. In this regard, the non-random organization of our genome, chromatin and the process of transcription itself are expected to play paramount roles in how NER factors coordinate, prioritize and execute their distinct tasks during development and disease progression. At present, however, no solid evidence exists as to how NER is functionally involved in such complex processes, what are the NER-associated protein complexes and underlying gene networks or how NER factors operate within the complex chromatin architecture. This is primarily due to our difficulties in dissecting the diverse functional contributions of NER proteins in an intact organism. Here, we propose to use a unique series of knock-in, transgenic and NER progeroid mice to decode the functional role of NER in mammals, thus paving the way for understanding how genome maintenance pathways are connected to developmental defects and disease mechanisms in vivo.

Project End Date: **12/31/2020**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
334946	**RIBOCANCER**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Kim De Keersmaecker** kim.dekeersmaecker@kuleuven.be
Host Institution:	Katholieke Universiteit Leuven, BE

Ribosome defects in cancer

Cancer cells are defective in vital cell functions such as cell cycle control and response to growth signals. We found that cancer cells acquire defects in yet another vital function: translation of mRNA into proteins. We saw that 9.8% of children with T-cell leukemia (T-ALL) harbor acquired mutations in the ribosome, the cellular protein translation factory. We found mutations in RPL10, RPL5 and RPL22, 3 proteins of the large 60S ribosomal subunit. Strikingly, 6.5% of T-ALL patients had the same RPL10 R98S missense mutation. Although congenital ribosome defects were previously linked to higher cancer risk, the concept that defects in the ribosome are acquired during life and are selected for in cancer is novel. In addition, it is currently not understood by what mechanism ribosome defects are carcinogenic.

Patients with inherited ribosome defects are predisposed to all types of cancer. Therefore, other cancers than T-ALL may show acquired defects in the ribosome and I want to explore the prevalence of acquired ribosome defects in various cancer types. Second, I want to explore by which mechanism ribosome mutations promote cancer. Initially, I will focus on the RPL10 R98S mutation, the most frequent acquired ribosome defect we found so far. We will test the effect of RPL10 R98S on cell behavior parameters such as self-renewal capacity and resistance to apoptosis. I hypothesize that altered translation of a subset of cellular mRNAs, including mRNAs coding major tumor suppressors or oncogenes, may explain the oncogenic action of RPL10 R98S. Therefore, we will identify all mRNAs with altered translation efficiency or fidelity in RPL10 R98S cells. In addition, we will test if RPL10 R98S promotes cancer by altering extra-ribosomal roles of RPL10 or by driving inactivation of the TP53 pathway. Finally, acquired ribosome defects may represent a novel target for cancer therapy and we will test if ribosome defective cancer cells are hypersensitive to translation inhibitors.

Project End Date: **12/31/2018**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
638028	**AngioGenesHD**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Rui Benedito** Rui.benedito@cnic.es
Host Institution:	Fundacion Centro Nacional De Investigaciones Cardiovasculares Carlos Iii, ES

Epistasis analysis of angiogenes with high cellular definition

Blood and lymphatic vessels have been the subject of intense investigation due to their important role in cancer development and in cardiovascular diseases. The significant advance in the methods used to modify and analyse gene function have allowed us to obtain a much better understanding of the molecular mechanisms involved in the regulation of the biology of blood vessels. However, there are two key aspects that significantly diminish our capacity to understand the function of gene networks and their intersections in vivo. One is the long time that is usually required to generate a given double mutant vertebrate tissue, and the other is the lack of single-cell genetic and phenotypic resolution. We have recently performed an in vivo comparative transcriptome analysis of highly angiogenic endothelial cells experiencing different VEGF and Notch signalling levels. These are two of the most important molecular mechanisms required for the adequate differentiation, proliferation and sprouting of endothelial cells. Using the information generated from this analysis, the overall aim of the proposed project is to characterize the vascular function of some of the previously identified genes and determine how they functionally interact with these two signalling pathways. We propose to use novel inducible genetic tools that will allow us to generate a spatially and temporally regulated fluorescent cell mosaic matrix for quantitative analysis. This will enable us to analyse with unprecedented speed and resolution the function of several different genes simultaneously, during vascular development, homeostasis or associated diseases. Understanding the genetic epistatic interactions that control the differentiation and behaviour of endothelial cells, in different contexts, and with high cellular definition, has the potential to unveil new mechanisms with high biological and therapeutic relevance.

Project End Date: **2/29/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
323099	**CardioNect**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Peter Kohl** peter.kohl@universitaets-herzzentrum.de
Host Institution:	Universitaetsklinikum Freiburg, DE

Cardiac Connective Tissue: Beat-by-Beat Relevance for Heart Function in Health and Disease

Cardiac connective tissue is regarded as passive in terms of cardiac electro-mechanics. However, recent evidence confirms that fibroblasts interact directly with cardiac muscle cells in a way that is likely to affect their beat-by-beat activity. To overcome limitations of traditional approaches to exploring these interactions in native tissue, we will build and explore murine models that express functional reporters (membrane potential, Vm; calcium concentration, [Ca2+]i) in fibroblasts, to identify how they are functionally integrated in native heart (myocyte => fibroblast effects). Next, we will express light-gated ion channels in murine fibroblast, to selectively interfere with their Vm (fibroblast => myocyte effects). Fibroblast-specific observation and interference will be conducted in normal and pathologically remodelled tissue, to characterise fibroblast relevance for heart function in health & disease. Based on these studies, we will generate 2 transgenic rabbits (fibroblast Vm reporting / interfering). Rabbit cardiac structure-function is more amenable to translational work, e.g. to study fibroblast involvement in normal origin & spread of excitation across the heart, in pathological settings such as arrhythmogenicity of post-infarct scars (a leading causes of sudden death), or as a determinant of therapeutic outcomes such as in healing of atrial ablation lines (interfering with a key interventions to treat atrial fibrillation). The final 'blue-skies' study will assess whether modulation of cardiac activity, from 'tuning' of biological pacemaker rates to 'unpinning' / termination of re-entrant excitation waves, can be achieved by targeting not myocytes, but fibroblasts. The study integrates basic-science-driven discovery research into mechanisms and dynamics of biophysical myocyte-fibroblast interactions, generation of novel transgenic models useful for a broad range of studies, and elucidation of conceptually new approaches to heart rhythm management.

Project End Date: **6/30/2019**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681493	**CD40-INN**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Esther Lutgens** E.Lutgens@amc.uva.nl
Host Institution:	Academisch Medisch Centrum Bij De Universiteit Van Amsterdam, NL

CD40 goes innate: defining and targeting CD40 signaling intermediates in the macrophage to treat atherosclerosis

Atherosclerosis, the underlying cause of the majority of cardiovascular diseases (CVD), is a lipid driven, inflammatory disease of the large arteries. Despite a 25% relative risk reduction achieved by lipid-lowering treatment, the vast majority of atherosclerosis-induced CVD risk remains unaddressed. Therefore, characterizing mediators of the inflammatory aspect of atherosclerosis is a widely recognized scientific goal with great therapeutic implications.

Co-stimulatory molecules are key players in modulating immune interactions. My laboratory has defined the co-stimulatory CD40-CD40L dyad as a major driver of atherosclerosis. Inhibition of CD40, and of its interaction with the adaptor molecule TRAF6 by genetic deficiency, antibody treatment or (nanoparticle based) small molecule inhibitor (SMI) treatment, is one of the most powerful therapies to reduce atherosclerosis in a laboratory setting. Although CD40-CD40L interactions are associated with adaptive immunity, I recently identified the macrophage as a driver of CD40-induced inflammation in atherosclerosis. We will use state-of-the-art in vitro experiments, live cell-, super resolution imaging, proteomics approaches and mutant mouse models to unravel the role of macrophage CD40 in atherosclerosis. Moreover, using structure based virtual ligand screening, I will develop lead SMIs targeting macrophage CD40-signaling, which I will deliver using macrophage-targeting nanoparticles. My goal is to define the role of macrophage CD40 in inflammation and immunity and disentangle how its activation affects atherosclerosis. I will finally test the feasibility of targeting macrophage CD40-signaling as a treatment for CVD.

These studies will define the role of CD40-signaling in the innate immune system in health and (cardiovascular) disease. As components of macrophage CD40-signaling have the potential to be amenable to pharmacological manipulation, we will establish their feasibility as novel targets for (CVD) treatment.

Project End Date: **11/30/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714472	**Mitomorphosis**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Timothy Wai** Timothy.wai@inserm.fr
Host Institution:	Centre National De La Recherche Scientifique, FR

Metabolic regulation of mitochondrial morphology

The need for mitochondria in the body is ubiquitous yet the shapes these organelles take vary widely across tissues and change rapidly in response to nutrient availability. How and why this occurs is not well understood. Therefore, we propose an interdisciplinary research program that will investigate the molecular basis and metabolic regulation of mitochondrial morphology. Mitochondrial morphology is defined by opposing events of fission and fusion, which must be tightly controlled. We discovered that accelerated mitochondrial fission impairs cardiac metabolism and causes heart failure in mice, revealing an intriguing link between mitochondrial dynamics and metabolism. Seeking to understand how metabolic signals drive mitochondrial fission, we will characterize the inner membrane protein MTP18, whose fission activity is controlled by the PI3K nutrient-signalling pathway. First, we will define the interactome of MTP18 to discover the molecular components of the inner membrane fission machinery. Second, we will investigate the how mitochondrial fission is regulated by PI3K nutrient-signalling pathway the heart, liver, and kidney. We will determine whether cardiac dysfunction, liver cancer, and kidney failure caused by over-active PI3K signalling in the mouse can be rescued by blunting the downstream activity of MTP18 and re-balancing mitochondrial dynamics. Third, we will determine the disease relevance of mitochondrial fission in humans. For the first time, mitochondrial morphology from patient-derived cells will be evaluated in automated, high content screens to identify human mutations that drive imbalanced mitochondrial dynamics in a truly unbiased manner. Genome-wide RNAi screens in these cells will reveal novel modulators of mitochondrial dynamics. Taken together, this work aims to understand the metabolic pathways that control mitochondrial morphology and to develop a new technology to identify yet unknown modulators of mitochondrial dynamics.

Project End Date: **3/31/2022**

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** dieter.saur@tum.de
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: **1/31/2021**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
695190	**MANNA**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Nektarios Tavernarakis** tavernarakis@imbb.forth.gr
Host Institution:	Foundation For Research And Technology Hellas, GR

MacroAutophagy and Necrotic Neurodegeneration in Ageing

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

Project End Date: **12/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
669771	**AUROMYC**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Martin Eilers** martin.eilers@biozentrum.uni-wuerzburg.de
Host Institution:	Julius-Maximilians Universitaet Wuerzburg, DE

N-Myc and Aurora A: From Protein Stability to Chromosome TopologyN-Myc and Aurora A: From Protein Stability to Chromosome TopologyMyc and Aurora A: From Protein Stability to Chromosome Topology

There is an intense interest in the function of human Myc proteins that stems from their pervasive role in the genesis of human tumors. A large body of evidence has established that expression levels of one of three closely related Myc proteins are enhanced in the majority of all human tumors and that multiple tumor entities depend on elevated Myc function, arguing that targeting Myc will have significant therapeutic efficacy. This hope awaits clinical confirmation, since the strategies that are currently under investigation to target Myc function or expression have yet to enter the clinic. Myc proteins are global regulators of transcription, but their mechanism of action is poorly understood. Myc proteins are highly unstable in normal cells and rapidly turned over by the ubiquitin/proteasome system. In contrast, they are stabilized in tumor cells. Work by us and by others has shown that stabilization of Myc is required for tumorigenesis and has identified strategies to destabilize Myc for tumor therapy. This work has also led to the surprising observation that the N-Myc protein, which drives neuroendocrine tumorigenesis, is stabilized by association with the Aurora-A kinase and that clinically available Aurora-A inhibitors can dissociate the complex and destabilize N-Myc. Aurora-A has not previously been implicated in transcription, prompting us to use protein crystallography, proteomics and shRNA screening to understand its interaction with N-Myc. We have now identified a novel protein complex of N-Myc and Aurora-A that provides an unexpected and potentially groundbreaking insight into Myc function. We have also solved the crystal structure of the N-Myc/Aurora-A complex. Collectively, both findings open new strategies to target Myc function for tumor therapy.

Project End Date: **7/31/2020**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
341116	**PressBirth**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Kai Kaila** kai.kaila@helsinki.fi
Host Institution:	Helsingin Yliopisto, FI

Arginine vasopressin and ion transporters in the modulation of brain excitability during birth and birth asphyxia seizures

A transient period of asphyxia in the newborn is an obligatory part of normal parturition. A more prolonged disturbance in cerebral blood supply is a major cause of neonatal seizures. Current therapies of birth asphyxia seizures are ineffective and the underlying mechanisms are unknown.

Our recent landmark work on a rat model of birth asphyxia showed that asphyxia is followed by brain alkalosis, which triggers seizures. The brain-confined alkalosis is generated by activation of Na/H exchange in the blood-brain barrier (BBB). Both alkalosis and the consequent seizures can be suppressed by graded restoration of the high CO2 level after asphyxia and with blockers of Na/H exchange.

Our pilot data indicate that arginine vasopressin (AVP) triggers the post-asphyxia seizures by activating the BBB-located luminal V1a receptor-coupled Na/H exchanger. Akin to human infants, a very high level of plasma copeptin (a part of pro-AVP) is seen following asphyxia but, notably, the copeptin levels remain low with graded restoration of normocapnia. Moreover, intravenous AVP V1a receptor antagonists, acting on the BBB, block the generation of seizures. In striking contrast, AVP suppresses network excitability when acting on V1aRs in the neonate hippocampus.

Thus, I hypothesize that AVP acts on the BBB to promote neonatal seizures, and that this effect is paralleled by a central anticonvulsant action. Next to nothing is known about AVP actions on ionic regulation in the brain. Our pilot data indicate that AVP inhibits the Na-K-2Cl cotransporter NKCC1 and activates the K-Cl cotransporter KCC2 in a manner consistent with reduction of excitability.

My laboratory has an internationally leading role in work on neuronal pH and Cl- regulation and on functions of the immature brain. Understanding the mechanisms of AVP actions during normal birth and birth asphyxia will provide novel insights on the control of the excitability of the newborn brain. This work has a high translational impact.

Project End Date: **1/31/2019**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
669220	**OxygenSensing**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Jose Lopez-Barneo** lbarneo@us.es
Host Institution:	Universidad De Sevilla, ES

Molecular mechanisms of acute oxygen sensing.

Oxygen (O2) is essential for life on Earth. This proposal deals with the study of the molecular mechanisms underlying acute O2 sensing by cells, a long-standing issue that is yet to be elucidated. In recent years, the discovery of hypoxia inducible transcription factors and their regulation by the O2-dependent hydroxylases has provided a solid framework for understanding genetic responses to sustained (chronic) hypoxia. However the mechanisms of acute O2 sensing, necessary for the activation of rapid, life-saving, compensatory respiratory and cardiovascular reflexes (e.g. hyperventilation and sympathetic activation), are unknown. While the primary goal of the project is to characterize the molecular mechanisms underlying acute O2 sensing by arterial chemoreceptors (carotid body –CB- and adrenal medulla –AM-), we will also extend our study to other organs (e.g. pulmonary and systemic arteries) of the homeostatic acute O2-sensing system. We will investigate the role of mitochondria, in particular complex I (MCI), in acute O2 sensing. Previous data from our group demonstrated that rotenone, a MCI blocker, selectively occludes responsiveness to hypoxia in CB cells. In addition, our unpublished data indicate that sensitivity to hypoxia (but not to other stimuli) is lost in mice with genetic disruption of MCI genes in CB and AM cells. We have shown that the adult CB is a plastic organ that contains a population of multipotent neural stem cells. Hence, another objective of the project is to study the role of these stem cells in CB modulation (over- or infra-activation), which may participate in the pathogenesis of diseases. In the past, our group has made seminal contributions to unveiling the cellular bases of arterial chemoreception. The discovery of stem cells in the CB and the generation of new genetically modified mouse models, put us in a leading position to elucidate the molecular bases of acute O2 sensing and their biomedical implications.

Project End Date: **10/31/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715895	**CAVEHEART**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Mathilda Mommersteeg** mathilda.mommersteeg@dpag.ox.ac.uk
Host Institution:	The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Heart regeneration in the Mexican cavefish: The difference between healing and scarring

Whereas the human heart cannot regenerate cardiac muscle after myocardial infarction, certain fish efficiently repair their hearts. Astyanax mexicanus, a close relative of the zebrafish, is a single fish species comprising cave-dwelling and surface river populations. Remarkably, while surface fish regenerate their heart after injury, cavefish cannot and form a permanent fibrotic scar, similar to the human heart. Using transcriptomics analysis and immunohistochemistry, we have identified key differences in the scarring and inflammatory response between the surface and cavefish heart after injury. These differences include extracellular matrix (ECM) proteins, growth factors and macrophage populations present in one, but not the other population, suggesting properties unique to the surface fish scar that promote heart regeneration. The objective of the proposed project is to characterise and utilise these findings to identify therapeutic targets to heal the human heart after myocardial infarction. First, we will analyse the identified differences in scarring and immune response between the fish in detail, before testing the role of the most interesting proteins and macrophage populations during regeneration using CRISPR mutagenesis and clodronate liposomes. Next, we will link the key scarring and inflammatory differences directly to both the genome and the ability for heart regeneration using new and prior Quantitative Trait Loci analyses. This will allow to find the most fundamental molecular mechanisms directing the wound healing process towards regeneration versus scarring. Together with an in vitro and in vivo small molecule screen directed specifically at influencing scarring towards a more 'fish-like' regenerative phenotype in the cavefish and mouse heart after injury, this will provide targets for therapeutic strategies to maximise the endogenous regenerative potential of the mammalian heart, with the aim to find a cure for myocardial infarction.

Project End Date: **2/28/2022**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
678119	**SiCMetabol**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Grzegorz Sumara** grzegorz.sumara@uni-wuerzburg.de
Host Institution:	Julius-Maximilians Universitaet Wuerzburg, DE

Signaling Cascades in Metabolic Diseases

Over 380 million people suffer from diabetes worldwide, with majority of cases being attributed to type 2 diabetes (T2D). Obesity is a major risk factor predisposing to the development of this disease. T2D is characterized by peripheral insulin resistance in combination with relative insulin deficiency that results in hyperglycemia and hyperlipidemia. Liver and adipose tissue are central for regulation of glucose and lipids levels. However, during T2D the hepatic glucose uptake is reduced while rates of gluconeogenesis and lipogenesis are increased. In the adipose tissue, T2D leads to decreased glucose uptake, perturbations in secretion of adipokines and increased lipolysis. Importantly, dysfunction of the liver and the adipose tissue during T2D is caused by defective phosphorylation signaling cascades and normalization of these pathways was shown to attenuate the course of T2D. However, the specific roles of different classes of signaling molecules in these organs remain poorly characterized. We hypothesize that the cross-talk of different classes of signaling molecules determines regulation of metabolism.

Thus, we aim to identify the signaling networks regulating metabolism. The results generated in my own laboratory suggest that the Pkd family kinases are the crucial regulators of metabolic homeostasis. Specifically, Pkd1 and Pkd2 promote obesity and diabetes while Pkd3 controls liver function. Thus, we plan to characterize the molecular mechanisms controlling Pkds signaling. In parallel, we will utilize screening approaches to identify novel, non-canonical signaling modules (phosphatases and components of the ubiquitin system) regulating abundance, localization and phosphorylation of targets of Pkds and, in the long term, also other kinases implicated in T2D.

By identifying and characterizing the essential signaling networks in liver and adipose tissue the project will contribute to more targeted pharmacological strategies for the treatment of T2D.

Project End Date: **5/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
639795	**HemNichMDS**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Hind Medyouf** medyouf@gsh.uni-frankfurt.de
Host Institution:	Chemotherapeutisches Forschungsinstitut Georg-Speyer-Haus Stiftung, DE

Functional and Molecular Analyses of the Interplay between Hematopoietic and Mesenchymal Niche Cells in Human Myelodysplastic Syndromes.

Myelodysplastic syndromes (MDS) are heterogeneous clonal hematopoietic stem cell diseases mainly affecting the elderly (45/100,000 in >70 years). The prevalence of MDS is expected to rise mainly as a result of an aging population. MDS is characterized by ineffective production of mature blood cells with peripheral cytopenias and the propensity to evolve to acute myeloid leukemia. Most MDS patients rely on continuous blood transfusions resulting in significant costs to healthcare systems and, most importantly, secondary effects leading to complications and patient deaths. The only potential curative treatment for MDS is hematopoietic stem cells (HSC) transplantation, which is limited to younger patients with suitable donors (<10% of MDS patients).

Increasing evidence indicates that myeloid neoplasms can be triggered by abnormal functional properties of the bone marrow microenvironment in mice. However, it remains to be seen whether this also applies to human hematopoietic neoplasms. Our work revealed that patient-derived mesenchymal niche cells are essential to propagate human MDS HSCs in vivo, thus highlighting the crucial role of the niche in human MDS. Moreover, our data indicate that human MDS hematopoietic cells may “educate” their niche environment into a self-reinforcing one.

The goal of our proposal is to decipher the interplay between hematopoietic and mesenchymal niche cells in human MDS, and to assess innovative means by which we could target diseased cells to improve MDS patient outcomes.

We will perform a comprehensive molecular characterization of highly purified primary mesenchymal niche cells to define new prognostic/therapeutic niche factors in MDS. More importantly, we will take advantage of our unique xenograft model of MDS to translate our findings into groundbreaking novel therapeutic strategies for MDS patients, by disrupting essential niche/MDS stem cell interactions.

Project End Date: **7/31/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
337327	**MitoPexLysoNETWORK**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Nuno Raimundo** nuno.raimundo@med.uni-goettingen.de
Host Institution:	Universitaetsmedizin Goettingen - Georg-August-Universitaet Goettingen - Stiftung Oeffentlichen Rechts, DE

Mitochondria, Peroxisomes and Lysosomes - the "menage a trois" of cellular metabolism

The metabolic roles of mitochondria, peroxisomes and lysosomes are well established. Numerous genetic defects affecting the function of these organelles result in a wide spectrum of metabolic diseases. The involvement of these organelles in signalling pathways is receiving increasing attention. Furthermore, interactions between them and other cellular components have been elucidated. Evidence is now emerging that dysfunction in mitochondria, peroxisomes or lysosomes causes secondary perturbations in the other two organelles. The fundamental hypothesis presiding to this proposal is that mitochondria, peroxisomes and lysosomes form an interdependent network (MytoPexLyso), which is likely to have fundamental roles in cell biology, metabolism and metabolic diseases.

To test this hypothesis and elucidate the role of the MitoPexLyso network in physiology and disease, we will employ state-of-the-art imaging and systems biology approaches. First, we will uncover how dysfunction of each MitoPexLyso organelle affects the network. We will test if mitochondrial dysfunction can trigger lysosome biogenesis, and also systematically address how perturbations in one organelle affect the other two. Second, we will identify signalling pathways sensing perturbations on the MytoPexLyso network, and elucidate their pathologic significance, both in cell lines and in animal models of metabolic diseases. Third, we will test a novel strategy to cure mitochondrial diseases: enhanced removal of damaged mitochondria through increased lysosomal autophagic capacity. We will generate a novel mouse model with higher lysosomal capacity in the skeletal muscle, and use a mouse model of mitochondrial myopathy, to test this premise in vivo.

This proposal addresses key questions in cell biology and metabolism, and will lay the foundation for a new field of “organelle networks” which will profoundly impact our understanding of metabolism and metabolic diseases and drive future research endeavours.

Project End Date: **1/31/2019**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
692511	**PROVASC**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Christian Weber** chweber@med.lmu.de
Host Institution:	Ludwig-Maximilians-Universitaet Muenchen, DE

Cell-specific vascular protection by CXCL12/CXCR4

Cardiovascular disease including coronary heart disease remains the leading cause of death worldwide. Atherosclerosis as the underlying pathology is a lipid-driven inflammatory disease of arteries giving rise to vulnerable lesions prone to rupture and thrombotic occlusion. Lesions develop at predilection sites with disturbed flow, where endothelial damage promotes intimal retention of lipoproteins and inflammatory leukocyte recruitment. Past research has largely focused on atherogenic factors and their inhibition but not on boosting a counterbalance by protective mechanisms. We have recently found that the CXCL12/CXCR4 chemokine-receptor axis protects against atherosclerosis by controlling neutrophil homeostasis and facilitating endothelial regeneration in mice. This is supported by genome-wide association studies, identifying genetic variants near CXCL12 associated with the risk of coronary heart disease. The protective regulation of endothelial repair by microRNAs also involves CXCL12/CXCR4. However, the causal and cell-specific impact of this axis remains unclear.

To balance the ongoing expansion of genetic risk variants, PROVASC aims to discover/elucidate novel mechanisms for protective cell homeostasis and regeneration counteracting atherosclerosis in depth. To this end, we will dissect cell-specific effects of the CXCR4-CXCL12 axis using an array of mouse lines for conditional deletion and bone marrow chimeras to compare resident versus hemato-poietic cell compartments. We will validate a role of coding and non-coding genetic risk variants affecting CXCL12/CXCR4 in different cell types and humanized mouse models. By identifying relevant microRNAs targeting CXCL12/CXCR4, we will unravel a regulation of this axis by cell type-specific microRNAs. Given the ubiquitous relevance of CXCL12/CXCR4, we expect that the impact of such new mechanisms will extend to other chronic inflammatory diseases, allowing for tailored strategies of tissue protection and regeneration.

Project End Date: **9/30/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647888	**iPROTECTION**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Luis Moita** lmoita@igc.gulbenkian.pt
Host Institution:	Fundacao Calouste Gulbenkian, PT

Molecular mechanisms of induced protection against sepsis by DNA damage responses

Severe sepsis remains a poorly understood systemic inflammatory condition with high mortality rates and limited therapeutic options outside of infection control and organ support measures. Based on our recent discovery that anthracycline drugs prevent organ failure without affecting the bacterial burden in a model of severe sepsis, we propose that strategies aimed at target organ protection have extraordinary potential for the treatment of sepsis and possibly for other inflammation-driven conditions. However, the mechanisms of organ protection and disease tolerance are either unknown or poorly characterized.

The central goal of the current proposal is to identify and characterize novel cytoprotective mechanisms, with a focus on DNA damage response dependent protection activated by anthracyclines as a window into stress-induced genetic programs conferring disease tolerance. To that end, we will carry out a combination of candidate and unbiased approaches for the in vivo identification of ATM-dependent and independent mechanisms of tissue protection. We will validate the leading candidates through adenovirus-mediated delivery of constructs for overexpression (gain-of-function) or shRNA for gene silencing (loss-of-function) to the lung, based on our recent finding that rescuing this organ is essential and perhaps sufficient in anthracycline-induced protection against severe sepsis. The candidates showing the most promise will be characterized using a combination of in vitro and in vivo genetic, biochemical, cell biological and physiological methods.

The results arising from the current proposal are likely not only to inspire the design of transformative therapies for sepsis but also to open a completely new field of opportunity to molecularly understand core surveillance mechanisms of basic cellular processes with a critical role in the homeostasis of organ function and whose activation can ultimately promote quality of life during aging and increase lifespan.

Project End Date: **9/30/2020**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
695136	**Secret-Cells**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Tibor Harkany** Tibor.Harkany@meduniwien.ac.at
Host Institution:	Medizinische Universitaet Wien, AT

Cellular diversity and stress-induced cell-state switches in the mammalian hypothalamus

The hypothalamus is an essential interface among neuroendocrine, autonomic and somatomotor systems, allowing dynamic bodily adaptations to environmental cues via the orchestration of complex physiological processes. Hypothalamic nuclei exhibit unprecedented molecular, structural and functional diversity of neurons, reflecting the breadth of neuroendocrine output. To date, a significant portion of hypothalamic neurons remains unaccounted for given the lack of identity markers. For known hypothalamic neuron subtypes, their ability to undergo stimulus-dependent expressional switches challenge their neurotransmitter- and neuropeptide-based classifications. These gaps of knowledge limit conceptual advances on neuronal loci, dynamic synapse recruitment and network hierarchy for metabolic control, and the molecular origins of disease. We have established the single cell transcriptome landscape of the paraventricular nucleus including its magno- and parvocellular domains. We will use this template to reveal novel cell identities and cell-state switches upon acute stress. We describe >25 neuronal subtypes under stress-free conditions, surpassing the resolution of any prior approach. Thus, we will resolve neurotransmitter-neuropeptide relationships at the single neuron level, with a focus on corticotropin-releasing hormone (CRH), determine biophysical parameters of CRH co-release with a fast neurotransmitter, and decipher changes to afferent organization upon stress. A novel parvocellular subclass constitutively expresses secretagogin, a calcium-sensor, which is indispensable for CRH release. We will link secretagogin loss-of-function in CRH neurons to Addison's disease (chronic adrenal insufficiency associated with insulin resistance). Moreover, we propose a (pro-)hormone-like role for secretagogin released from CRH neurons into the circulation. Overall, our work program will produce new understanding on cellular diversity and organizational rules in the hypothalamus.

Project End Date: **8/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682421	**TENSION**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Marcel van Vugt** m.vugt@umcg.nl
Host Institution:	Academisch Ziekenhuis Groningen, NL

Targeting replication stress recovery pathways in oncology

Genomic instability characterizes tumors, which have no clear 'oncogenic-driver' mutation, including triple-negative breast cancers (TNBCs). These patients do not benefit from molecularly targeted treatment and urgently need better treatment options. Increasing evidence points to replication stress as the driver of genomic instability. Since replication stress compromises cell viability, cells have evolved mechanisms to mitigate this threat.

Recently, I discovered a novel cellular mechanism—mitotic Replication Stress Recovery (RSR)—that acts as an 'emergency brake' during mitosis, allowing recovery from high levels of replication stress. This machinery is critical for tumor cell survival, and therefore constitutes a promising target for anti-cancer drug development. However, it is unclear how this mitotic RSR is organized molecularly and how it can be targeted therapeutically. In this project, I aim to molecularly define and therapeutically target the Mitotic Replication Stress Recovery (RSR) machinery in triple-negative breast cancer cells. To this end, I will implement a series of complementary innovative strategies. First, I will use mass-spec-based proteomics to molecularly characterize components and wiring of the mitotic RSR machinery. Second, to identify the genetic profiles of cancer subgroups that are sensitive to inactivation of the mitotic RSR, functional genetic screens will be combined with visualization and quantification of replication stress in genomically-defined human cancer samples. Finally, my findings will be translated to the pre-clinical situation by exploring the feasibility of therapeutic inactivation of the RSR machinery in vitro and in vivo in a panel of triple-negative breast cancer models. In summary, TENSION will provide advanced insight into the composition and wiring of the mitotic RSR machinery and will reveal the potency of targeting this pathway therapeutically for TNBCs and other hard-to-treat, genomically instable cancers.

Project End Date: **7/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
336860	**ChromatinTargets**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Johannes Zuber** zuber@imp.ac.at
Host Institution:	Forschungsinstitut Fur Molekulare Pathologie Gesellschaft Mbh, AT

Systematic in-vivo analysis of chromatin-associated targets in leukemia

Recent advances in genome sequencing illustrate the complexity, heterogeneity and plasticity of cancer genomes. In leukemia - a group of blood cancers affecting 300,000 new patients every year – we know over 100 driver mutations. This genetic complexity poses a daunting challenge for the development of targeted therapies and highlights the urgent need for evaluating them in combination. One gene class that has recently emerged as highly promising target space are chromatin regulators, which maintain aberrant cell fate programs in leukemia. The dependency on altered chromatin states is thought to provide great therapeutic opportunities, since epigenetic aberrations are reversible and controlled by a machinery that is amenable to drug modulation. However, the precise mechanisms underlying these dependencies and the most effective and safe targets to exploit them therapeutically remain unknown. Here we propose an innovative approach combining genetically engineered leukemia mouse models and advanced in-vivo RNAi technologies to explore chromatin-associated vulnerabilities at an unprecedented level of depth. Following a first screen in MLL-AF9;Nras-driven AML, which led to the discovery of BRD4 as a promising therapeutic target, we aim to (1) construct a knockdown-validated shRNA library targeting 520 chromatin regulators and use it to comparatively probe chromatin-associated dependencies in diverse leukemia subtypes; (2) explore the mechanistic basis of response and resistance to suppression of BRD4 and new chromatin-associated targets; and (3) pioneer a system for multiplexed combinatorial RNAi screening and use it to identify synergies between established and new chromatin-associated targets. We envision that this ERC-funded project will generate a comprehensive functional-genetic dataset that will greatly complement ongoing genome and epigenome profiling studies and ultimately guide the development of targeted therapies for leukemia and, potentially, other cancers.

Project End Date: **12/31/2018**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
335605	**LIPintoECtion**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Karina Yaniv** karina.yaniv@weizmann.ac.il
Host Institution:	Weizmann Institute Of Science, IL

Lipoproteins and angiogenesis: A new look at an old problem

Cardiovascular diseases (CVDs) are the leading cause of death throughout the world. Elevated Low Density Lipoprotein (LDL) is a well-known cardiovascular risk factor and endothelial (ECs)-lipoprotein (LIPs) interactions underlie the initiation and progression of atherogenesis, thrombosis and other CVDs.

The endothelium is a monolayer of cells that segregates the vascular contents from adjacent tissues. In spite of being continually exposed to LIPs, ECs were long thought of as inert barriers, through which lipids are exchanged between plasma and surrounding tissues. In contrast to this view, recent work from my laboratory has uncovered a deleterious role of ApoB-LIPs as direct inhibitors of angiogenesis in the developing embryo. These findings present only the tip of the iceberg, and the underlying cellular and molecular mechanisms are largely unknown. In this proposal, we will tackle this question by undertaking three independent but complementary approaches, aimed at characterizing LIP-EC interactions at a different level: cellular, molecular or pathological. We will explore these facets in zebrafish and mammals, utilizing live imaging, sophisticated lipidomic and biochemical analyses, as well as tumor xenografts and genetic mutants. An important and unique aspect of our approach is the focus on in vivo dynamics, in contrast to the extensive body of literature on LIP effects on cultured ECs. When completed this proposal will have shed light on a little explored, but critical aspect in the etiology of CVDs. Furthermore it will provide answers to important unresolved questions: What are the signaling pathways activated in ECs upon LIP binding? How are LIPs transported within ECs? Does ApoB possess additional functions beyond that of cholesterol carrier? Can high LIPs levels inhibit tumor angiogenesis and metastasis? In a broader sense, a deeper understanding of the effects of LIPs on ECs will be valuable for identifying new targets for therapeutic intervention.

Project End Date: **11/30/2018**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
694798	**INTEGRATE**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Bernard Thorens** bernard.thorens@unil.ch
Host Institution:	Universite De Lausanne, CH

Central integration of metabolic and hedonic cues in metabolic health

During evolution the brain has selected glucose as a main source of metabolic energy. This has imposed homeostatic and behavioral constraints. First, the glycemic levels must be maintained at a minimum of ~5 mM to ensure constant energy supply to the brain. Second, a high reward value has to be attributed to glucose-containing foods to increase the motivation to obtain them. These homeostatic and hedonic regulations depend on glucose sensing cells and neuronal circuits in the central nervous system. These cells and circuits regulate the activity of the sympathetic and parasympathetic nerves, which control the function of peripheral organs (liver, fat, muscles) and the secretion of glucagon and insulin by pancreatic islet cells. They also attribute a reward value to glucose-containing foods to control food-seeking behavior, a process that involves the mesolimbic dopaminergic system. Here, we will focus on three interrelated aims: 1. Identify the physiological role of glucose sensing neurons of the ventromedial hypothalamic nucleus (VMN, a key feeding and glucoregulatory center) in glucose homeostasis and food preference; identify their cellular diversity and their molecular make-up; and characterize their deregulations in metabolic diseases.2. Characterize the molecular physiology of glucose sensing neurons of the paraventricular thalamus, which modulate the activity of the mesolimbic dopaminergic system to control motivated sucrose-seeking behavior; determine their control by other interoceptive signals, including from glucose sensing cells of the VMN.3. Establish new molecular approaches to characterize, at the molecular and functional levels, the impact of early postnatal nutrition on the development and function of central glucose sensing cells in the control of adult animal physiology. These studies will open-up new perspectives in the understanding of homeostatic and hedonic regulatory pathways, which preserve metabolic health over a lifetime.

Project End Date: **9/30/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
638573	**SILENCE**	**LS4 - Physiology, Pathophysiology and Endocrinology**

Principal Investigator:	**Dr. Henriette Uhlenhaut** Henriette.uhlenhaut@helmholtz-muenchen.de
Host Institution:	Helmholtz Zentrum Muenchen Deutsches Forschungszentrum Fuer Gesundheit Und Umwelt Gmbh, DE

Mechanisms of Gene Silencing by the Glucocorticoid Receptor

I propose to decipher the unresolved molecular paradox of positive versus negative gene regulation by the Glucocorticoid Receptor (GR). GR is one of the most potent anti-inflammatory drug targets in clinical use today, and one of the most powerful metabolic regulators. Unfortunately, its unique ability to efficiently shut off inflammatory gene expression is accompanied by serious side effects. These undesired effects are attributed to the transcriptional activation of its metabolic target genes and limit its therapeutic use.SILENCE uses cutting-edge genome-wide approaches to identify the molecular mechanisms underlying the transcriptional repression, or silencing, of inflammatory genes by GR. The general, open question I want to address is how one transcription factor can simultaneously both activate and repress transcription.GR is a member of the nuclear hormone receptor family of ligand-gated transcription factors. Upon hormone binding, GR can regulate gene expression both positively and negatively, but the mechanism governing this choice is unknown. I have previously shown that classical models and existing paradigms are insufficient to explain GR-mediated gene silencing. Therefore, I postulate the existence of unknown coregulator proteins, cis-regulatory DNA sequences, noncoding RNAs, or combinations thereof. To test these hypotheses, I plan 1. a large scale RNAi screen to identify those cofactors that specify repression versus activation, 2. ChIP-exo experiments to map genomic GR binding sites at an unprecedented resolution, and 3. GRO-Seq studies to define the role of noncoding RNAs during the silencing of inflammatory genes.Inflammation is known to contribute to the pathogenesis of numerous human illnesses, including cancer, autoimmune diseases, diabetes and cardiovascular disease. Understanding the specific mechanisms involved in the silencing of inflammatory gene expression carries transformative potential for novel therapies and safer drugs.

Project End Date: **7/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
670958	**PRION2020**	**LS5 - Neurosciences and Neural Disorders**

Principal Investigator:	**Dr. Adriano Aguzzi** adriano.aguzzi@usz.ch
Host Institution:	Universitaet Zuerich, CH

Function and malfunction of the prion protein

Transmissible spongiform encephalopathies (TSE) are caused by the ordered aggregation of PrPC into prions consisting of PrPSc. Similar pathogenetic principles operate in Alzheimer's and Parkin-son's disease, and a growing list of further diseases whose prevalence is steadily rising. Familial TSE are invariably associated with PrPC mutations, and the dearth of genetic modifiers has hampered our understanding of prion diseases. Therefore, the first objective of my proposal utilizes a cell-based high-throughput quantitative prion replication assay (developed during my previous ERC instalment) for genome-wide unbiased screens employing new genetics tools (CRISPR, siRNA li-braries, next-gen sequencing) to identify modifiers of prion uptake, replication, and secretion. The second objective aims at clarifying the basis of prion neurotoxicity and will be developed along two alleys: (a) we will uncover the molecular basis of spongiosis (the neuronal vacuolation characteristic of prion diseases), which we suspect to be a main driver of pathology, and (b) we will perform CRISPR-based synthetic lethality screens to identify genes that become essential to prion-infected cell lines (which do not experience prion toxicity) and may not be expressed by neurons. The third objective is to understand the function of PrPC in cellular physiology, and focuses on our evidence that (a) PrPC interacts with an orphan G-protein coupled receptor to maintain peripheral myelin integrity and (b) that PrPC may trigger cell death in response to ER stressors. While certain pathways of degeneration will undoubtedly be specific to prion infections, I expect that some targets will prove common to a variety of protein aggregation diseases including Alzheimer's and Parkinson's disease, and may perhaps translate into novel diagnostics and therapeutics. Hence the proposed project may not only open new perspectives in prion biology but also yield insights applicable to much more common diseases.

Project End Date: **10/31/2020**

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** sumbre@biologie.ens.fr
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: **4/30/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
341139	**COREFEAR**	**LS5 - Neurosciences and Neural Disorders**

Principal Investigator:	**Dr. Cornelius Gross** gross@embl.it
Host Institution:	European Molecular Biology Laboratory, DE

Functional wiring of the core neural network of innate fear

Fear is an emotion that exerts powerful effects on our behavior and physiology. A large body of research implicates the amygdala in fear of painful stimuli, but virtually nothing is known about the circuits that support fear of predators and social threats, despite their primal importance in human behavior and pathology. Unlike painful stimuli, predator and social threats activate the medial hypothalamus, a cluster of highly conserved brain nuclei that control motivated behavior. Intriguingly, predator and social threats recruit largely non-overlapping nuclei in the medial hypothalamus, and we have recently demonstrated that separate medial hypothalamic circuits are essential for predator and social fear. We aim to build a functional wiring diagram of predator and social fear in the mouse that will explain how these fears are triggered, coordinated, and remembered. Such a functional wiring diagram will reveal the network logic of innate fear and put us in a position to selectively intervene in fear processing. Electrical stimulation of the medial hypothalamus in humans elicits panic responses and pharmacological agents that block these circuits will offer unexplored therapeutic approaches to treat anxiety disorders such as panic, social phobia, and post-traumatic stress disorder. Moreover, the relatively simple architecture of the medial hypothalamic fear network and its robust and direct behavioral readout in the mouse will be a powerful platform to test the role of several fundamental circuit features that are common to a wide range of behavioral networks, but whose function remains unknown, including the role of feedback loops, sparse cellular encoding of behavior, and overlapping processing of distinct behavioral responses. In this way, the project will provide the first circuit-level understanding of predator and social fear and answer a series of fundamental questions about how neural networks control behavior.

Project End Date: **2/28/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
335561	**ChemosensoryCircuits**	**LS5 - Neurosciences and Neural Disorders**

Principal Investigator: **Dr. Emre Yaksi**
emre.yaksi@ntnu.no

Host Institution: Norges Teknisk-Naturvitenskapelige Universitet Ntnu, NO

Function of Chemosensory Circuits

Smell and taste are the least studied of all senses. Very little is known about chemosensory information processing beyond the level of receptor neurons. Every morning we enjoy our coffee thanks to our brains ability to combine and process multiple sensory modalities. Meanwhile, we can still review a document on our desk by adjusting the weights of numerous sensory inputs that constantly bombard our brains. Yet, the smell of our coffee may remind us that pleasant weekend breakfast through associative learning and memory. In the proposed project we will explore the function and the architecture of neural circuits that are involved in olfactory and gustatory information processing, namely habenula and brainstem. Moreover we will investigate the fundamental principles underlying multimodal sensory integration and the neural basis of behavior in these highly conserved brain areas. To achieve these goals we will take an innovative approach by combining two-photon calcium imaging, optogenetics and electrophysiology with the expanding genetic toolbox of a small vertebrate, the zebrafish. This pioneering approach will enable us to design new types of experiments that were unthinkable only a few years ago. Using this unique combination of methods, we will monitor and perturb the activity of functionally distinct elements of habenular and brainstem circuits, in vivo. The habenula and brainstem are important in mediating stress/anxiety and eating habits respectively. Therefore, understanding the neural computations in these brain regions is important for comprehending the neural mechanisms underlying psychological conditions related to anxiety and eating disorders. We anticipate that our results will go beyond chemical senses and contribute new insights to the understanding of how brain circuits work and interact with the sensory world to shape neural activity and behavioral outputs of animals.

Project End Date: **3/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682622	**ALS-Networks**	**LS5 - Neurosciences and Neural Disorders**

Principal Investigator:	**Dr. Edor KABASHI** edor.kabashi@icm-institute.org
Host Institution:	Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

Defining functional networks of genetic causes for ALS and related neurodegenerative disorders

Brain and spinal cord diseases affect 38% of the European population and cost over 800 billion € annually; representing by far the largest health challenge. ALS is a prevalent neurological disease caused by motor neuron death with an invariably fatal outcome. I contributed to ALS research with the groundbreaking discovery of TDP-43 mutations, functionally characterized these mutations in the first vertebrate model and demonstrated a genetic interaction with another major ALS gene FUS. Emerging evidence indicates that four major causative factors in ALS, C9orf72, TDP-43, FUS & SQSTM1, genetically interact and could function in common cellular mechanisms. Here, I will develop zebrafish transgenic lines for all four genes, using state of the art genomic editing tools to combine simultaneous gene knockout and expression of the mutant alleles. Using these innovative disease models I will study the functional interactions amongst these four genes and their converging effect on key ALS pathogenic mechanisms: autophagy degradation, stress granule formation and RNA regulation. These studies will permit to pinpoint the molecular cascades that underlie ALS-related neurodegeneration. We will further expand the current ALS network by proposing and validating novel genetic interactors, which will be further screened for disease-causing variants and as pathological markers in patient samples. The power of zebrafish as a vertebrate model amenable to high-content phenotype-based screens will enable discovery of bioactive compounds that are neuroprotective in multiple animal models of disease. This project will increase the fundamental understanding of the relevance of C9orf72, TDP-43, FUS and SQSTM1 by developing animal models to characterize common pathophysiological mechanisms. Furthermore, I will uncover novel genetic, disease-related and pharmacological modifiers to extend the ALS network that will facilitate development of therapeutic strategies for neurodegenerative disorders

Project End Date: **3/31/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681181	**ALZSYN**	**LS5 - Neurosciences and Neural Disorders**

Principal Investigator: **Dr. Tara Spires-Jones**
tara.spires-jones@ed.ac.uk

Host Institution: The University Of Edinburgh, UK

Imaging synaptic contributors to dementia

Alzheimer's disease, the most common cause of dementia in older people, is a devastating condition that is becoming a public health crisis as our population ages. Despite great progress recently in Alzheimer's disease research, we have no disease modifying drugs and a decade with a 99.6% failure rate of clinical trials attempting to treat the disease. This project aims to develop relevant therapeutic targets to restore brain function in Alzheimer's disease by integrating human and model studies of synapses. It is widely accepted in the field that alterations in amyloid beta initiate the disease process. However the cascade leading from changes in amyloid to widespread tau pathology and neurodegeneration remain unclear. Synapse loss is the strongest pathological correlate of dementia in Alzheimer's, and mounting evidence suggests that synapse degeneration plays a key role in causing cognitive decline. Here I propose to test the hypothesis that the amyloid cascade begins at the synapse leading to tau pathology, synapse dysfunction and loss, and ultimately neural circuit collapse causing cognitive impairment. The team will use cutting-edge multiphoton and array tomography imaging techniques to test mechanisms downstream of amyloid beta at synapses, and determine whether intervening in the cascade allows recovery of synapse structure and function. Importantly, I will combine studies in robust models of familial Alzheimer's disease with studies in postmortem human brain to confirm relevance of our mechanistic studies to human disease. Finally, human stem cell derived neurons will be used to test mechanisms and potential therapeutics in neurons expressing the human proteome. Together, these experiments are ground-breaking since they have the potential to further our understanding of how synapses are lost in Alzheimer's disease and to identify targets for effective therapeutic intervention, which is a critical unmet need in today's health care system.

Project End Date: **10/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
683209	**PRIORS**	**LS5 - Neurosciences and Neural Disorders**

Principal Investigator:	**Dr. Jaime de la Rocha** jrochav@clinic.cat
Host Institution:	Consorci Institut D'Investigacions Biomediques August Pi I Sunyer, ES

Neural circuit dynamics underlying expectation and their impact on the variability of perceptual choices

Just as our experience has its origin in our perceptions, our perceptions are fundamentally shaped by our experience. How does the brain build expectations from experience and how do expectations impact perception? In a Bayesian framework, expectations determine the environment's prior probability, which combined with stimulus information, can yield optimal decisions. While the accumulation-to-bound model describes temporal integration of sensory inputs and their combination with the prior, we still lack electrophysiological evidence showing neural circuits that integrate previous events adaptively to generate advantageous expectations.

I aim to understand (1) how circuits in the cerebral cortex integrate the recent history of stimuli and rewards to generate expectations, (2) how expectations are combined with sensory input across the processing hierarchy to bias decisions and (3) whether the dynamics of the expectation can dominate neuronal and choice variability. I will train rats in a new auditory discrimination task using predictable stimulus sequences that, once learned, are used to compute adaptive priors that improve discrimination. I will perform population recordings and optogenetic manipulations to identify the brain areas involved in the computation of priors in the task. To reveal the circuit mechanisms underlying the observed dynamics I will train a computational network model to classify fluctuating inputs and, by adapting its dynamics to the statistics of the stimulus sequence, accumulate evidence across trials to maximize performance. The model will generalize the accumulation-to-bound model by integrating information across various time scales and will partition choice variability into that caused by the dynamics of the prior or by fluctuations in the stimulus response. My proposal points at a paradigm shift from viewing neuronal variability as a corrupting source of noise to the result of our brain's inevitable tendency to predict the future.

Project End Date: **8/31/2021**

European Research Council
Executive Agency

Established by the European Commission

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

Principal Investigator: **Dr. Balazs Hangya**
hangya.balazs@koki.mta.hu

Host Institution: Institute Of Experimental Medicine - Hungarian Academy Of Sciences, HU

Synergy and antagonism of cholinergic and dopaminergic systems in associative learning

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

Project End Date: **4/30/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677687	**NeuroVisEco**	**LS5 - Neurosciences and Neural Disorders**

Principal Investigator:	**Dr. Tom Baden** t.baden@sussex.ac.uk
Host Institution:	University Of Sussex, UK

Zebrafish vision in its natural context: from natural scenes through retinal and central processing to behaviour.

All visual systems are specialised to best serve an animal's sensory niche, yet how such specialisations are achieved through phylogenetic and developmental adaptations of the 'common vertebrate visual system blueprint' are poorly understood. I will study these adaptations in the visual system of zebrafish. I will use two-photon functional imaging and computational modelling to investigate how the visual system of zebrafish samples and processes behaviourally meaningful stimuli in the natural world. I will then use optogenetic manipulations while zebrafish navigate a virtual reality environment to directly probe the role of visual circuits in driving behaviour. Specifically, I will pursue four Aims: 1. What is the zebrafish eye designed to see?
2. How does the fish retina form feature selective output channels?
3. What does the fish's eye tell the fish's brain?
4. How does visual input to the brain lead to behaviour? Visual specialisations begin in the optics and movements of the eyes, and are subsequently deeply rooted in every step of neuronal computation. Therefore, I will study visual processing at these different organisational levels. Here, the highly 'visual' zebrafish present a powerful model. They (i) offer exquisite genetic tools to record and manipulate neurons, (ii) have transparent larval stages permitting optical access to the entire nervous system and (iii) there is a large array of well-studied and easily quantifiable visual behaviours. In addition, zebrafish undergo two distinct life-stages, from larva to adult - with distinct lifestyles in different visual environments and hence different feature-detection requirements. Comparison of processing strategies employed by the (a) larval and (b) adult zebrafish visual system with that of other species, including a complementary database already recorded in mice (c), will lead to an increasingly generalised understanding of biological vision.

Project End Date: **5/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
680235	**COSI**	**LS5 - Neurosciences and Neural Disorders**

Principal Investigator:	**Dr. Martijn Schonewille** m.schonewille@erasmusmc.nl
Host Institution:	Erasmus Universitair Medisch Centrum Rotterdam, NL

Cerebellar modules and the Ontogeny of Sensorimotor Integration

The perfect execution of a voluntary movement requires the appropriate integration of current bodily state, sensory input and desired outcome. To assure that this motor output becomes and remains appropriate, the brain needs to learn from the result of previous outputs. The cerebellum plays a central role in sensorimotor integration, yet -despite decades of studies- there is no generally excepted theory for cerebellar functioning. I recently demonstrated that cerebellar modules, identified based on anatomical connectivity and gene expression, differ distinctly in spike activity properties. It is my long-term goal to identify the ontogeny of anatomical and physiological differences between modules, and their functional consequences. My hypothesis is that these differences can explain existing controversies, and unify contradicting results into one central theory.
To this end, I have designed three key objectives. First, I will identify the development of connectivity and activity patterns at the input stage of the cerebellar cortex in relation to the cerebellar modules (key objective A). Next, I will relate the differences in gene expression levels between modules to differences in basal activity and strength of plasticity mechanisms in juvenile mice (key objective B). Finally, I will determine how module specific output develops in relation to behavior and what the effect of module specific mutations is on cerebellum-dependent motor tasks and higher order functions (key objective C).
Ultimately, the combined results of all key objectives will reveal how distinct difference between cerebellar modules develop, and how this ensemble ensures proper cerebellar information processing for optimal coordination of timing and force of movements. Combined with the growing body of evidence for a cerebellar role in higher order brain functions and neurodevelopmental disorders, a unifying theory would be fundamental for understanding how the juvenile brain develops.

Project End Date: **5/31/2021**

European Research Council
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Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
670283	**SYNPRIME**	**LS5 - Neurosciences and Neural Disorders**

Principal Investigator: **Dr. Nils Brose**
brose@em.mpg.de

Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Presynaptic Regulatory Principles in Synaptic Plasticity, Neuronal Network Function, and Behaviour

Neuronal signalling via synaptic vesicle (SV) fusion is the fastest membrane fusion event in mammalian cells. Its speed and the ability of presynapses to sustain SV fusion at high stimulation rates are key requirements for brain function. Plastic changes of SV fusion rates have long been thought to control complex brain processes such as working memory, but the link between presynaptic plasticity and complex brain functions remains hypothetical. A key determinant of presynaptic efficacy is that synapses maintain a release-ready or primed SV pool that can be refilled rapidly. SV priming is mediated by a set of dedicated priming proteins (Munc13s, CAPSs, and accessory proteins), which are of pervasive and essential functional importance for synaptic efficacy, and - based on in vitro studies - of capacious potential to regulate exactly the type of synaptic plasticity that is associated with brain circuit characteristics involved in complex behaviours. However, this 'catholic' role of the SV priming machinery in brain function has never been tested, mainly because essential genetic models for studies in vivo have been lacking. Using (i) 4 newly generated conditional KO and KI mouse lines, (ii) 17 additional KOs/KIs (12 ours), (iii) high-end EM approaches (iv) KO-replacement strategies, (v) electrophysiological and optophysiological analyses, and (vi) behavioural studies, we will examine the SV priming machinery in intact circuits in order to (a) define the mechanisms and cell biological basis of SV priming, of its dynamics, and of defined priming-dependent synaptic plasticity states, and to (b) define the causal links between SV priming, synapse function, synaptic plasticity, circuit characteristics, and behaviour. These studies will generate a comprehensive delineation of the role of SV priming in intact neural circuits, which is not only essential for basic science but also for psychiatry, because all key priming proteins are linked to neuropsychiatric diseases.

Project End Date: **8/31/2020**

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** kriegstein@cbs.mpg.de
Host Institution:	Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., 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: **12/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
616905	**hMRI**	**LS5 - Neurosciences and Neural Disorders**

Principal Investigator:	**Dr. Nikolaus Weiskopf** weiskopf@cbs.mpg.de
Host Institution:	Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Non-Invasive In-Vivo Histology in Health and Disease Using Magnetic Resonance Imaging (MRI)

Understanding of the normal and diseased brain crucially depends on reliable knowledge of its microstructure. Important functions are mediated by small cortical units (columns) and even small changes in the microstructure can cause debilitating diseases. So far, this microstructure can only be determined using invasive methods such as, e.g., ex-vivo histology. This limits neuroscience, clinical research and diagnosis. My research vision is to develop novel methods for high-resolution magnetic resonance imaging (MRI) at 3T-9.4T to reliably characterize and quantify the detailed microstructure of the human cortex. This MRI-based histology will be used to investigate the cortical microstructure in health and focal cortical degeneration. Structure-function relationships in visual cortex will be elucidated in-vivo, particularly, ocular dominance columns and stripes. Specific microstructural changes in focal cortical degeneration due to Alzheimer's disease and monocular blindness will be determined, including amyloid plaque imaging. To resolve the subtle structures and disease related changes, which have not previously been delineated in-vivo by anatomical MRI, unprecedented isotropic imaging resolution of up to 250 µm is essential. Methods for high-resolution myelin and iron mapping will be developed from novel quantitative MRI approaches that I have previously established. Super-resolution diffusion and susceptibility imaging will be developed to capture the neuropil microstructure. Anatomical imaging will be complemented by advanced high-resolution functional MRI. The multi-modal MRI data will be integrated into a unified model of MRI contrasts, cortical anatomy and tissue microstructure. My ambitious goal of developing in vivo MRI-based histology can only be achieved by an integrative approach combining innovations in MR physics, modelling and tailored (clinical) neuroscience experiments. If successful, the project will transform research and clinical imaging.

Project End Date: **8/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716862	**BrainDyn**	**LS5 - Neurosciences and Neural Disorders**

Principal Investigator:	**Dr. Mathilde Bonnefond** mathilde.bonnefond@inserm.fr
Host Institution:	Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

Tracking information flow in the brain:
A unified and general framework for dynamic communication in brain networks

The brain is composed of a set of areas specialized in specific computations whose outputs need to be transferred to other specialized areas for cognition to emerge. To account for context-dependent behaviors, the information has to be flexibly routed through the fixed anatomy of the brain. The aim of my proposal is to test a general framework for flexible communication between brain areas based on nested oscillations which I recently developed. The general idea is that internally-driven slow oscillations (<20Hz) either set-up or prevent the communication between brain areas. Stimulus-driven gamma oscillations (>30Hz), nested in the slow oscillations, can then be directed to task-relevant areas of the network. I plan to use a multimodal, multi-scale and transversal (human and monkey) approach in experiments manipulating visual processing, attention and memory to test core predictions of my framework. The theoretical approach and the methodological development used in my project will provide the basis for future fundamental and clinical research.

Project End Date: **1/31/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716643	**FLEXNEURO**	**LS5 - Neurosciences and Neural Disorders**

Principal Investigator: **Dr. Timothy O'Leary**
tso24@cam.ac.uk

Host Institution: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

Flexible and robust nervous system function from reconfiguring networks

It is now possible to monitor and manipulate neurons in live, awake animals, revealing how patterns of neural activity represent information and give rise to behaviour. Very recent experiments show that many circuits have physiology and connectivity that is highly variable and that changes continually, even when an animal's behaviour and environment are stable. Existing theories of brain function assume that neural circuit parameters only change as required during learning and development. This paradigm cannot explain how consistent behaviour can emerge from circuits that continually reconfigure, nor what mechanisms might drive variability and continual change. Understanding this deep puzzle requires new theory and new ways to interpret experimental data. I will develop a theory of reconfiguring circuits by significantly generalizing my previous work that uses control theory to show how network activity can be maintained in spite of variability and continual turnover of crucial circuit components. We will analyse how biological plasticity mechanisms steer collective properties of neurons and circuits toward functional states without requiring individual parameters to be fixed, resulting in circuit models with consistent output but variable and mutable internal structures. In close collaboration with leading experimentalists we will challenge these modelling principles to account for new findings which reveal that navigation, sensory percepts and learned associations are underpinned by surprisingly dynamic, variable circuit connectivity and physiology. This will generate new, exciting questions that will drive experiments and theory together: how can known plasticity mechanisms generate reconfigurable neural representations? Do continually reconfiguring networks possess unique functional flexibility and robustness, and are they vulnerable to specific pathologies? And how can we design new experiments to test theories of robust, reconfigurable networks?

Project End Date: **1/31/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
322966	**DCVfusion**	**LS5 - Neurosciences and Neural Disorders**

Principal Investigator:	**Dr. matthijs Verhage** matthijs@cncr.vu.nl
Host Institution:	Stichting Vumc, NL

Telling the full story: how neurons send other signals than by classical synaptic transmission

The regulated secretion of chemical signals in the brain occurs principally from two organelles, synaptic vesicles and dense core vesicles (DCVs). Synaptic vesicle secretion accounts for the well characterized local, fast signalling in synapses. DCVs contain a diverse collection of cargo, including many neuropeptides that trigger a multitude of modulatory effects with quite robust impact, for instance on memory, mood, pain, appetite or social behavior. Disregulation of neuropeptide secretion is firmly associated with many diseases such as cognitive and mood disorders, obesity and diabetes. In addition, many other signals depend on DCVs, for instance trophic factors and proteolytic enzymes, but also signals that typically do not diffuse like guidance cues and pre-assembled active zones. Hence, it is beyond doubt that DCV signalling is a central factor in brain communication. However, many fundamental questions remain open on DCV trafficking and secretion. Therefore, the aim of this proposal is to characterize the molecular principles that account for DCV delivery at release sites and their secretion. I will address 4 fundamental questions: What are the molecular factors that drive DCV fusion in mammalian CNS neurons? How does Ca2+ trigger DCV fusion? What are the requirements of DCV release sites and where do they occur? Can DCV fusion be targeted to synthetic release sites in vivo? I will exploit >30 mutant mouse lines and new cell biological and photonic approaches that allow for the first time a quantitative assessment of DCV-trafficking and fusion of many cargo types, in living neurons with a single vesicle resolution. Preliminary data suggest that DCV secretion is quite different from synaptic vesicle and chromaffin granule secretion. Together, these studies will produce the first systematic evaluation of the molecular identity of the core machinery that drives DCV fusion in neurons, the Ca2+-affinity of DCV fusion and the characteristics of DCV release sites.

Project End Date: **4/30/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681978	**Brain3.0**	**LS5 - Neurosciences and Neural Disorders**

Principal Investigator: **Dr. Suliann Ben Hamed**
benhamed@isc.cnrs.fr

Host Institution: Centre National De La Recherche Scientifique, FR

Invasive cognitive brain computer interfaces to enhance and restore attention: proof of concept and underlying cortical mechanisms.

The present project focuses on a barely scratched aspect of invasive cognitive brain-computer interfaces (cBCIs), i.e. closed-loop invasive cBCIs to augment and restore attentional functions. Its aim is to achieve an efficient enhanced cognition protocol both in the healthy brain and in the damaged brain and to study the local and global plasticity mechanisms underlying these effects. The project relies on the unique methodological combination of multi-electrode multisite intracortical recordings and functional magnetic resonance imaging, in association with reversible cortical lesions and intracortical microstimulations, in an experimental model allowing to approach the attentional human function and its dysfunctions to the best. Our goal is to achieve:

1. A closed-loop invasive cBCI for augmented attention, by providing the subjects with a feedback on their cortical spatial and feature attention information content as estimated from real-time population decoding procedures, using reinforcement learning, to have them improve this cognitive content, and as a result, improve their overt attentional behavioural performance.
2. A closed-loop invasive cBCI for restored attention, by inducing a controlled attentional loss thanks to reversible cortical lesions targeted to key functionally-identified cortical regions and using the closed-loop cBCI to restore attentional performance.
3. An invasive cBCI for stimulated attentional functions. We will identify the neuronal population changes leading to a voluntary enhancement of attentional functions as quantified in aim 1 and inject these changes, using complex patterns of microstimulations, mimicking spikes, to enhance or restore attention, in the absence of any active control by the subjects.

This project will contribute to the development of novel therapeutical applications to restore acute or chronic severe attentional deficits and to provide an in depth understanding of the neural bases underlying closed-loop cBCIs.

Project End Date: **9/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
337069	**CogOpto**	**LS5 - Neurosciences and Neural Disorders**

Principal Investigator: **Dr. Marie Carlén**
marie.carlen@ki.se

Host Institution: Karolinska Institutet, SE

The role of parvalbumin interneurons in cognition and behavior

Cognition is a collective term for complex but sophisticated mental processes such as attention, learning, social interaction, language production, decision making and other executive functions. For normal brain function, these higher-order functions need to be aptly regulated and controlled, and the physiology and cellular substrates for cognitive functions are under intense investigation. The loss of cognitive control is intricately related to pathological states such as schizophrenia, depression, attention deficit hyperactive disorder and addiction. Synchronized neural activity can be observed when the brain performs several important functions, including cognitive processes. As an example, gamma activity (30-80 Hz) predicts the allocation of attention and theta activity (4-12 Hz) is tightly linked to memory processes. A large body of work indicates that the integrity of local and global neural synchrony is mediated by interneuron networks and actuated by the balance of different neuromodulators. However, much knowledge is still needed on the functional role interneurons play in cognitive processes, i.e. how the interneurons contribute to local and global network processes subserving cognition, and ultimately play a role in behavior. In addition, we need to understand how neuro-modulators, such as dopamine, regulate interneuron function. The proposed project aims to functionally determine the specific role the parvalbumin interneurons and the neuromodulator dopamine in aspects of cognition, and in behavior. In addition, we ask the question if cognition can be enhanced. We are employing a true multidisciplinary approach where brain activity is recorded in conjunctions with optogenetic manipulations of parvalbumin interneurons in animals performing cognitive tasks. In one set of experiments knock-down of dopamine receptors specifically in parvalbumin interneurons is employed to probe how this neuromodulator regulate network functions.

Project End Date: **1/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
616268	**F-TRACT**	**LS5 - Neurosciences and Neural Disorders**

Principal Investigator:	**Dr. Olivier David** olivier.david@inserm.fr
Host Institution:	Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

Functional Brain Tractography

Single-pulse direct electrical stimulation of cortical regions in patients suffering from focal drug-resistant epilepsy who are explored using intracranial electrodes induces electrophysiological responses. Such cortico-cortical induced potentials can be used to infer functional and anatomical brain connectivity. We will develop methods to analyse those responses using neuroimaging tools in order to create a new probabilistic atlas of functional tractography of the human brain, which will be made freely available to the clinical and neuroscience community. Several thousands of stimulation runs performed in several hundreds of patients will be included in the atlas database to reach a nearly full coverage of the human cortex (inclusion of 540 patients retrospectively and of 172 patients/year prospectively, from 8 French and 1 Czech epilepsy surgery centres). As a proof of concept, we generated for F-TRACT scientific document a preliminary database of 1535 stimulation runs performed in 35 adult patients. To illustrate the potential of our approach, in particular to refine neurobiological models of cognitive systems, we use here this preliminary atlas to demonstrate the asymmetry of the functional connectivity between Wernicke's area and Broca's area, two key nodes of the language network. This new atlas of functional tractography will be very useful to understand how the brain works and to develop neurocomputational models at a large scale. It will also allow the development of new clinical tools for the presurgical evaluation of intractable epilepsy. It is very complementary to other structural and functional approaches, such as MRI diffusion and functional mapping derived from metabolic, optical and electromagnetic techniques. The open access to this unique atlas of functional tractography will allow to explore in the future its numerous properties in relation to distributed brain networks in the domains of neuroanatomy, neurocognition and neurophysiopathology.

Project End Date: **7/31/2019**

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. stéphanie Baulac** stephanie.baulac@upmc.fr
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: **9/30/2021**

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** nave@em.mpg.de
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: **3/31/2021**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
335590	**NEVAI**	**LS5 - Neurosciences and Neural Disorders**

Principal Investigator: **Dr. Dario Bonanomi**
bonanomi.dario@hsr.it

Host Institution: Ospedale San Raffaele, IT

Neurovascular Interactions and Pathfinding in the Spinal Motor System

Neurons and blood vessels rely on common guidance signals to wire into elaborate neural and vascular networks that are closely juxtaposed and interdependent: vascular supply of oxygen and nutrients is essential to sustain the high metabolic rate of the nervous system, and conversely neural control of vascular tone is crucial for circulatory homeostasis. However, it remains unclear how the nervous and vascular systems establish an intimate physical and functional relationship. This proposal seeks to reveal the developmental mechanisms that link neuronal connectivity and vascularization of the nervous system, focusing on the interactions between vascular endothelial cells and spinal motor neurons that control locomotion, respiration and autonomic responses. Motor neuron diseases and a variety of other neurodegenerative conditions are precipitated by vascular abnormalities. Thus, understanding the molecular basis of neurovascular crosstalk may offer novel therapeutic opportunities.

My group will use mutagenesis-based forward genetics in reporter mice combined with gene profiling of motor neurons and endothelial cells to screen for novel regulators of neurovascular interactions and pathfinding. Candidate genes will be further characterized using in vivo mouse and chick models, in addition to in vitro studies to uncover the mechanisms of action. Through this multi-disciplinary approach, the proposal will address these fundamental questions: (i) Do neurovascular interactions instruct the assembly of neural and vascular networks? (ii) What signaling pathways connect region-specific vascularization of the CNS to the local metabolic and functional demand of neuronal tissues? (iii) What mechanisms account for specificity, spatiotemporal control and integration of guidance signaling? In addition, this research plan will generate comprehensive transcriptional/proteomic datasets and novel mouse mutants for future studies of neurovascular communication and patterning.

Project End Date: **12/31/2019**

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** gabriela.constantin@univr.it
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: **8/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677006	**CMIL**	**LS6 - Immunity and Infection**

Principal Investigator:	**Dr. Andreas Bergthaler** abergthaler@cemm.oeaw.ac.at
Host Institution:	Cemm - Forschungszentrum Fuer Molekulare Medizin Gmbh, AT

Crosstalk of Metabolism and Inflammation

Inflammation is a response to noxious stimuli and initiates tissue repair. If resolution fails, however, chronic inflammation develops, which drives tissue damage in many diseases including autoimmunity, cancer and infections. Inflammatory processes are increasingly being appreciated as tightly integrated with metabolic pathways. The molecular crosstalk occurs on different levels including secreted metabolites and cytokines. I hypothesise that this interface of metabolism and inflammation represents a functional rheostat that shapes tissue damage and disease. Here, I propose to analyse the metabolic and inflammatory processes in a mouse model of chronic viral hepatitis. I chose this model to explore the inflammatory rheostat because the liver is the central organ for metabolism and a hotspot for receiving, processing and distributing local and systemic signals. Cutting-edge technologies including deep sequencing, quantitative proteomics and metabolomics will let us create longitudinal multi-dimensional maps of virus-induced alterations. Paired with immunological, virological and pathological analyses, I expect to identify novel regulatory nodes between metabolism and inflammation. Within our systems-wide experiments and supported by preliminary results, we will specifically focus on the immunomodulatory roles of the metabolite bile acids and oxidative metabolism. These as well as other candidates will be investigated by genetic and pharmacological perturbations in cell culture and in mouse models. Bioinformatics integration of the orthogonal profiling kinetics is expected to reveal novel properties of the molecular networks mediating between metabolism and inflammation. This proposed cross-disciplinary approach aims to improve our understanding of the crosstalk of metabolism and inflammation. The results of this project may be relevant to viral hepatitis in man and bear broader implications for other inflammatory diseases.

Project End Date: **3/31/2021**

European Research Council
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Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677251	**CD4DNASP**	**LS6 - Immunity and Infection**

Principal Investigator:	**Dr. Lionel Apetoh** lionel.apetoh@inserm.fr
Host Institution:	Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

Cell intrinsic control of CD4 T cell differentiation by cytosolic DNA sensing pathways

This proposal aims to investigate the role of cytosolic DNA sensing pathways in CD4 T cell differentiation.

Cellular host defense to pathogens relies on the detection of pathogen-associated molecular patterns including deoxyribonucleic acid (DNA), which can be recognized by host myeloid cells through Toll-like receptor (TLR) 9 binding. Recent evidence however suggests that innate immune cells can also perceive cytoplasmic DNA from infectious or autologous origin through cytosolic DNA sensors triggering TLR9-independent signaling. Activation of cytosolic DNA sensor-dependent signaling pathways has been clearly shown to trigger innate immune responses to microbial and host DNA, but the contribution of cytosolic DNA sensors to the differentiation of CD4 T cells, an essential event for shaping adaptive immune responses, has not been documented. This proposal aims to fill this current knowledge gap.

We aim to decipher the molecular series of transcriptional events triggered by DNA in CD4 T cells that ultimately result in altered T cell differentiation. This aim will be addressed by combining in vitro and in vivo approaches such as advanced gene expression analysis of CD4 T cells and use of transgenic and gene-deficient mice. Structure activity relationship and biophysical studies will also be performed to unravel novel immunomodulators able to affect CD4 T cell differentiation.

Project End Date: **7/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
637304	**HBV1**	**LS6 - Immunity and Infection**

Principal Investigator:	**Dr. Marcus Dorner** m.dorner@imperial.ac.uk
Host Institution:	Imperial College Of Science, Technology And Medicine, UK

Innate immune responses to human hepatotropic viral infections

Chronic hepatotropic infections including hepatitis B (HBV) and C (HCV) are a major public health concern. Even though both viruses belong to completely distinct families the pathogenesis they elicit is strikingly similar, leading to liver fibrosis and cirrhosis. Treatment for HBV and HCV consists of either direct-acting antivirals or pegylated interferon (IFN)α. In contrast to HCV, these treatment regimen are noncurative for HBV. Little is known to date about the host/pathogen interactions determining viral persistence.Both viruses are sensitive to IFN, activating the JAK/STAT signalling pathway to activate interferonstimulated gene expression (ISG), which are ultimately acting as antiviral immune effectors. Nevertheless, neither type I or III IFN are very effective in their treatment.

Here, we suggest investigating the mechanistic details of type I and type III IFN action on HCV and HBV in vitro and vivo with the goal of uncovering not only the differential ISG induction but furthermore characterise viral immune evasion strategies. Building on our previous success in dissecting the host response to HCV and creating the first immunocompetent mouse model for HCV we aim at using both, novel microfluidic culture systems based on 3D hepatocyte cultures susceptible to both HCV and HBV as well as human liver-chimeric mice in combination with single-cell analysis of the antiviral response against

HBV and HCV elicited by type I and III IFN. Additionally, we will utilize lentiviral high throughput screening used previously for HCV to identify interferon effector molecules active against HBV. This project will not only provide new insights into the innate immune response to chronic hepatotropic virus infections but furthermore holds the potential of uncovering novel drug targets, aiding in the curative therapy for both, HCV and HBV and offer novel insights into vaccine design.

This project has the aim of identifying novel host factors and drug targets enabling the development of immunomodulatory antiviral drugs. This ranks the scope of the proposal between LS6 Immunity and Infection and LS9 Applied Life Sciences and Non-Medical Biotechnology. Evaluating novel bioengineered human liver culture systems and building on human liver-chimeric mice clearly places this proposal at the forefront of identifying novel drug targets and assisting in the development of novel biotechnology and preclinical projects.

Project End Date: **5/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
614562	**MitoFun**	**LS6 - Immunity and Infection**

Principal Investigator:	**Dr. Robin May** r.c.may@bham.ac.uk
Host Institution:	The University Of Birmingham, UK

Mitochondria as regulators of fungal virulence

Fungal diseases represent a significant and growing threat to human health, particularly since the AIDS pandemic and increasing use of immunosuppressive drugs has produced a massive population of people with impaired immunity who are vulnerable to fungal infections. A great challenge in medical mycology is to understand how fungal virulence evolves. The vast majority of fungal species are not human pathogens and, for those that are, virulence appears to have evolved independently on many different occasions. Identifying the step(s) that convert an environmental fungus into a human pathogen, as well as subsequent changes in virulence within a pathogenic lineage, is therefore of fundamental importance. Based on a number of lines of evidence, I hypothesise that a critical regulator of fungal virulence in animal hosts is the activity of the fungal mitochondrion, an energy-generating organelle present in almost all eukaryotes. I propose to test this hypothesis comprehensively by combining genetic and cell biological approaches with high-resolution imaging methods.

Project End Date: **2/28/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
615680	**ViVARNAsilencing**	**LS6 - Immunity and Infection**

Principal Investigator: **Dr. Ronald van Rij**
ronald.vanrij@radboudumc.nl

Host Institution: Stichting Katholieke Universiteit, NL

Antiviral Defense in the Vector Mosquito Aedes aegypti: induction and suppression of RNA silencing pathways

BACKGROUND: Mosquitoes and other blood-feeding arthropods transmit important human and animal viruses (arthropod-borne viruses, arboviruses). With the increasing global threat of arboviruses, it is essential to understand the virus-vector interactions that determine virus transmission. The mosquito antiviral immune response is a key determinant of virus replication and transmission. We recently showed that arboviruses are targeted by a poorly-understood RNA silencing pathway in the major vector mosquito Aedes aegypti: the Piwi-interacting RNA (piRNA) pathway. Our (published and unpublished) observations imply that the piRNA pathway contributes to antiviral defense against different classes of viruses in somatic tissues of mosquitoes. Moreover, we identified a novel class of endogenous gene-derived piRNAs in mosquitoes that may form a new paradigm for piRNA-based regulation of cellular gene expression. AIM: This proposal has a three-fold aim: i) to delineate the biogenesis and function of the novel classes of virus- and gene-derived piRNAs, ii) to characterize mechanisms by which (arbo)viruses suppress or evade antiviral RNA silencing pathways, and by doing so, iii) to establish mosquitoes as an experimental model to characterize the complex piRNA machinery. APPROACH: We will use Aedes cell lines that recapitulate all aspects of piRNA biogenesis. This allows us to use a unique, powerful approach of genomic, cell biological, biochemical, and proteomic methodologies to study piRNA biogenesis and function. IMPORTANCE AND INNOVATION: This is the first study to comprehensively characterize viral and cellular piRNA biogenesis and function in mosquitoes. This proposal provides novel insights into the antiviral response in mosquitoes and may uncover novel regulatory functions of endogenous piRNAs. Moreover, it establishes a platform for functional and biochemical dissection of the complex biogenesis of piRNAs - the most enigmatic class of small silencing RNAs.

Project End Date: **7/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
339984	**Bacterial Response**	**LS6 - Immunity and Infection**

Principal Investigator:	**Dr. Sigal Ben-Yehuda** sigalb@ekmd.huji.ac.il
Host Institution:	The Hebrew University Of Jerusalem., IL

New Concepts in Bacterial Response to their Surroundings

Bacteria in nature exhibit remarkable capacity to sense their surroundings and rapidly adapt to diverse conditions by gaining new beneficial traits. This extraordinary feature facilitates their survival when facing extreme environments. Utilizing Bacillus subtilis as our primary model organism, we propose to study two facets of this vital bacterial attribute: communication via extracellular nanotubes, and persistence as resilient spores while maintaining the potential to revive. Exploring these fascinating aspects of bacterial physiology is likely to change our view as to how bacteria sense, respond, endure and communicate with their extracellular environment.

We have recently discovered a previously uncharacterized mode of bacterial communication, mediated by tubular extensions (nanotubes) that bridge neighboring cells, providing a route for exchange of intracellular molecules. Nanotube-mediated molecular sharing may represent a key form of bacterial communication in nature, allowing for the emergence of new phenotypes and increasing survival in fluctuating environments. Here we propose to develop strategies for observing nanotube formation and molecular exchange in living bacterial cells, and to characterize the molecular composition of nanotubes. We will explore the premise that nanotubes serve as a strategy to expand the cell surface, and will determine whether nanotubes provide a conduit for phage infection and spreading. Furthermore, the formation and functionality of interspecies nanotubes will be explored. An additional mode employed by bacteria to achieve extreme robustness is the ability to reside as long lasting spores. Previously held views considered the spore to be dormant and metabolically inert. However, we have recently shown that at least one week following spore formation, during an adaptive period, the spore senses and responds to environmental cues and undergoes corresponding molecular changes, influencing subsequent emergence from quiescence.

Project End Date: **3/31/2019**

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** dominique.soldati-favre@unige.ch
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 cyst2. Determine the parasite factors responsible for CW formation and maturation via targeted and unbiased approaches3. 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 persistenceWe 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: **9/30/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681829	**INVADIS**	**LS6 - Immunity and Infection**

Principal Investigator: **Dr. Marc Lecuit**
marc.lecuit@pasteur.fr

Host Institution: Institut Pasteur, FR

Microbial invasion and dissemination within the host, mechanisms and effects

An infection is defined by the deleterious consequences of the interactions between a pathogen and a host. Thus, studying the biology of infection reveals critical properties of hosts and pathogens, and is a way forward to address basic biological questions and improve health.

We study listeriosis, a systemic infection caused by Listeria monocytogenes (Lm). Lm is a human foodborne pathogen that crosses the intestinal barrier, disseminates systemically, replicates in liver and spleen and reaches the central nervous system (CNS) and fetoplacental unit. Given the remarkable journey Lm makes in its host, studying listeriosis offers unprecedented opportunities to understand host cell biology, physiology and immune responses, guided by Lm. The mucosal, CNS and fetoplacental tropisms of Lm are shared by other microbes which pathogenesis is far less understood. Lm therefore stands as a unique model microorganism of general biological and medical significance.

The major challenge of this project is to go beyond reductionist approaches and embrace the complexity of actual infections.

We will use stem cell-derived organoids, live imaging, genetically engineered mouse models, the clinical and biological data from a unique cohort of 900 patients and the corresponding causative Lm strains, to investigate the molecular mechanisms of Lm tissue invasion, dissemination and host responses.

Specifically, we will (i) decipher the cell biology of microbial translocation across the intestinal epithelium; (ii) study the impact of microbial portal of entry on microbial fate, dissemination and host responses; (iii) harness Lm biodiversity to identify novel virulence factors and (iv) discover new host factors predisposing to invasive infections.

Building on the unique combination of advanced experimental systems and exclusive clinical data, this integrative and innovative project will reveal novel, physiologically relevant mechanisms of infection, with scientific and biomedical implications.

Project End Date: **10/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714224	**MIX-Effectors**	**LS6 - Immunity and Infection**

Principal Investigator:	**Dr. Dor Salomon** dorsalomon@mail.tau.ac.il
Host Institution:	Tel Aviv University, IL

T6SS MIX-effectors: secretion, activities and use as antibacterial treatment

Bacteria use various mechanisms to combat competitors and colonize new niches. The Type VI Secretion System (T6SS), a contact-dependent protein delivery apparatus, is a widespread, recently discovered machine used by Gram-negative bacteria to target competitors. Its toxicity is mediated by secreted proteins called effectors, yet the identity of many effectors, the mechanism of secretion of different effector classes, and their toxic activities remain largely unknown. I recently uncovered a widespread class of T6SS effectors that share a domain called MIX. MIX-effectors are polymorphic proteins carrying various toxin domains, many of which with unknown activities.

Many bacterial pathogens have acquired resistance to contemporary antibiotic treatments, becoming a public health threat and necessitating the development of novel antibacterial strategies. Thus, as a relatively untapped antibacterial system, studying the T6SS and its MIX-effectors presents a double incentive: 1) previously uncharacterized antibacterial activities of MIX-effectors can illuminate novel cellular targets for antibacterial drug development; 2) the T6SS machinery can be used as a novel toxin delivery platform to combat multi-drug resistant bacterial infections, using polymorphic MIX-effectors.

In this proposal, I will focus on T6SS MIX-effectors and elucidate their activities, mechanism of secretion, and utilization as antibacterial agents, by combining microbiology, molecular biology, genetic, biochemical, and proteomic approaches. Specifically, the goal of this proposal is to utilize T6SSs and MIX-effectors to develop a novel T6SS-based, antibacterial therapeutic platform in which a nonpathogenic bacterium will be engineered to carry a T6SS that can secrete a diverse repertoire of polymorphic antibacterial MIX-effectors. This innovative platform has several advantages over current antibacterial strategies, and can be used as an adjustable tool to combat multi-drug resistant bacteria.

Project End Date: **1/31/2022**

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Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
614578	**Danger ATP**	**LS6 - Immunity and Infection**

Principal Investigator:	**Dr. Pablo Pelegrin** pablo.pelegrin@imib.es
Host Institution:	Fundacion Para La Formacion E Investigacion Sanitarias De La Region De Murcia, ES

Regulation of inflammatory response by extracellular ATP and P2X7 receptor signalling: through and beyond the inflammasome.

Inflammatory diseases affect over 80 million people worldwide and accompany many diseases of industrialized countries, being the majority of them infection-free conditions. There are few efficient anti-inflammatory drugs to treat chronic inflammation and thus, there is an urgent need to validate novel targets. We now know that innate immunity is the main coordinator and driver of inflammation. Recently, we and others have shown that the activation of purinergic P2X7 receptors (P2X7R) in immune cells is a novel and increasingly validated pathway to initiate inflammation through the activation of the NLRP3 inflammasome and the release of IL-1β and IL-18 cytokines. However, how NLRP3 sense P2X7R activation is not fully understood. Furthermore, extracellular ATP, the physiological P2X7R agonist, is a crucial danger signal released by injured cells, and one of the most important mediators of infection-free inflammation. We have also identified novel signalling roles for P2X7R independent on the NLRP3 inflammasome, including the release of proteases or inflammatory lipids. Therefore, P2X7R has generated increasing interest as a therapeutic target in inflammatory diseases, being drug like P2X7R antagonist in clinical trials to treat inflammatory diseases. However, it is often questioned the functionality of P2X7R in vivo, where it is thought that extracellular ATP levels are below the threshold to activate P2X7R. The overall significance of this proposal relays to elucidate how extracellular ATP controls host-defence in vivo, ultimately depicting P2X7R signalling through and beyond inflammasome activation. We foresee that our results will generate a leading innovative knowledge about in vivo extracellular ATP signalling during the host response to infection and sterile danger.

Project End Date: **8/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647455	**RegulRNA**	**LS6 - Immunity and Infection**

Principal Investigator:	**Dr. Sébastien Pfeffer** spfeffer@unistra.fr
Host Institution:	Centre National De La Recherche Scientifique, FR

Modulation of RNA-based regulatory processes by viruses

Small and large non-coding RNAs are essential components at the heart of gene expression regulation. The past fifteen years have witnessed the emergence of a new field of research impacting diverse domains of biology. Among these, virology is no exception and discoveries such as the antiviral role of RNA silencing, virus-encoded microRNAs (miRNAs), or miRNA-based regulation of viruses have notably shifted our views of host-virus interactions. Although we know a lot about the mechanisms of action of ncRNAs, and their role in the context of viral infections, we know much less regarding the control of the regulatory RNAs themselves. In other words, how are the regulators regulated? To provide answers to this burning question, we propose to use different viruses as models to investigate the various levels where modulation of regulatory RNA can occur. Thus, we will study the importance of RNA secondary and tertiary structure as well as accessory proteins in the regulation of miRNA primary transcript processing. In a second axis, we propose to investigate how the functional, mature miRNAs can be controlled. To this end, we will focus on the mechanisms of target-mediated miRNA decay and the role of competing endogenous RNAs. We will finally turn to the regulation of antiviral RNA silencing. Although it seems that this kind of defence mechanism exist in mammalian cells, it is not yet clear how physiologically relevant it is and how it interfaces with other innate immune mechanisms. In this multidisciplinary project, we will use a combination of techniques ranging from bioinformatics to cellular biology to achieve our goal to get a comprehensive view of how RNA silencing processes are regulated during virus infection.

Project End Date: **12/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647355	**M-Imm**	**LS6 - Immunity and Infection**

Principal Investigator: **Dr. Satu Mustjoki**
satu.mustjoki@helsinki.fi

Host Institution: Helsingin Yliopisto, FI

Novel etiology of autoimmune disorders: the role of acquired somatic mutations in lymphoid cells

Molecular pathogenesis of most immune-mediated disorders, such as of autoimmune diseases, is poorly understood. These common maladies carry a heavy burden both on patients and on society. Current therapy is non-targeted and results in significant short- and long-term adverse effects.Large granular lymphocyte (LGL) leukemia is characterized by expansion of cytotoxic T- or NK-cells and represents an intriguing clinical continuum between a neoplastic and an autoimmune disorder. Patients suffer from autoimmune cytopenias and rheumatoid arthritis (RA), which are thought to be mediated by LGL cells targeting host tissues. My group recently discovered that 40-50% of LGL leukemia patients carry in their lymphoid cells acquired, activating mutations in the STAT3 gene – a key regulator of immune and oncogenic processes (Koskela et al, N Engl J Med, 2012). This breakthrough discovery gives insight to the pathogenesis of autoimmune disorders at large. I present here a hypothesis that a strong antigen-induced proliferation is a mutational driver, which causes somatic mutations in lymphoid cells. When mutations hit key activating pathways, autoreactive cells acquire functional advantage and expand. The target antigen of the expanded clone determines the clinical characteristics of the autoimmune disease induced. To prove this hypothesis, we will separate small lymphocyte clones from patients with autoimmune diseases and use sensitive next-generation sequencing methods to characterize the spectrum of somatic mutations in lymphoid cells. Further, we will study the function of mutated lymphocytes and examine the mechanisms of autocytotoxicity and end-organ/tissue damage. Finally, we aim to understand factors, which induce somatic mutations in lymphoid cells, such as the role of viral infections.The results will transform our understanding of molecular pathogenesis of autoimmune diseases and lead to accurate diagnostics and discovery of novel drug targets.

Project End Date: **8/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
646891	**ERVE**	**LS6 - Immunity and Infection**

Principal Investigator: **Dr. Andrew Firth**
aef24@cam.ac.uk

Host Institution: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

Systematic discovery of functional elements in RNA virus genomes: an Encyclopedia of RNA Virus Elements

Identification of the full complement of genes and other functional elements in any virus is crucial to fully understand its molecular biology and guide the development of effective control strategies. Our recent discoveries of new 'hidden' genes in the potyviruses, alphaviruses, arteriviruses, flaviviruses and influenza A virus have demonstrated that, even in the most well-studied and economically-important viruses, small overlapping genes can remain undetected throughout decades of research. Comparative computational analyses can be used to efficiently identify hidden features and target experimental analyses, thus saving time and cost, and minimizing animal experiments. With the rapid increase in sequencing data, for the first time it is now possible to map out at high resolution functional elements genome-wide in hundreds of important virus species.Our research involves the development of powerful new tools for virus comparative genomics, and the application of these tools to uncover hidden genes and other functional elements in RNA virus and retrovirus genomes. Hidden genes are often translated via non-canonical mechanisms, such as programmed ribosomal frameshifting, and we are particularly interested in discovering and characterizing new types of non-canonical translation. Deciphering these 'exceptions-to-the-rule' enhances our understanding of the mechanics of protein synthesis. Further, these novel mechanisms may also be relevant to cellular gene expression.The goals of this project are:1) To computationally identify all 'hidden' genes and major functional non-coding elements in the genomes of RNA viruses and retroviruses of medical, veterinary and agricultural importance.2) To experimentally characterize the most interesting new features.3) To characterize novel translation mechanisms utilized by RNA viruses.4) To develop web interfaces to our software and an interactive RNA virus comparative genomics database.

Project End Date: **8/31/2020**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
724469	**VascArbor**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Jeroen Rouwkema** j.rouwkema@utwente.nl
Host Institution:	Universiteit Twente, NL

Vascular Tree Formation in Multi-Structural Tissue Engineering

Engineered tissues offer a great promise to the field of medicine as an alternative for donor tissues, for which the supply is not meeting the demands. However, the clinical application of engineered tissues is hampered. The integration of engineered tissues after implantation is limited due to the lack of a vascular network. Currently, strategies to include vascular networks rely on the spontaneous organization of vascular cells, or on the patterning of these cells. However, this results in either vascular networks that are not organized, or networks that lose their initial organization fast. This project will use a unique and novel approach to control vascular development and will therefore result in a vascular network with a controllable long-term organization. By allowing for anastomosis, and increasing nutrient delivery, this project will tackle an essential problem and will greatly enhance the clinical applicability of engineered tissues. Within VascArbor, fluid flows through engineered tissues will be designed and controlled to guide vascular organization. Apart from that, growth factors will be patterned in space and time to further direct the formation of a vascular network with a controlled organization. In parallel, computational models will be developed that can predict vascular organization and development based on processing parameters. This will be a breakthrough in vascularized tissue engineering by enabling a direct link between a desired vascular organization, and the tissue construct geometry and processing conditions that are needed to acquire this organization. To maximize the impact of VascArbor on the field of tissue engineering and medicine, the principles that will guide vascular organization are compatible with multiple current and future tissue fabrication technologies. Within VascArbor, tissue building blocks and bio-printing will be used to engineer vascularized cardiac muscle tissue based on the principles developed in this project.

Project End Date: **3/31/2022**

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** gunter.schumann@kcl.ac.uk
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 artifical 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 targetted early intervention, identification of novel pharmaceutical targets and the establishment of neurobehaviourally informed endpoints for clinical trials.

Project End Date: **9/30/2021**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
681712	**PATHAD**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Henrik Zetterberg** henrik.zetterberg@gu.se
Host Institution:	Goeteborgs Universitet, SE

Pathways to Alzheimer's disease

Critical to our understanding of Alzheimer's disease (AD) and also to finding therapies is determining how key pathological factors interact and relate to neuronal toxicity, symptoms and disease progression. My research has focussed on amyloid beta (Aβ) moities and demonstrated that cerebrospinal fluid (CSF) Aβ42 correlates with cerebral Aβ pathology; that Aβ accumulates in the brain 10-20 years prior to onset of symptoms; and that CSF Aβ abnormalities precede CSF tau changes. However, it is increasingly clear that a simple linear model of AD aetiology and progression is inadequate. This proposal aims at developing and validating new diagnostic and prognostic biomarker tools to examine the AD pathogenesis in humans taking a broad view of AD's multiple pathophysiological features and their putative biomarkers. The major questions, all relevant to therapeutic research, that will be addressed in my proposal include: (i) how are different forms of Aβ produced and modified; (ii) what is the toxicity of these different forms; (iii) how is this toxicity mediated; and iv) what other pathologies may contribute to or modify AD-like phenotypes? We and others have shown that Aβ monomers are relatively non-toxic. We will address the hypothesis that Aβ starts to accumulate in the brains of certain individuals due to defective clearance of the peptide. Once aggregated, Aβ acquires chemical modifications during brain incubation over years. These modified Aβ forms then induce tau hyperphosphorylation and concomitantly over-activate the immune system, resulting in neurotoxicity. Other pathologies, including α-synuclein and TDP-43, may contribute in this process. In PATHAD, we will develop and validate new diagnostic and prognostic tools using a combination of groundbreaking technologies and unique clinical materials to dissect the underlying molecular pathogenesis of AD in much greater detail than what has been possible before and facilitate the development of effective treatments.

Project End Date: **11/30/2021**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
681742	**NASCENT**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator: **Dr. Paul Franks**
paul.franks@med.lu.se

Host Institution: Lunds Universitet, SE

Novel Approach to Systematically Characterize Exercise- and Nutrient- responsive genes in Type 2 diabetes and cardiovascular disease

Proposal summary

Type 2 diabetes and cardiovascular disease are devastating and costly morbidities whose prevalences are increasing rapidly around the world. As such, there is an urgent need to develop innovative and effective prevention and treatment strategies. As numerous clinical trials have shown, lifestyle modification is by far the best way to prevent these diseases, with lifestyle being twice as effective as the best drugs, less costly and free from side effects. Yet, human biology is complex, causing some people to respond well and others poorly to the same lifestyle interventions. Thus, a huge, as yet unrealised opportunity exists to optimize the prevention and treatment of cardiometabolic diseases by tailoring lifestyle interventions to the patient's unique biology.

NASCENT is an integrated programme of research through which I will functionally annotate and later translate discoveries of gene-lifestyle interactions made through the interrogation of large epidemiological (N>100,000) datasets at my disposal. The functional annotation of these discoveries will be done using state-of-the-art epigenomic and targeted gene editing tools, whereas the translation of those findings will be achieved using a innovative and powerful clinical trial design that focuses on treatments that are tailored to the participant's genotype (genotype-based recall).

NASCENT capitalizes on a solid foundation of cohorts, methods, and expertise that I have built-up over the past fifteen years, but also exploits state-of-the-art epigenomic and gene-editing technologies that have not previously been used in studies of gene-lifestyle interactions. I expect the integration of these established and new approaches in NASCENT to propel major advances in understanding gene-lifestyle interactions in cardiometabolic disease that help optimise disease prevention.

Project End Date: **1/31/2022**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681893	**EPIScOPE**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Gonçalo Castelo Branco** goncalo.castelo-branco@ki.se
Host Institution:	Karolinska Institutet, SE

Reversing the epigenetic state of oligodendrocyte precursors cells in multiple sclerosis

Oligodendrocytes (OL) are glial cells that mediate myelination of neurons, a process that is defective in multiple sclerosis (MS). Although OL precursor cells (OPCs) can initially promote remyelination in MS, this regenerative mechanism eventually fails in progressive MS. OPCs go through several epigenetic states that ultimately define their potential to differentiate and myelinate. OPCs in progressive MS stall in a distinct epigenetic state, incompatible with differentiation and remyelination. We hypothesize that these OPCs regress to an epigenetic state reminiscent of the state of embryonic OPCs, which remain undifferentiated.

In this proposal, we aim to uncover the causes behind the remyelination failure upon disease progression in MS. We will determine the epigenetic/transcriptional states of OPCs during development and in MS, using single cell and bulk RNA sequencing and quantitative proteomics. We will further investigate how the interplay between transcription factors (TFs), chromatin modifiers (ChMs) and non-coding RNAs (ncRNAs) contributes to the transition between epigenetic states of OPCs. The results will allow the identification of ChMs and ncRNAs that can modulate these states and thereby control OPC differentiation and myelination. We will use this knowledge to investigate whether we can reverse the epigenetic state of OPCs in MS, in order to promote their differentiation and remyelination. The unique combination of leading-edge techniques such as SILAC coupled with immunoprecipitation and mass-spectrometry, single-cell RNA sequencing, ChIP-Sequencing, among others, will allow us to provide insights into novel epigenetic mechanisms that might be underlying the effects of environmental and lifestyle risk factors for MS. Moreover, this project has the potential to lead to the discovery of new targets for epigenetic-based therapies for MS, which could provide major opportunities for improved clinical outcome of MS patients in the near future.

Project End Date: **8/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
637780	**BIOELECPRO**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Martin OHalloran** martin.ohalloran@nuigalway.ie
Host Institution:	National University Of Ireland, Galway, IE

Frontier Research on the Dielectric Properties of Biological Tissue

The dielectric properties of biological tissues are of fundamental importance to the understanding of the interaction of electromagnetic fields with the human body. These properties are used to determine the safety of electronic devices, and in the design, development and refinement of electromagnetic medical imaging and therapeutic devices. Many historical studies have aimed to establish the dielectric properties of a broad range of tissues. A growing number of recent studies have sought to more accurately estimate these dielectric properties by standardising measurement procedures, and in some cases, measuring the dielectric properties in-vivo. However, these studies have often produced results in direct conflict with historical studies, casting doubt on the accuracy of the currently utilised dielectric properties. At best, this uncertainty could significantly delay the development of electromagnetic imaging or therapeutic medical devices. At worst, the health dangers of electromagnetic radiation could be under-estimated. The applicant will embark upon frontier research to develop improved methods and standards for the measurement of the dielectric properties of biological tissue. The research programme will accelerate the design and development of electromagnetic imaging and therapeutic devices, at a time when the technology is gaining significant momentum. The primary objective of the research is to develop a deep understanding of the fundamental factors which contribute to errors in dielectric property measurement. These factors will include in-vivo/ex-vivo measurements and dielectric measurement method used, amongst many others. Secondly, a new open-access repository of dielectric measurements will be created based on a greatly enhanced understanding of the mechanisms underlying dielectric property measurement. Finally, new electromagnetic-based imaging and therapeutic medical devices will be investigated, based on the solid foundation of dielectric data.

Project End Date: **9/30/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
617060	**DIRECT**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator: **Dr. Marc Vooijs**
mvooys@gmail.com

Host Institution: Universiteit Maastricht, NL

Disabling Radiotherapy resistance in Cancer Treatment

Cancer is a devastating disease affecting 1 in 3 people in their lifetime. The incidence is rising because of our aging population and causes a huge economic impact on our society because of hospitalization and lost productivity. Radiotherapy alone or in combination with surgery and/or chemotherapy is used in ~50% of all patients and uses ionizing radiation to induce DNA breaks that are lethal to cells. While significant progress has been made, radiotherapy is often limited because of side-effects in normal tissues and tumor control often fails because of resistance and metastases. Novel treatment paradigms are urgently needed. Among the key classical biological factors that determine radiation response in normal and tumor cells are the 4R; Reoxygenation, Repopulation, Redistribution and Repair. They are determined by intrinsic (genetic) as well as extrinsic factors from the tumor microenvironment and underlie tumor heterogeneity a hallmark of cancers and a decisive factor in clinical response. Yet, standard cancer treatments are largely based on the flawed assumption that tumors are homogenous within and between patients. We hypothesized that NOTCH signaling and tumor hypoxia cause tumor heterogeneity and are tumor selective therapeutic targets. First we will study key biological mechanisms that determine intra tumor heterogeneity, second we will establish their role in therapy response and third we will exploit this knowledge to enhance radiotherapy and provide proof of concept of a highly innovative approach to selectively activate cancer therapeutics targeting the NOTCH stem cell pathway in therapy resistant tumor cells without adverse effects in normal tissues.

DIRECT interrogates the molecular details of key cancer therapy response parameters providing opportunities for the next generation of tumor cell specific treatments that improve disease outcome.

Project End Date: **4/30/2019**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
678905	**CoBABATI**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Jordan Dimitrov** jordan.dimitrov@crc.jussieu.fr
Host Institution:	Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

Cofactor Binding Antibodies – Basic Aspects and Therapeutic Innovations

The immune repertoire of healthy individuals contains a fraction of antibodies (Abs) that are able to bind with high affinity various endogenous or exogenous low molecular weight compounds, including cofactors essential for the aerobic life, such as riboflavin, heme and ATP. Despite identification of cofactor-binding Abs as a constituent of normal immune repertoires, their fundamental characteristics and have not been systematically investigated. Thus, we do not know the origin, prevalence and physiopathological significance of cofactor-binding Abs. Moreover, the molecular mechanisms of interaction of cofactors with Abs are ill defined. Different proteins use cofactors to extend the chemistry intrinsic to the amino acid sequence of their polypeptide chain(s). Thus, one can speculate that the alliance of Abs with low molecular weight compounds results in the emergence of untypical properties of Abs and offers a strategy for designing a new generation of therapeutic Abs. Moreover, cofactor-binding Abs may be used for delivery of cytotoxic compounds to particular sites in the body, or for scavenging pro-inflammatory compounds. The principal goal of the present proposal is to gain a basic understanding on the fraction of cofactor-binding Abs in immune repertoires and to use this knowledge for the rational design of novel classes of therapeutic Abs. In this project, we will address the following questions: 1) understand the origin and prevalence of cofactor-binding Abs in immune repertoires; 2) characterize the molecular mechanisms of interaction of cofactors with Abs; 3) Understand the physiopathological roles of cofactor-binding Abs, and 4) use cofactor binding for the development of novel types of therapeutic Abs. A comprehensive understanding of various aspects of cofactor-binding Abs should lead to advances in fundamental understanding and in the development of innovative therapeutic and diagnostic tools.

Project End Date: **8/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682540	**TransMID**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Niel Hens** niel.hens@uhasselt.be
Host Institution:	Universiteit Hasselt, BE

Translational and Transdisciplinary research in Modeling Infectious Diseases

TransMID focuses on the development of novel methods to estimate key epidemiological parameters from both serological and social contact data, with the aim to significantly expand the range of public health questions that can be adequately addressed using such data. Using new statistical and mathematical theory and newly collected as well as readily available serological and social contact data (mainly from Europe), fundamental mathematical and epidemiological challenges as outlined in the following work packages will be addressed: (a) frequency and density dependent mass action relating potential effective contacts to transmission dynamics in (sub)populations of different sizes with an empirical assessment using readily available contact data, (b) behavioural and temporal variations in contact patterns and their impact on the dynamics of infectious diseases, (c) close contact household networks and the assumption of homogeneous mixing within households, (d) estimating parameters from multivariate and serial cross-sectional serological data taking temporal effects and heterogeneity in acquisition into account in combination with the use of social contact data, and (e) finally the design of sero- and social contact surveys with specific focus on serial cross-sectional surveys. TransMID is transdisciplinary in nature with applications on diseases of major public health interest, such as pertussis, cytomegalovirus and measles. Translational methodology is placed at the heart of TransMID resulting in the development of a unifying methodology for other diseases and settings. The development of a toolbox and accompanying software allow easy and effective application of these fundamentally improved techniques on many infectious diseases and in different geographic contexts, which should maximize TransMID's impact on public health in Europe and beyond.

Project End Date: **9/30/2021**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
677772	**RespMicroFlows**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Josue Sznitman** sznitman@bm.technion@.ac.il
Host Institution:	Technion - Israel Institute Of Technology., IL

Unravelling respiratory microflows in silico and in vitro: novel paths for targeted pulmonary delivery in infants and young children

Fundamental research on respiratory transport phenomena, quantifying momentum and mass transfer in the lung depths, is overwhelmingly focused on adults. Yet, children are not just miniature adults; their distinct lung structures and heterogeneous ventilation patterns set them aside from their parents. In RespMicroFlows, we will break this cycle and unravel the complex microflows characterizing alveolar airflows in the developing pulmonary acini. Our discoveries will foster ground-breaking transport strategies to tackle two urgent clinical needs that burden infants and young children. The first challenge relates to radically enhancing the delivery and deposition of therapeutics using inhalation aerosols; the second involves targeting liquid bolus installations in deep airways for surfactant replacement therapy. By developing advanced in silico numerical simulations together with microfluidic in vitro platforms mimicking the pulmonary acinar environment, our efforts will not only deliver a gateway to reliably assess the outcomes of inhaling aerosols and predict deposition patterns in young populations, we will furthermore unravel the fundamentals of liquid bolus transport to achieve optimal surfactant delivery strategies in premature neonates. By recreating cellular alveolar environments that capture underlying physiological functions, our advanced acinus-on-chips will deliver both at true scale and in real time the first robust and reliable in vitro screening platforms of exogenous therapeutic materials in the context of inhaled aerosols and surfactant-laden installations. Combining advanced engineering-driven flow visualization solutions with strong foundations in transport phenomena, fluid dynamics and respiratory physiology, RespMicroFlows will pave the way to a new and unprecedented level in our understanding and quantitative mapping of respiratory flow phenomena and act as catalyst for novel targeted pulmonary drug delivery strategies in young children.

Project End Date: **5/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
639125	**DE-ORPHAN**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. David Gloriam** david.gloriam@sund.ku.dk
Host Institution:	Københavns Universitet, DK

DEtermination of Orphan Receptor PHysiological Agonists and sigNals

G protein-coupled receptors make up both the largest membrane protein and drug target families. DE-ORPHAN aims to determine the close functional context; specifically physiological agonists and signaling pathways; and provide the first research tool compounds, of orphan peptide receptors.
Determination of physiological agonists (aka de-orphanization), by high-throughput screening has largely failed. We will introduce a new research strategy: 1) developing highly innovative bioinformatics methods for handpicking of all orphan receptor targets and candidate ligand screening libraries; and 2) employing a screening technique that can measure all signaling pathways simultaneously. The first potent and selective pharmacological tool compounds will be identified by chemoinformatic design of focused screening libraries. We will establish the ligands' structure-activity relationships important for biological activity and further optimization towards drugs. The first potent and selective Gs- and G12/13 protein inhibitors will be designed by structure-based re-optimization from a recent crystal structure of a Gq-inhibitor complex, and applied to determine orphan receptor signaling pathways and ligand pathway-bias. They will open up for efficient dissection of important signaling networks and development of drugs with fewer side effects. DE-ORPHANs design hypotheses are based on unique computational methods to analyze protein and ligand similarities and are founded on genomic and protein sequences, structural data and ligands. The interdisciplinary research strategy applies multiple ligands acting independently but in concert to provide complementary receptor characterization. The results will allow the research field to advance into studies of receptor functions and exploitation of druggable targets, ligands and mechanisms. Which physiological insights and therapeutic breakthroughs will we witness when these receptors find their place in human pharmacology and medicine?

Project End Date: **4/30/2020**

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**
g.j.boink@amc.nl

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: **3/31/2022**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
671055	**NSETHIO**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Robert Colebunders** Robert.colebunders@uantwerpen.be
Host Institution:	Universiteit Antwerpen, BE

Nodding Syndrome: a trans-disciplinary approach to identify the cause and decrease the incidence of river epilepsy

Nodding syndrome (NS) is a neurological, incurable syndrome, currently affecting mainly children between 5 and 15 years of age in South Sudan, Uganda and Tanzania. Since 1950, when NS was first described, its cause has remained a mystery. NS is characterized by head-nodding (an atonic form of epilepsy), often followed by clonic - tonic seizures, developmental retardation and faltering growth. In the affected regions, NS is a major public health problem associated with severe socio-economic consequences. After exploratory missions to South Sudan, Uganda and the Democratic Republic of the Congo (DRC), we gathered epidemiological evidence that supports the hypothesis that NS is a disease caused by a pathogen transmitted by blackflies, the vectors that transmit the parasitic worm that causes onchocerciasis. This pathogen could be an unknown neurotropic virus or another pathogen that is transmitted either independently or as a symbiont of the worm. We postulate that this pathogen is able to cause typical NS, but also other forms of epidemic epilepsy. We hypothesise that the same disease is also endemic in other onchocerciasis hyper-endemic regions e.g. in the Mbam valley, Cameroon and the Orientale Province, DRC (where it is referred to as “river epilepsy”). In this project we aim to investigate our hypotheses in South Sudan, Uganda, Tanzania, Cameroon and the DRC with a trans-disciplinary approach including clinical-epidemiological, post-mortem, eco-entomological, and metagenomic studies. We will study the effect of vector control methods and ivermectin distribution on the incidence of river epilepsy. So far a multi-country study on NS was never done and nearly all previous studies were cross-sectional, carried out during short country visits. With this long term research plan we hope to finally discover the cause of NS and detect effective control strategies to decrease the incidence of epilepsy in onchocerciasis endemic areas.

Project End Date: **9/30/2020**

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Project ID:	Project Acronym:	Evaluation Panel:
681524	**LeukaemiaTargeted**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Irmela Jeremias** Irmela.Jeremias@helmholtz-muenchen.de
Host Institution:	Helmholtz Zentrum Muenchen Deutsches Forschungszentrum Fuer Gesundheit Und Umwelt Gmbh, DE

Selecting genetic lesions with essential function for patients' leukaemia in vivo as targets for precision medicine

In Europe, around two million individuals die from cancer each year. Cancer is a genetic disease and each patient's tumour contains several genetic lesions which are identified by next generation sequencing (NGS) and influence patient's outcome. A global current challenge lies in translating NGS data into benefit of cancer patients.

As attractive novel therapeutic concept, precision medicine addresses genetic lesions using targeted therapies. A large number of targeted drugs and compounds exist and are currently developed such as kinase inhibitors; unfortunately, numerous clinical trials on targeted therapies failed.

In order to better exploit NGS data, it is important to discriminate between genetic lesions that are required and maintain patients' tumours in vivo and others that do not – an impossible mission so far. My proposal aims at solving this key question.

Using acute leukaemia as model tumour disease, we propagate primary tumour cells from patients in immuno-deficient mice. We recently pioneered a worldwide unique technique which allows the distinct genetic manipulation of individual patients' tumour cells while they grow in vivo.

We will molecularly target tumour-specific genetic lesions one by one; if tumour load is reduced, the lesion fulfils an essential function; essential lesions represent attractive therapeutic targets. Using our cutting edge technology, we will identify genetic lesions with essential, tumour-relevant function

(i) in established tumour disease and

(ii) in the clinically challenging situations of minimal residual disease and relapse.

Our approach implements a new paradigm for target selection in oncology. Our work introduces molecular target validation as important step into the value chain of precision medicine which will tailor drug development by industry and academia. Our approach will improve patient care and the success rate of clinical trials for the benefit of patients suffering acute leukaemia and putatively other cancers.

Project End Date: **7/31/2021**

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Project ID:	Project Acronym:	Evaluation Panel:
681870	**OCLD**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Yaakov Nahmias** ynahmias@cs.huji.ac.il
Host Institution:	The Hebrew University Of Jerusalem., IL

Tracking the Dynamics of Human Metabolism using Spectroscopy-Integrated Liver-on-Chip Microdevices

The liver is the main organ responsible for the systemic regulation of human metabolism, responding to hormonal stimulation, nutritional challenges, and circadian rhythms using fast enzymatic processes and slow transcriptional mechanisms. This regulatory complexity limits our ability to create efficient pharmaceutical interventions for metabolic diseases such as fatty liver disease and diabetes. In addition, circadian changes in drug metabolism can impact pharmacokinetics and pharmacodynamics affecting our ability to optimize drug dosage or properly assess chronic liver toxicity.

The challenge in rationally designing efficient drug interventions stems from current reliance on end-point assays and animal models that provide intermittent information with limited human relevance. Therefore, there is a need to develop systems capable of tracking transcriptional and metabolic dynamics of human tissue with high-resolution preferably in real time. Over the past 5 years, we established state-of-the-art models of human hepatocytes; oxygen nanosensors; and cutting-edge liver-on-chip devices, making us uniquely suited to address this challenge.

We aim to develop a platform capable of tracking the metabolism of tissue engineered livers in real time, enabling an accurate assessment of chronic liver toxicity (e.g. repeated dose response) and the deconstruction of complex metabolic regulation during nutritional events. Our approach is to integrate liver-on-chip devices, with real time measurements of oxygen uptake, infrared microspectroscopy, and continuous MS/MS analysis. This innovative endeavour capitalizes on advances in nanotechnology and chemical characterization offering the ability to non-invasively monitor the metabolic state of the cells (e.g. steatosis) while tracking minute changes in metabolic pathways. This project has the short-term potential to replace animal models in toxicity studies and long-term potential to elucidate critical aspects in metabolic homeostasis.

Project End Date: **9/30/2021**

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Project ID:	Project Acronym:	Evaluation Panel:
336493	**NATURE NANODEVICES**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Francesco Ricci** francesco.ricci@uniroma2.it
Host Institution:	Universita Degli Studi Di Roma Tor Vergata, IT

Nature-inspired theranostic nanodevices for tumor imaging, early diagnosis and targeted drug-release

Late diagnosis and difficult treatment represent major obstacles in the fight against cancer. I propose here the development of self-regulated theranostic nanodevices supporting both early cancer diagnosis and targeted, tumor-cell-specific drug-release. Specifically, I will exploit the “designability” of nucleic acids to design and optimize molecular nanodevices that undergo binding-induced conformational changes upon target binding and, in doing so, signal the presence of a specific tumor marker or release a toxic therapeutic cargo. The inspiration behind my approach is derived from nature, which employs similar nanometer-scale protein and nucleic-acid-based “switches” as devices to detect –and respond to- specific molecules even against the complex background “noise” of the physiological environment. Furthering on this “nature-inspired” synthetic biology view I will also exploit naturally occurring regulatory mechanisms (e.g., allostery, cooperativity, etc.) to tune and edit the dose-response curve of these nanodevices, improve their analytical sensitivity, and optimize drug-release efficiency. In summary, I will use biomimetic “tricks’ taken directly from nature to move beyond the state-of-the-art of sensor design, with the goal being improved diagnostics and “smarter,” more effective drug delivery. Achieving these goals will require multidisciplinary expertise in the field of analytical chemistry, biophysics, electrochemistry, bioengineering, computational chemistry and synthetic biology. In my career I have demonstrated skills and expertise in similarly complex projects and in each of these challenging fields. Finally, the development of the proposed nanodevices will significantly impact the safety, compliance and efficacy of therapies and medical procedures bringing to scientific, technological and socio-economic benefits.

Project End Date: **3/31/2019**

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

Principal Investigator: **Dr. Thomas Helleday**
thomas.helleday@scilifelab.se

Host Institution: Karolinska Institutet, SE

Targeting oxidative repair proteins for treatment of cancer and inflammation

Oxidative damage and defects in DNA repair are frequently underlying many diseases, e.g., cancer, autoimmune diseases, ischemia/reperfusion injury, neurodegenerative disorders, viral diseases and ageing. Although some molecular understanding into oxidative DNA lesions and repair proteins exist, a thorough understanding on the link to diseases is largely missing, and therapies exploiting oxidative DNA damage and repair have not emerged. Here, we will study mechanisms of nucleotide metabolism and oxidative DNA damage and repair, and generate 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: **7/31/2021**

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Project ID:	Project Acronym:	Evaluation Panel:
670951	**CleverGenes**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator: **Dr. Seppo Yla-Herttuala**
seppo.ylaherttuala@uef.fi

Host Institution: Ita-Suomen Yliopisto, FI

Novel Gene Therapy Based on the Activation of Endogenous Genes for the Treatment of Ischemia - Concepts of endogenetherapy, release of promoter pausing, promoter-targeted ncRNAs and nuclear RNAi

Background: Therapeutic angiogenesis with vascular endothelial growth factors (VEGFs) has great potential to become a novel, minimally invasive new treatment for a large number of patients with severe myocardial ischemia. However, this requires development of new technology. Advancing state-of-the-art: We propose a paradigm shift in gene therapy for chronic ischemia by activating endogenous VEGF-A,-B and -C genes and angiogenic transcription programs from the native promoters instead of gene transfer of exogenous cDNA to target tissues. We will develop a new platform technology (endogenetherapy) based on our novel concept of the release of promoter pausing and new promoter-targeted upregulating short hairpinRNAs, tissue-specific superenhancerRNAs activating specific transcription centers involving gene clusters in different chromosomal regions, small circularRNAs formed from self-splicing exons-introns that can be regulated with oligonucleotides and small molecules such as metabolites, nuclear RNAi vectors and specific CRISPR/gRNAmutatedCas9-VP16 technology with an ability to target integration into genomic safe harbor sites. After preclinical studies in mice and in a newly developed chronic cardiac ischemia model in pigs with special emphasis on the analysis of clinically relevant blood flow, metabolic and functional outcomes based on MRI, ultrasound, photoacoustic and PET imaging, the best construct will be taken to a phase I clinical study in patients with severe myocardial ischemia. Since endogenetherapy also involves epigenetic changes, which are reversible and long-lasting, we expect to efficiently activate natural angiogenic programs. Significance: If successful, this approach will begin a new era in gene therapy. Since there is a clear lack of technology capable of targeted upregulation of endogenous genes, the novel endogenetherapy approach may become widely applicable beyond cardiovascular diseases also in other areas of medicine and biomedical research.

Project End Date: **10/31/2020**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
636855	**ONCOMECHAML**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Florian Grebien** florian.grebien@lbicr.lbg.ac.at
Host Institution:	Ludwig Boltzmann Gesellschaft Gmbh, AT

Common Oncogenic Mechanisms in Multi-Partner Translocation Families in Acute Myeloid Leukemia

Acute Myeloid Leukemia (AML) is the most frequent cancer of the blood system, with >80% mortality within 5 years of diagnosis. Straightforward clinical decisions are complicated by the genetic complexity of AML. In particular, fusion proteins arising from chromosomal aberrations are recurrently found in AML and often act as strong driver oncogenes. In “Multi-Partner Translocation” (MPT) families, one specific gene is fused to many recipient loci. Due to this modular architecture, MPT families are of particular interest to comparative studies of oncogenic mechanisms. The three most common MPT families in AML represent translocations of the MLL, RUNX1 and NUP98 genes. Despite their clinical significance, the molecular mechanism of transformation remains unknown for the majority of fusion proteins and it is unclear if transforming mechanisms are conserved within and across different MPT families.We hypothesize that common oncogenic mechanisms of fusion proteins are encoded in physical and genetic cellular interaction networks that are specific to MPT families. We propose to delineate critical common effectors of oncogenic mechanisms in AML driven by MPT families through a comprehensive, comparative, functional analysis of 20 clinically representative MLL-, RUNX1- and NUP98-fusion proteins using a unique experimental pipeline. Characterization of protein interactomes and their effects on gene expression will identify common cellular denominators of MPT families, whose functional contribution will be assessed through pooled shRNA screens in clinically relevant model systems. High-confidence hits will be validated in mouse models and primary cells from AML patients. This project will generate large informative datasets and novel experimental systems that are of relevance for basic and clinical cancer research. It will contribute to improved understanding of oncogenic mechanisms, which may directly impact on diagnostic and therapeutic strategies in the management of AML.

Project End Date: **5/31/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681219	**PeptiCrad**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Vincenzo Cerullo** vincenzo.cerullo@helsinki.fi
Host Institution:	Helsingin Yliopisto, FI

Personalized oncolytic vaccines for cancer immunotherapy

This grant application proposes to develop a novel, customizable and personalized anti-cancer vaccine: peptide-coated conditionally replicating adenovirus (PeptiCrad).

Anti-cancer vaccines represent a promising approach for cancer treatment because they elicit durable and specific immune response that destroys primary tumors and distant metastases. Oncolytic viruses (OVs) are of significant interest because in addition to cytolysis they stimulate anti-tumor immune responses, thereby functioning as anti-tumor vaccines. However, their efficacy among cancer patients has been modest. One reason for this shortcoming is that the immune responses generated by virus infection primarily target the virus rather than the tumor. In addition, tumors differ across patients. Specific and personalized approaches (rather than generic virus infection strategies) are required to optimize therapy. To this end we propose to develop a novel vaccine platform that combines the strengths of OVs with the specificity of vaccines. Our technology is called PeptiCrad. PeptiCrad is a virus “dressed as a tumor”. It directly kills cancer cells (i.e., oncolytic viruses) and expresses immunomodulatory molecules (i.e., cytokines or the immune checkpoint inhibitors anti-CTLA4 or anti-PDL1); most importantly, it diverts immunity toward the tumor (i.e., the capsid becomes covered with MHC-I-restricted tumor-specific peptides).

The method that we have developed to cover the virus with tumor peptides is novel and exceeds current state-of-the-art. Importantly, it is fast and does not require genetic or chemical manipulation of the virus; this feature has a significant impact on the translational capability of the project.

Our preliminary results show great potential but significant questions regarding the development and the personalization of PeptiCrad remain to be studied. In this grant I propose two lines of research, one focused on the development and the other one on the personalization of PeptiCrad.

Project End Date: **6/30/2021**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
682379	**OPTOACOUSTOGENETICS**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Daniel Razansky** dr@tum.de
Host Institution:	Helmholtz Zentrum Muenchen Deutsches Forschungszentrum Fuer Gesundheit Und Umwelt Gmbh, DE

Hybrid Volumetric Optoacoustic-Ultrasound Tomography for Noninvasive Large-Scale Recording of Brain Activity with High Spatiotemporal Resolution

Non-invasive observation of fast spatiotemporal activity patterns of large neural populations distributed over entire brains is a longstanding goal of neuroscience. Not only would such abilities significantly promote our knowledge on brain function and its pathophysiology but they are also expected to accelerate development of novel therapies targeting neurological and neuropsychiatric disorders. The progress is hampered by the limited capacity of state-of-the-art functional neuroimaging tools, which do not permit simultaneous monitoring of whole-brain activity with an adequate spatiotemporal resolution. Our recently developed five-dimensional optoacoustic tomography technique is ideally poised to overcome these limitations – it has shown excellent capacity for imaging intrinsic contrast in entire brains of vertebrates and rodents non-invasively; delivers unmatched temporal resolution in the milliseconds range for true volumetric imaging in real time; capable of label-free observations of hemodynamic changes and sensitive to genetic markers of neural activity.

Yet, several fundamental challenges ought to be addressed before true potential of optoacoustic functional neuroimaging is unveiled. First, optoacoustic monitoring of fast neural activation under physiologically relevant stimuli and in real disease models has not been achieved. Furthermore, a variety of acoustic effects introduced by the skull compromise performance of optoacoustics in transcranial imaging of murine models, further hindering its clinical translation potential. Finally, technology needs to be developed that can deliver information from single neurons while maintaining high volumetric imaging speed. By resolving those challenges, the current project will yield a unique and groundbreaking functional neuroimaging method that can truly transform the existing paradigms in neuroscience by delivering real time information from hundreds of thousands or even millions of neurons simultaneously.

Project End Date: **9/30/2021**

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Project ID:	Project Acronym:	Evaluation Panel:
340918	**PREDIMED PLUS**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator: **Dr. Miguel Angel Martínez González**
mamartinez@unav.es

Host Institution: Universidad De Navarra, ES

Long-term effects of an energy-restricted Mediterranean diet on mortality and cardiovascular disease: the PREDIMED PLUS Study

The impact of weight loss on cardiovascular disease risk within the frame of the Mediterranean dietary pattern has not yet been tested using a sufficiently large randomized trial (Malik, Hu, 2007). We propose to run a parallel group, multi-center, randomized, primary prevention trial (PREDIMED PLUS) on men aged 55-75 years and women 65-75 years, with a body mass index ≥27 to <40 kg/m2 and meeting at least 3 criteria for the metabolic syndrome. The objective of the present research is to address the cardiovascular effect of an intensive weight-loss lifestyle intervention based on an energy-restricted traditional Mediterranean diet in comparison with a less intensive program using Mediterranean diet, but with no energy restriction, behavioural intervention or physical activity programme. The end-point is a composite of major hard clinical cardiovascular events. We hypothesize that an intensive weight-loss lifestyle intervention, including physical activity, based on the traditional Mediterranean food pattern is a sustainable long-term approach for weight reduction among overweight/obese adults and that the achieved lifestyle changes will exert beneficial effects on cardiovascular disease incidence, according to our experience (Estruch R et al., 2012) and research by other investigators (Shai et al., 2008). The rationale for the proposed investigation is that it can provide a new, affordable, and sustainable approach to reduce excess cardiovascular morbidity and mortality among overweight/obese adults, beyond what was already observed in the PREDIMED I trial.

Project End Date: **4/30/2019**

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

Principal Investigator:	**Dr. Jason Holland** jason.holland@chem.uzh.ch
Host Institution:	Universitaet Zuerich, CH

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

Spatial and temporal changes in the underlying biochemistry of cancer control disease progression and response/resistance to treatment. Developing methods to detect changes in oncogenic signaling at an early stage is vital to further our understanding of cancer, and will advance the next generation of anti-cancer therapies. 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 now a new opportunity to develop hybrid imaging protocols that can simultaneously take advantage of the functional and anatomic information available from PET/MRI to address changes in oncogenic signaling pathways. The work outlined in this interdisciplinary ERC Project is designed to advance new chemistry and imaging methods to measure changes in oncogenic signaling in various cancers before, during and after treatment using PET/MRI. The long-term goals are to expand the scope and utility of radiolabelled nanomedicines as dual-modality PET/MRI probes for detecting changes in oncogenic signaling in various cancers and develop efficient methods for translating new technologies to the clinic. Successful completion of this ERC Project has the potential to transform personalised clinical management of cancer patients via advanced PET/MRI detection of oncogenic signaling processes.

Project End Date: **8/31/2021**

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Project ID:	Project Acronym:	Evaluation Panel:
339977	**GlycoTreat**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Yvette van Kooyk** Y.vanKooyk@vumc.nl
Host Institution:	Stichting Vumc, NL

Novel vaccine generation for the treatment of cancer. A glyco-nanomedial approach instructing T cells

There is an urgent need to develop vaccines for the induction of CD8+ T-cell immunity to treat cancer and infectious diseases. Dendritic Cells (DC) have shown potential to induce antigen specific CD8+ T-cell responses with the help of CD4+ T cells, yet the efficacy by which the induction is achieved still has its limitations. The main challenge is: (a) to increase targeting efficacy to the complete repertoire of DC subsets; (b) to trigger T-cell responses by the DC that is powerful enough to eliminate a tumour (c) to implement novel human read-out systems, that mimic he human body response to evaluate vaccine efficacy. The aim of this research project is to develop new glycan-based nanomedicines targeted to DC to induce powerful T-cell responses. Within the scope of this research project these new glycan-based nanomedicines will be tested to (i) trigger a strong T-cell response to pathogens, (ii) induce a powerful and adequate T-cell response to self antigen in a tumour induced immune suppressive environment and (iii) render fundamental insights to establish a vaccine platform relevant for the treatment of cancer and infectious diseases. GlycoTreat employs an unconventional, novel glycan biotechnology approach to target a multitude of DC subsets in the human skin to validate the groundbreaking hypothesis that the local administration and molecular size and glycan valency of the targeting compound affect the efficiency of the T-cell stimulating vaccine. This research project joins the chemical design of glyco-nanomedical vaccines with immunological outcomes in our advanced in-vitro, in-situ human skin and in-vivo mouse DC model systems. While crossing the established disciplinary boundaries between chemistry, biology and medicine, Prof. van Kooyk will generate a new field of expertise in vaccine development applied in the field of cancer treatment.

Project End Date: **1/31/2019**

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Project ID:	Project Acronym:	Evaluation Panel:
639888	**REGENETHER**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Deniz Dalkara** deniz.dalkara@inserm.fr
Host Institution:	Universite Pierre Et Marie Curie - Paris 6, FR

Modeling and treating retinal degenerative disease

Gene therapy using adeno-associated viral (AAV) vectors has shown early promise in clinical trials. The therapeutic transgene cassette can be packaged in different AAV capsid pseudotypes, each having a unique transduction profile. At present, AAV capsid serotype selection for a specific clinical trial is based on effectiveness in small animal models. We (and others) have shown substantial progress in improving gene therapy for eye diseases in rodents. However, small animal studies are not often predictive of human outcome when it comes to the efficacy of viral delivery. Moreover, non-human primates used as pre-clinical animal models do not display any pathology making them unsuitable for testing efficacy. Here, I propose to overcome these bottlenecks in translational gene therapy by generating non-human primate models of retinal degeneration where effects of therapies and prosthesis on sight restoration can be tested. Generating transgenic primates using germline transgenesis would be very costly and ethically problematic. I thus propose to induce retinal disease locally, following delivery of pathogenic genes within specific subsets of cells in the non-human primate retina (Aim A). In Aim B, I propose to develop novel AAVs for use in human gene therapy using directed evolution. This bioengineering approach has yielded AAVs with enhanced delivery properties in the murine retina and applying it to post-mortem human retinas will generate AAVs responding to a clinical need in gene therapy. All together, the creation of models of disease in primates combined with novel AAVs tested in human post-mortem retinas will enable us to validate therapies aiming at vision restoration and neuroprotection in retinas with a macula and high central visual acuity, removing a major roadblock in the development of ocular therapeutics for humans.

Project End Date: **11/30/2019**

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Project ID:	Project Acronym:	Evaluation Panel:
682549	**VIREX**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator: **Dr. Mette Marie Rosenkilde**
rosenkilde@sund.ku.dk

Host Institution: Københavns Universitet, DK

Mumps VIRus EXploitation of the human adhesion receptor GPR125

Mumps virus is a re-emerging pathogen that causes painful inflammatory symptoms, such as parotitis (salivary gland infection) and orchitis (testis infection). It is highly neurotropic with evidence of brain infection in half of cases and clinical evidence in up to 10%. It is a small RNA virus belonging to the family of paramyxoviridae that includes e.g. viruses for measles and pneumonia, all having a huge impact on global economics and human health. Current vaccine programs have not managed to eliminate mumps and infections occur also in vaccinated individuals.

Seven transmembrane (7TM) receptors are important drug targets. Large DNA viruses (herpes- and pox-) assign large parts of their genomes to exploit 7TM receptors. No such mechanism has however yet been described for small viruses.Based on strong preliminary data, I will in this interdisciplinary project test the groundbreaking hypothesis that the adhesion 7TM receptor GPR125 is central for the organ damage caused by mumps virus via an interaction with the mumps virus-encoded short-hydrophobic (SH)-protein. I will do so by determining:
1 - The functional consequences of GPR125-SH-interaction at a single cell, organ and whole body level within the context of mumps virus infection
2 - The structural requirements for the GPR125-mumps virus interaction using NMR and resolution of crystal structure in preparation for future drug design
The project is high risk and high gain, yet the gain clearly exceeds the risk. On account of my past expertise in pharmacology and virology, and that of several expert collaborators, the project is indeed feasible. It has tremendous perspectives as SH-proteins are present also in other viruses. The SH-GPR125 complex might thus represent a general principle for organ damage and a mode of action more generally amenable to therapeutic interference. In fact, novel approaches, mechanism-based, might be seen as more appealing to those who fear current vaccination 'modes'.

Project End Date: **6/30/2021**

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Project ID:	Project Acronym:	Evaluation Panel:
338999	**TRANSLATE**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. STEFANO BIFFO** STEFANO.BIFFO@UNIMI.IT
Host Institution:	Universita Degli Studi Di Milano, IT

Noncoding and Translational Modulation of Gene Expression and Epigenetic Changes

Gene expression studies rely on high throughput techniques, which do not take in account conceptual limits. I will overcome this situation by exploiting two biological facts. First, RNAs that are important in tissue function are a subset of the global mass, but are always associated with the ribosomal machinery and as such should be identified. Second, gene expression is the outcome of dynamic fluctuations that with time create a unique expression pattern. We need to dynamically label cell populations that undergo stress and follow them to generate a gene expression signature. To achieve my goal, I will consider: 1. Translational stress generated by viral infection or accumulation of misfolded proteins; 2. human CD4+ T lymphocyte subsets which are key to orchestrate immune responses; 3. EIF6 model of metabolic reprogramming.

1. Activation of eIF2alpha phosphorylation by viral infection generates a translational response in which silent mRNAs containing upstream ORFs (uORF) are translated. I will exploit this observation to construct the first in vivo reporter model of translational stress. We will label genetically cells that have translational stress, to identify all the changes that a single cell undergoes after viral infection/accumulation of undegraded proteins.

2. I will selectively sequence for the first time mRNAs and ncRNAs associated with the ribosomal machinery in human cells with a defined functional status.

3. Spectacular data have shown that translation factor eIF6 regulates tumorigenesis by inducing a profound metabolic reprogramming. This observation suggests that, in vivo, translation acts upstream of transcription. We will model how a short translational input results in a complex epigenetic change.

Significance: a revolution in finding biomarkers/drug targets. Generate a map of predictors of the process from stress to disease. Dscriminate biologically active sequences from background. Define how transient translation reshapes gene expression.

Project End Date: **4/30/2019**

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Project ID:	Project Acronym:	Evaluation Panel:
336267	**3D-OA-HISTO**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator: **Dr. Simo Saarakkala**
simo.saarakkala@oulu.fi

Host Institution: Oulun Yliopisto, FI

Development of 3D Histopathological Grading of Osteoarthritis

Background: Osteoarthritis (OA) is a common musculoskeletal disease occurring worldwide. Despite extensive research, etiology of OA is still poorly understood. Histopathological grading (HPG) of 2D tissue sections is the gold standard reference method for determination of OA stage. However, traditional 2D-HPG is destructive and based only on subjective visual evaluation. These limitations induce bias to clinical in vitro OA diagnostics and basic research that both rely strongly on HPG. Objectives: 1) To establish and validate the very first 3D-HPG of OA based on cutting-edge nano/micro-CT (Computed Tomography) technologies in vitro; 2) To use the established method to clarify the beginning phases of OA; and 3) To validate 3D-HPG of OA for in vivo use. Methods: Several hundreds of human osteochondral samples from patients undergoing total knee arthroplasty will be collected. The samples will be imaged in vitro with nano/micro-CT and clinical high-end extremity CT devices using specific contrast-agents to quantify tissue constituents and structure in 3D in large volume. From this information, a novel 3D-HPG is developed with statistical classification algorithms. Finally, the developed novel 3D-HPG of OA will be applied clinically in vivo. Significance: This is the very first study to establish 3D-HPG of OA pathology in vitro and in vivo. Furthermore, the developed technique hugely improves the understanding of the beginning phases of OA. Ultimately, the study will contribute for improving OA patients' quality of life by slowing the disease progression, and for providing powerful tools to develop new OA therapies.

Project End Date: **1/31/2019**

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Project ID:	Project Acronym:	Evaluation Panel:
680200	**MYELOMANEXT**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Bruno Paiva** bpaiva@unav.es
Host Institution:	Universidad De Navarra, ES

Integrated next-generation flow cytometry and sequencing to uncover the pathway of curability in multiple myeloma

Multiple myeloma (MM) represents a unique model to investigate cancer stem cells (CSCs), circulating tumour cells (CTCs), and the mechanisms of malignant transformation and chemoresistance. Despite the substantial improvement in MM patients' outcome, the vast majority of patients eventually relapse and the disease remains largely incurable. For those patients failing to achieve deep remissions, biologically targeted research on the ultra-chemoresistant minimal residual disease (MRD) clone may allow us to understand the cellular mechanisms driving chemoresistance, and design novel therapeutic to overcome; importantly, such effort should be equally performed on two additional key players: CSCs and CTCs. On the opposite side, it is unquestionable that a selected group of patients does experience long-term survival irrespectively of the depth of response achieved, but we fail to understand the mechanisms driving sustained disease control. Is it because of persistent residual benign clones? Is it because of immune surveillance? Here, we will integrate next-generation flow cytometry and sequencing to define i) the signature of CTCs and ultra-chemoresistant MRD cells, ii) the hierarchical place of putative CSCs, iii) the genomic landscape of benign vs. malignant clones; and iv) the role of immune surveillance to achieve functional cures. Hence, we will characterize for the first-time-ever the highly-professional subclones responsible for malignant transformation, disease dissemination, and dramatic relapses after optimal response to therapy. Noteworthy, the innovative approach of this scientific proposal strongly relies on the use and expertise of highly-sensitive next-generation flow cytometry, coupled with optimized DNA- and RNA-sequencing for low-cell-numbers, and prospective patient samples longitudinally available within the scope of well-controlled clinical trials. Herein, we believe that all requirements are met to conduct this ground-breaking research program.

Project End Date: **8/31/2021**

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Project ID:	Project Acronym:	Evaluation Panel:
339228	**SEECAT**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Pablo Artal** pablo@um.es
Host Institution:	Universidad De Murcia, ES

Seeing through cataracts with advanced photonics

Cataract is the opacification of the crystalline lens of the human eye. It is usually related with age and is one of the leading causes of blindness. The increase in light scatter in the lens reduces the contrast in the retinal images severely degrading vision. The current solution is to perform surgery to remove the natural lens that is substituted by an artificial intraocular lens. This is a successful procedure restoring good quality of vision in most patients. However, in many situations it would be incredible advantageous to actually “see” through a cataractous eye. The optics of the eye is affected by two factors: aberrations and scatter. In the last decade, correcting optical aberrations in the eye was accomplished by using adaptive optics techniques. This permitted to obtain high resolution images of the retina and also to improve vision. However, the possibility of correcting scatter in the eye was never considered before. We propose here the use of spatial and temporal advanced photonics techniques for imaging through the turbid media of the cataractous lens. We envision two direct applications of this technology: a dedicated fundus camera to register images of the retina in patients affected by cataracts and a novel type of opto-electronics spectacles restoring some vision in cataract patients. The fundus camera would offer clinicians the unique opportunity to determine if there is any retinal pathology underneath the cataractous eye. The scatter-correcting goggles would be useful in those cases where surgery were not possible for any reason or as a temporarily relieve until the surgery is performed. The same type of technology could be applied in the case of normal eyes with lower levels of scatter but desiring to achieve a better than normal vision for some specific tasks. This proposal presents a completely new and disruptive idea, which if successful would render immediate and significant benefits to patients worldwide.

Project End Date: **1/31/2019**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
336331	**INCELL**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Julien Valette** julien.valette@cea.fr
Host Institution:	Commissariat A L Energie Atomique Et Aux Energies Alternatives, FR

Exploring brain intracellular space using diffusion-weighted NMR spectroscopy in vivo

Alterations of the intracellular space, including intracellular protein accumulation, organelle and cytoskeleton dislocation, and modifications in cell shape, are an early hallmark of many neurodegenerative processes. The ability to assess and quantify these alterations non-invasively would be of tremendous interest, not only in a clinical context, but also for preclinical research. However, no tool currently exists allowing such measurements.

Diffusion-weighted magnetic resonance spectroscopy (DW-MRS) gives access to the apparent diffusion coefficient (ADC) of brain metabolites in vivo, which is related to their average quadratic displacement. Since metabolites are purely intracellular, their ADC is solely governed by the properties of the intracellular space. The dependency of the ADC on the delay during which displacement is measured (the “diffusion time” Td) tells how metabolite motion deviates from free diffusion, which can in theory help untangle and quantify the different factors governing motion.

So far, DW-MRS has only been performed in a limited number of studies, for Td ranging from ~10 to ~100 milliseconds, and has not yet demonstrated its ability to quantitatively assess the intracellular space. In the present work, we will develop cutting-edge DW-MRS methods to probe brain metabolite motion for Td varying over several orders of magnitude (from ~0.1 milliseconds to ~10 seconds). The dependency of the ADC over Td will provide unique insights about the mechanisms governing metabolite motion at very different scales. Data will be modeled to quantitatively extract parameters such as the intracellular viscosity, the size of intracellular structures, and cell shape and size. Estimated parameter values will be compared to values derived from other techniques, such as microscopy. Finally, developed methods will be used to investigate early alterations of the intracellular space in animal models of neurodegeneration.

Project End Date: **11/30/2018**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
715737	**QuantSURG**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Sylvain Gioux** sgioux@unistra.fr
Host Institution:	Universite De Strasbourg, FR

Quantitative Surgical Guidance for Colorectal Surgery using Endogenous Molecular Contrast

Despite significant advances in medical imaging technologies, there currently exist no tools to effectively assist healthcare professionals during colorectal surgery. Surgeons mainly rely on their own senses, vision and touch to identify diseased tissue that should be removed or healthy tissue that should be avoided. In turn, surgery remains subjective and dependent on the experience of the surgeon, resulting in unacceptable failure, recurrence and morbidity rates, as well as in significant quality of care disparities across hospitals. The hypothesis underlying our study is that near-infrared light travels deeply into living tissues and interacts with endogenous molecular constituents, namely oxy- and deoxy-hemoglobin, water and lipids, providing key information regarding tissue perfusion, oxygenation, hydration and metabolism. In turn, such information can be used to differentiate diseased from healthy tissue. We recently introduced a novel concept that enables the quantitative imaging of endogenous molecular information over large fields-of-view. Because this concept can be implemented in real-time, it is amenable to provide video-rate endogenous information during colorectal surgery. In this study, we propose to push the limits of this concept by developing ground-breaking theory & technology, and creating a novel surgical guidance device capable of real-time imaging of key endogenous information for colorectal surgery. Correlation between endogenous contrast measurements and histological tissue status will be investigated onto bowel ischemia and colorectal cancer animal models. Finally, a clinically-compatible imaging device will be fabricated and translated into a first-in-human study in patients undergoing colorectal surgery. If successful, this study has the potential to solve a longstanding clinical problem by providing real-time objective feedback during colorectal surgery.

Project End Date: **1/31/2022**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
338991	**VASCMIR**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Andy Baker** Andy.Baker@ed.ac.uk
Host Institution:	The University Of Edinburgh, UK

Vascular remodelling and miRNA therapeutics

The central hypothesis of VascmiR is that microRNAs (miRs) fundamentally control pathological remodelling of the vasculature. The complexity of vascular bed heterogeneity and subsequent response to injury, the potential importance of miRNA in vascular pathology and the paucity in knowledge relating to many facets of miRNA function in the vessel wall including target pathways, mechanistic features of miRNA-mediated cell:cell communication mediated by miRNA export and uptake etc. provides an excellent opportunity for groundbreaking basic and translational research in the field. VascmiR will envelop these concepts in a broad, cutting edge portfolio of high risk and in-depth studies that encompass fundamental research, mouse genetics to create novel models and miR intervention studies in small and large animal models coupled with targeted miRNA therapeutics. Collective synergy by assessing pulmonary as well as peripheral venous and arterial pathological vascular remodelling models of disease under a single funding mechanism will afford substantial scientific advancement. VascmiR will go beyond current state-of-the-art and create new knowledge of miRNA in vascular pathologies, all of which have important unmet clinical need. VascmiR will streamline fundamental new opportunities for targeted miRNA-based therapeutics to improve human health in cardiovascular setting. I envisage that a co-ordinated, multifaceted and integrative programme in these vascular pathology settings to better understand the mechanistic role of miRNA in vascular remodelling will have a major impact on the field, leading to early translation of advanced miRNA therapeutics in the vasculature.

Project End Date: **6/30/2019**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
716867	**EPI-Centrd**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Adam Williamson** adam.williamson@univ-amu.fr
Host Institution:	Universite D'Aix Marseille, FR

Epilepsy Controlled with Electronic Neurotransmitter Delivery

Many efficient drugs have been designed to treat neurological disorders, but have failed in the clinic because they were toxic, could not cross the blood-brain barrier, and/or had deleterious side effects in healthy regions. I propose a conceptual breakthrough to solve these three issues, with minimally-invasive organic electronic ion pumps (OEIPs) to provide targeted treatment where and when it is needed. I will use epilepsy as the disease model because of its high rate of drug-resistance (30%) and will offer concrete opportunities for clinical transfer of such state-of-the-art technology.

The clinical problem: Resective surgery is frequently the last option available to a patient with drug-resistant epilepsy (> 1 million persons in the EU). However, surgery fails in 30% of the cases and can have deleterious consequences with severe postoperative neurological deficits (impaired motor function, speech and memory). Furthermore, some cases of epilepsy are simply untreatable surgically because resective surgery would leave unacceptable damage to core functions. Clearly, a new therapeutic approach is needed when neurosurgery is not possible or deemed too risky.

The OEIP solution: As I have demonstrated, OEIPs combine state-of-the-art organic electronics and pharmacology to control epileptiform activity in vitro by directly delivering inhibitory neurotransmitters on-demand. I additionally demonstrated that thin-film flexible organic electronics can be used to create minimally-invasive depth probes for implantation which significantly reduced tissue damage compared to standard rigid implants in vivo. I will integrate OEIPs on such probes creating devices which will have both the high-quality recordings provided by the organic electrodes for electrophysiological seizure detection and the molecular delivery capability of the OEIP for seizure intervention. The devices will be a closed-loop system to detect seizure onset and intervene in the affected brain region.

Project End Date: **2/28/2022**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679777	**NORVAS**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Lars Maegdefessel** lars.maegdefessel@ki.se
Host Institution:	Karolinska Institutet, SE

Therapeutic and Biomarker Potential of long non-coding RNAs in Vascular Disease

The contribution of cardiovascular disease to human morbidity and mortality continues to steadily increase in our aging European society. In response, extraordinary efforts have been launched to determine the molecular and pathophysiological characteristics of its etiology. The collective work of multiple research groups has uncovered a complex transcriptional and post-transcriptional regulatory milieu, which is believed to be essential for maintaining cardiovascular homeostasis. Recently, non-coding RNAs, especially the ones with antisense capabilities such as microRNAs or 'natural antisense transcripts' (NATs) have received much attention. They have been identified as important transcriptional and post-transcriptional inhibitors of gene expression.

This current proposal describes the development of novel diagnostic and therapeutic strategies to limit the burden of cardiovascular disease in general, and abdominal aortic aneurysms as well as carotid stenosis and subsequent stroke in particular. Using transcriptomic profiling techniques on human diseased tissue samples, we have identified two NATs (SLFNL-AS1 and NUDT6) as novel crucial regulators of smooth muscle cell survival via targeting CTPS1 and the fibroblast growth factor 2 (FGF2) in the vascular system. We are using disease-relevant experimental in vivo models (rodents and LDLR-/- mini-pigs) to functionally assess how inhibition of these two NATs influences aneurysm progression and atherosclerotic plaque vulnerability. One focus of our studies is to utilize local delivery mechanisms for non-coding RNA modulators, such as drug eluting balloons and stents, to enhance the translational feasibility of our findings. Furthermore, we have access to unique human plasma material from patients with early and advanced forms of aneurysm disease, enabling us to investigate the biomarker value of non-coding RNAs in recognizing patients with acutely ruptured aneurysms, as well as predicting the future risk of rupture.

Project End Date: **4/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
336159	**MIXTURE**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator: **Dr. Andreas Bender**
ab454@cam.ac.uk

Host Institution: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

Synergistic Modelling of Molecular Effects via Chemical and Biological Data Integration

While conventionally effects of a chemical structure on a biological system have been determined for individual compounds, one at a time, it is now becoming apparent that biological effects of compound combination are not additive, but often conditional (antagonistic or synergistic) in nature. This phenomenon is of relevance both in the medicinal context (where drugs can be combined to have a synergistic effect), as well as the area of toxicology (where the simultaneous application of compounds shows a toxicity that is non-additive). However, it is not yet clear how to model, and anticipate, which compound combinations show this type of effect. Hence, in this work I will derive models of synergistic compound combinations, which will be prospectively validated in experiments. Furthermore, I will describe how to capture the effect of a chemical structure on a biological system on multiple levels, namely by considering structural features of the compound, its bioactivity profile, and pathway annotations and their relationship to the phenotypic effect observed. By integrating the data generated in a biologically meaningful way, this allows us to generate predictive models for the bioactivity of compound combinations. The relevance of this work ranges from the question which drugs can be combined in a synergistic manner and which combinations should rather be avoided to the safety assessment of chemicals. Hence, with this work I will be able to improve upon the current state-of-the-art in bioactivity data integration and modelling approaches, as well as deliver concrete models for the bioactivity assessment of compound combinations.

Project End Date: **1/31/2019**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
638965	**INTESTINANOS**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Christel Bergström** Christel.bergstrom@farmaci.uu.se
Host Institution:	Uppsala Universitet, SE

Intestinal Lipoidal Nanostructures - A Lipid Bridge to Increased Drug Delivery

My research program explores molecular interplay between drug, dosage form and the complex environment of the gastrointestinal tract (GIT). Drug molecules currently being discovered to cure e.g. CNS diseases, cancer and the metabolic syndrome show poor water solubility and 70-90% of recently discovered drugs have too poor solubility to allow absorption from the GIT. For such compounds the dosage form can significantly improve the absorption. My long-term goal is to establish a computational platform that predicts, from molecular structures and computational tools, the development potential of drug molecules to well-functioning orally administered medicines. A major gap to understand drug performance in the intestine is the poor knowledge of the dynamics of solubilizing lipoidal nanostructures (micelles, vesicles, oil droplets) present in the fluid. This project explores restructuring of these lipid colloids in response to intake of food or dosage forms, enzymatic digestion, absorption and transit along the GIT. Novel experimental tools are developed to reveal the impact of these nanostructures on drug solubilization, supersaturation and likelihood of precipitation in vivo, all being important for drug absorption. The experimental results are fed into in silico models taking use of Molecular Dynamics simulations to develop a computational platform predicting drug performance in the dynamic intestinal milieu. The novel tools designed herein will allow dosage forms that improve performance and increase drug absorption after oral administration to, for the first time, be designed by computational means. The results of this project, in particular the novel in silico tools exploring rearrangement of lipoidal nanostructures, are highly important to related areas such as GIT disease models and food processing but also have wider applications in e.g. studies of intracellular vesicle rearrangements and transport processes in plants.

Project End Date: **8/31/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
639377	**DrugsInPregnancy**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator: **Dr. Hedvig Nordeng**
h.m.e.nordeng@farmasi.uio.no

Host Institution: Universitetet I Oslo, NO

Effects of Medication Use in Pregnancy on Infant Neurodevelopment

Currently, thousands of pregnant women in the EU and worldwide are being increasingly prescribed medications for which we do not have sufficient information on fetal safety. I hypothesize that our current understanding of safety pharmacology is oversimplified and that medication prescribed during pregnancy may play an unrecognized role in the development of neurodevelopmental disorders.

In this research proposal we have the unique opportunity to use a large population-based birth cohort including over 100 000 mother-child pairs and biological data to study how medications may act on the offspring. This offers novel and innovative pharmaceutical insight into the safety of medications.

By linking several nationwide registries (National Prescription Data Base, Norwegian Patient Registry, Medical Birth Registry) to a population-based birth cohort (n=108 000) we specifically aim to 1) estimate the effect of prenatal exposure to psychotropics and analgesics on neurodevelopment in young children using a range of methodological approaches to strengthen causal inference.

With these data made available, we will 2) determine whether fetal exposure to specific medications results in epigenetic events (i.e. changes in DNA methylation) in the child, and 3) determine whether such changes increase the risks of neurodevelopmental disorders in childhood.

The recent availability of large scale human data, possibility of register linkages and genome-wide mapping of DNA methylation at affordable costs makes this research proposal now possible. The size and richness of data including over hundred thousand pregnancies and existence of biological material makes this project unique. The final outcome will be fundamentally new knowledge about how medications affect the developing unborn child and will open up new horizons and opportunities for future research in a new field of “pharmaco-epigenetics” and enhance our understanding of origins of neurodevelopmental disorders.

Project End Date: **8/31/2020**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
669545	**ObesityDevelop**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Deborah Lawlor** d.a.lawlor@bristol.ac.uk
Host Institution:	University Of Bristol, UK

Effects of maternal gestational adiposity on fetal development and perinatal, postnatal and next generation health.

Pregnant women who are overweight/obese have increased risks of adverse perinatal outcomes, and of having offspring who are subsequently overweight/obese. A potentially important consequence of this is that it will drive the obesity epidemic across generations. Evidence from animal models supports this, but it has not been explored in humans. Furthermore, we need to know the mechanisms linking maternal adiposity to adverse offspring and next generation outcomes in order to develop preventive interventions. I will use data from up to 100,000 participants from nine cohorts and two consortia to determine the effects of maternal pregnancy levels of adiposity and associated circulating nutrients on levels of adiposity and cardiometabolic health at three periods of the lifecourse: (i) fetal development, (ii) infancy to adulthood and (iii) in the next generation. My team is world leading in this area, and we will use state-of-the-art methods to advance the field by: (i) assessing a larger number of maternal nutrients than previously; (ii) accurately assessing maternal gestational fat deposition; (iii) determining the effects of maternal exposures on fetal fat and lean mass, and metabolic response; and (iv) measuring outcomes into the next generation. Effects will be replicated in several independent cohorts and triangulated across different state-of-the-art statistical methods: (i) cross-cohort comparisons between European and low and middle income country cohorts, in which confounding structures differ; (ii) comparisons of associations of maternal exposures to equivalent associations of paternal exposures, under the assumption that intrauterine effects are maternal specific; and (iii) Mendelian randomization using genetic variants as unconfounded proxies for maternal exposures. My proposed research is important because of how many women start pregnancy overweight/obese. It will provide a step-change in knowledge of how to prevent adverse outcomes across generations.

Project End Date: **10/31/2020**

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** thomas.baumert@unistra.fr
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: **12/31/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
646734	**IXSI3D**	**LS7 - Diagnostic Tools, Therapies and Public Health**

Principal Investigator:	**Dr. Hugo de Jong** h.w.a.m.dejong@umcutrecht.nl
Host Institution:	Universitair Medisch Centrum Utrecht, NL

Translating Hybrid Imaging for Interventions: Intra-operative Guidance and Evaluation using 2D and 3D Interventional X-ray Scintigraphy Imaging

I propose to research, build and evaluate Interventional X-ray and Scintigraphy Imaging (IXSI). This will provide for the first time real-time, multimodality imaging during medical interventions by combining live x-ray and live nuclear imaging simultaneously from an identical viewpoint. The hybrid x-ray/nuclear imaging device will enable surgeons and interventional radiologists to exploit the power of molecular imaging in the operating theatre and intervention room through i) live guidance using 2D imaging and ii) 3D quantitative evaluation (IXSI3D). Systems, like the successful PET/CT and SPECT/CT, have revolutionized diagnostic medical imaging; however they acquire x-ray (anatomical information) and nuclear images (molecular information) in sequence. Our new technology brings live, hybrid imaging to operations and interventions. This will have a broad and powerful impact, particularly in oncological applications, including internal radiotherapy, tumor resection and biopsies.For combined X-ray/nuclear imaging, an x-ray tube, an x-ray detector and a gamma camera with collimator are required. Our concept relies on placing these three elements in one line, thus enabling imaging of the same field-of-view. However, straight-forward combination of these elements would block the line of views. Inspired by how eyes see around the nose, I invented a gamma camera geometry that sees around the x-ray tube. I have created a prototype, and using a provisional set-up based on this novel concept (patent pending), I have demonstrated IXSI's basic principles. This proposal describes the quantum leap in medical imaging: clinical realization of IXSI for guidance, and the development of IXSI3D that enables intra-operative quantitative evaluation. I will develop algorithms and hardware, build a mobile system and prove it's potential in a clinical research protocol. This will be the start of a new era in image-guided intervention.

Project End Date: **11/30/2020**

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** y.chen.25@warwick.ac.uk
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: **3/31/2022**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
339873	**SpeciationGenetics**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. Chris Jiggins** c.jiggins@zoo.cam.ac.uk
Host Institution:	The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

The genomic architecture of speciation in tropical butterflies

These are exciting times for speciation research with a wealth of recent theoretical and empirical advances, but there is much we still do not understand. The Heliconius butterflies offer an excellent opportunity to gain novel insights into the genetic architecture of speciation and its genomic consequences, by integrating genomic data with the well-studied ecological and behavioural processes that underlie speciation in this group. Here I will bring together two lines of recent research in speciation, a) the evolution of genetic architectures, such as clustering of barrier genes, that facilitate divergence in the face of gene flow and b) the genomic patterns of divergence. First, I will apply large-scale whole genome resequencing to study divergence and gene flow between species, and test whether speciation proceeds through divergence of gradually expanding genomic islands under divergent selection. I will also develop novel theory to interpret these patterns. Second, I will test whether loci controlling behavioural and ecological traits that cause reproductive isolation are clustered in the genome, using a genome-wide quantitative trait analysis of reproductive isolation in two hybridizing species pairs. Third, I will investigate the role of chromosomal rearrangements in reducing between-species recombination rate where species hybridize, and directly study their influence on recombination rate. Overall, the project will integrate information on the distribution of genes controlling ecological, behavioural and genetic differences between species with patterns of recombination, in order to understand the process of genome divergence and adaptive radiation. This work will offer new insights into speciation, a process fundamental to evolution and biodiversity, but also has wider implications for our understanding of the processes that drive genome evolution.

Project End Date: **5/31/2019**

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** erik.poelman@wur.nl
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: **1/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724519	**Vis-a-Vis**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. Rafael Sanjuan** rafael.sanjuan@uv.es
Host Institution:	Universitat De Valencia, ES

Collective Infectious Units and the Social Evolution of Viruses

A widely accepted view in virology is that virions function as independent infectious units. However, recent work by us and others indicates that viruses are often transmitted as more complex structures, such as virion aggregates, lipid vesicles or protein matrices harbouring multiple infectious particles. This demonstrates that viruses can be transmitted as “collective infectious units”, in sharp contrast with the current paradigm. Critically, these recent discoveries now set the stage for the evolution of social interactions, a previously unappreciated facet of viruses. I propose to investigate how collective infectious units drive virus social evolution using state-of-the-art tools from the fields of virology, genetics, structural biology, and nanotechnology. The effects of collective infectivity on viral fitness will be tested directly using experimental evolution and genetic engineering, and confirmed in vivo. Three widely different viruses will be used to achieve generality: human enteroviruses, a vector-borne rhabdovirus, and a baculovirus. Furthermore, the implications of virus social interactions for the maintenance of genetic diversity, evolvability, virulence evolution, and the emergence of drug resistance will be investigated. Radically new processes such as the putative extracellular fusion of viral particles will be also explored. I expect that infectious units constituted by viruses from different species will be uncovered as well, with far-reaching implications for epidemiology. It is becoming increasingly recognized that parasite sociality is a disease determinant, and our results may therefore inspire new antiviral strategies. In sum, this project aims at laying the foundations of virus sociality from a mechanistically-informed, bottom-up approach. Importantly, beyond their practical importance viruses will also provide a simple and tractable system that will help us to establish more general principles of social evolution.

Project End Date: **4/30/2022**

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. Ssra Magalhaes** snmagalhaes@fc.ul.pt
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: **4/30/2022**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
678792	**HeteroDynamic**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. Anna Rosling Larsson** Anna.Rosling@ebc.uu.se
Host Institution:	Uppsala Universitet, SE

Evolutionary Stability of Ubiquitous Root Symbiosis

Virtually all terrestrial plants depend on symbiotic interactions with fungi. Arbuscular mycorrhizal (AM) fungi evolved over 450 million years ago, are obligate biotrophs and cannot complete their lifecycle without obtaining carbon from host roots. Mediating nutrient uptake and sequestering carbon in soil this symbiosis lie at the core of all terrestrial ecosystems. Plants on the other hand are facultative mycotrophs but under natural conditions all host roots are colonized as a result of multiple beneficial effects of AM fungi. In the symbiosis, both plants and fungi are promiscuous, forming interactions across individuals and species. In the absence of host-symbiont specificity and given their inability to discriminate among partners prior to interaction, evolutionary theory predicts that “free riders” would evolve and spread. Yet AM fungi remain evolutionary and ecologically successful. I propose that this is thanks to their unique genomic organization, a temporally dynamic heterokaryosis. Unlike other eukaryotes, AM fungi have no single nucleate stage in their life cycle, instead they reproduce asexually by forming large multinucleate spores. Genetic variation is high and nuclei can migrate and mix within extensive mycelial networks. My group has recently established a single nucleus genomics method to study genetic variation among nuclei within AM fungi. With this method I can resolve the extent of heterokaryosis in AM fungi and its temporal dynamics. I will study the emergence of “free riders” upon intra organismal segregation of genetically distinct nuclei during AM fungal adaptation to host. Further I will study how hyphal fusion and nuclear mixing counteract segregation to stabilize the symbiosis. The research program has great potential for novel discoveries of fundamental importance to evolutionary and environmental biology and will also contribute to agricultural practice and management of terrestrial ecosystems.

Project End Date: **3/31/2021**

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Project ID:	Project Acronym:	Evaluation Panel:
639096	**HybridMiX**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. Frank Chan** frank.chan@tue.mpg.de
Host Institution:	Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Genetic Mapping of Evolutionary Developmental Variation using Hybrid Mouse in vitro Crosses

Discovering the genetic changes underlying species differences is a central goal in evolutionary genetics. Most evolutionarily important traits affecting fitness are complex or quantitative traits, whose genetic bases are elusive. In mammals, dissecting the genetic basis of complex trait variation is particularly challenging, because efficient genetic mapping requires enormous pedigrees or specialized genetic panels that are typically beyond the resources of individual groups. Using a radically novel method to circumvent breeding limitations by “breeding” mice in vitro, I propose to dissect the genetic basis of evolutionary developmental variation. This ground-breaking approach will allow me to create large genetic mapping panels of potentially any size from mouse interspecific hybrids of increasing evolutionary divergence. In vitro crosses promise a breakthrough in evolutionary biology: by bypassing hybrid sterility and inviability, we will ask which genetic changes underlie species differences. The proposed experiments address how genetic changes accumulate during evolution of new species to shape gene regulatory networks and cause phenotypic changes at the gene expression, fitness and organismal level. This research has the potential to revolutionize genetic mapping. If realized, its impact on personalized medicine, agricultural science and evolutionary research cannot be understated.

Project End Date: **7/31/2020**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
666971	**BIOSTASES**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. Michel Loreau** michel.loreau@cnrs.fr
Host Institution:	Centre National De La Recherche Scientifique, FR

BIOdiversity, STAbility and sustainability in Spatial Ecological and social-ecological Systems

Biodiversity loss is one of the greatest environmental challenges of our time. There is mounting evidence that biodiversity increases the stability of ecosystem functions and services, suggesting that it may be critical to the sustainability of ecosystems and human societies in the face of environmental changes. Classical ecological theory, however, has focused on measures of stability that cannot explain and predict these stabilizing effects, especially in spatial systems. The goal of BIOSTASES is to develop a coherent body of new theory on the stability of ecosystems and coupled social–ecological systems and its relationships with biodiversity at multiple spatial scales that can better inform empirical research. BIOSTASES will reach this goal through four complementary objectives. First, it will propose a mathematical framework focused on temporal variability as an empirically relevant measure of stability, and use this framework to build robust early warning signals for critical transitions. Second, it will use dynamical metacommunity models to explore a wide range of novel questions related to ecosystem stability and diversity–stability relationships across scales. Third, it will study the stability of complex meta-ecosystems to provide new perspectives on the stability of food webs and on synergies and trade-offs between multiple ecosystem services across space. Fourth, it will develop novel theory to study the long-term dynamics and sustainability of coupled social–ecological systems. BIOSTASES proposes an ambitious innovative research programme that will provide new perspectives on the stability and sustainability of ecological and coupled social–ecological systems in the face of environmental changes. It will contribute to bridging the gaps between theoretical and empirical ecology and between ecology and social sciences, and to developing new approaches in biodiversity conservation, landscape management, and sustainable development.

Project End Date: **8/31/2020**

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Project ID:	Project Acronym:	Evaluation Panel:
637643	**TREECLIMBERS**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. Hans Verbeeck** hans.verbeeck@ugent.be
Host Institution:	Universiteit Gent, BE

Modelling lianas as key drivers of tropical forest responses to climate change

Tropical forests are essential components of the earth system. Yet, much uncertainty exists about the exact role of this biome in the global carbon cycle. Our limited understanding of tropical forest functioning is reflected in uncertain global vegetation model projections. A large source of uncertainty in these models is their representation of ecosystem demographic processes. Interestingly, fieldwork has revealed lianas as important components of tropical forests, which are apparently increasing in abundance. Liana proliferation might be a key adaptation mechanism of tropical forests to climate change, which has potentially large impacts on the long term tropical forest biome carbon balance. Nevertheless, no single terrestrial ecosystem model currently includes lianas. TREECLIMBERS will generate important insights into the mechanisms by which lianas influence the carbon balance of tropical forests, by building the first vegetation model that includes lianas. We will make the first integrative study of (1) the contribution of lianas to instantaneous carbon and water fluxes, (2) liana contribution and influence on canopy structure, (3) their role for long term demographic processes, and (4) of their role in forest responses to drought events. TREECLIMBERS will develop the first liana plant functional type (PFT) by combining a unique global meta-analysis of existing data with innovative terrestrial LiDAR 3D measurements of the canopy to study the contribution of lianas to the canopy structure. New and available data will be integrated in the Ecosystem Demography (ED) model, a forerunner of the next generation of vegetation models. By using model-data fusion we will, for the first time, integrate the large amount of available and emerging liana data, leading to an integrated insight into the role of lianas in tropical forest functioning. This project aims to show that shifts in floristic composition due to global change may have important impacts in tropical forests.

Project End Date: **3/31/2020**

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

Principal Investigator:	**Dr. Matthias Rillig** matthias.rillig@fu-berlin.de
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: **9/30/2021**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
648861	**EVOMESODERM**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. Andreas Hejnol** andreas.hejnol@uib.no
Host Institution:	Universitetet I Bergen, NO

The evolution of mesoderm and its differentiation into cell types and organ systems

Mesoderm, the embryonic germ layer between ectoderm and endoderm, gives rise to major organs within the circulatory and excretory systems and to stabilizing tissues (muscles, bones, connective tissue). Although mesoderm is a key-innovation in evolutionary history, its origin and further diversification into the different organs and cell types of a broad range of animals has not been elucidated. Our knowledge of mesoderm development is mainly based on work performed in prominent model systems including vertebrates (fish, frog and mouse) and invertebrates that are distantly-related and considered to be highly derived (Drosophila and C. elegans). The project proposed herein aims to study mesoderm development in a variety of highly informative animal taxa and trace its differentiation into cell types and organs, with the ultimate aim of reconstructing the history of mesoderm during animal evolution. Our approach combines advanced bioinformatics, live-imaging and molecular methods, and will be carried out in nine representative species belonging to under-investigated animal groups. We will describe the morphological and molecular development of mesoderm in these species, and the differentiation of two important mesodermal cell types: nephridia and blood. Using this information we will be able to infer the embryology and mesodermal cell type composition of ancestors at six important nodes in the animal tree of life. We will also be able to comprehend when shifts in mesoderm development have occurred and how these shifts have remodeled the animal body plans. Further, our implementation of advanced methods in under-studied species will provide new model systems and a more comprehensive framework for further studies in evolutionary developmental biology as well as in other research fields.

Project End Date: **5/31/2020**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
716575	**MetaPG**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. Nicola Segata** nicola.segata@unitn.it
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: **3/31/2022**

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

Principal Investigator:	**Dr. Roger Butlin** r.k.butlin@shef.ac.uk
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: **8/31/2021**

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Project ID:	Project Acronym:	Evaluation Panel:
678148	**ComplexSex**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. Jessica Abbott** jessica.abbott@biol.lu.se
Host Institution:	Lunds Universitet, SE

Sex-limited experimental evolution of natural and novel sex chromosomes: the role of sex in shaping complex traits

The origin and evolution of sexual reproduction and sex differences represents one of the major unsolved problems in evolutionary biology, and although much progress had been made both via theory and empirical research, recent data suggest that sex chromosome evolution may be more complex than previously thought. The concept of sexual antagonism (when there is a positive intersexual genetic correlation in trait expression but opposite fitness effects of the trait(s) in males and females) has become essential to our understanding of sex chromosome evolution. The goal of this proposal is to understand how the interacting effects of sexual antagonism, sex-linked genetic variation, and sex-specific selection shape the genetic architecture of complex traits. I will test the hypotheses that: 1) individual sexually antagonistic loci are common in the genome, both in separate-sexed species and in hermaphrodites, and drive patterns of sexual antagonism often seen on the trait level. 2) That the response to sex-specific selection in sex-linked loci is usually due to standing sexually antagonistic genetic variation. 3) That sexually antagonistic variation is primarily non-additive in nature. To accomplish this, I will use a combination of approaches, including sex-limited experimental evolution of the X chromosome and reciprocal sex chromosome introgression among distantly related populations of Drosophila, quantitative genetic analysis and experimental evolution mimicking the creation of a novel sex chromosome in the hermaphroditic flatworm Macrostomum, and analytical and simulation modeling. This project will serve to confirm or refute the assumption that trait-level sexual antagonism reflects the contributions of many individual sexually antagonistic loci, increase our understanding of the contribution of coevolution of the sex chromosomes to population divergence, and help provide us with a better general understanding of how genotype maps to phenotype.

Project End Date: **4/30/2021**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
680951	**GuppY**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. Judith Mank** Judith.mank@ucl.ac.uk
Host Institution:	University College London, UK

Recombination, sex-specific adaptation and evolution of the poeciliid sex chromosomes

Sex chromosomes have evolved independently countless times throughout the eukaryotes. As such, sex chromosomes represent one of the most pervasive examples of convergent evolution, as analogous yet unrelated sex chromosomes share many unique features that distinguish them from the rest of the genome. Although models for sex chromosome evolution have been proposed, they have been difficult to empirically test, largely because most model systems are at a terminal phase of sex chromosome divergence, and the majority of studies have therefore focused on the consequences of sex chromosome evolution. In order to understand the forces catalyzing sex chromosome evolution, we require a study system at earlier stages of sex chromosome divergence, ideally one where there is still extensive polymorphism among populations and closely related species in the degree and region of recombination suppression, and with easily identified sexually antagonistic traits. These traits are all exhibited by the Poeciliid fishes, the focus of GuppY, which is designed to test long-standing theories about sex chromosome evolution. The overarching goals of the project are to: 1) identify the mechanisms, catalysts and consequences of recombination suppression between the sex chromosomes, and 2) to quantify the role of sex-specific selection and sexual conflict in sex chromosome evolution and subsequent divergence. These goals will be accomplished through the synthesis of phenotypic, experimental and next-generation molecular genetic approaches in order to provide a cohesive and multi-faceted understanding of sex chromosome evolution. Moreover, these goals will be performed across three evolutionary levels, integrating patterns of variation within populations, among populations, and across related species, permitting insights encompassing short, medium and long time-spans and yielding unprecedented insight into multiple stages of evolutionary history.

Project End Date: **7/31/2021**

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Project ID:	Project Acronym:	Evaluation Panel:
639192	**ALH**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. Thomas Reed** treed@ucc.ie
Host Institution:	University College Cork - National University Of Ireland, Cork, IE

Alternative life histories: linking genes to phenotypes to demography

Understanding how and why individuals develop strikingly different life histories is a major goal in evolutionary biology. It is also a prerequisite for conserving important biodiversity within species and predicting the impacts of environmental change on populations. The aim of my study is to examine a key threshold phenotypic trait (alternative migratory tactics) in a series of large scale laboratory and field experiments, integrating several previously independent perspectives from evolutionary ecology, ecophysiology and genomics, to produce a downstream predictive model. My chosen study species, the brown trout Salmo trutta, has an extensive history of genetic and experimental work and exhibits 'partial migration': individuals either migrate to sea ('sea trout') or remain in freshwater their whole lives. Recent advances in molecular parentage assignment, quantitative genetics and genomics (next generation sequencing and bioinformatics) will allow unprecedented insight into how alternative life history phenotypes are moulded by the interaction between genes and environment. To provide additional mechanistic understanding of these processes, the balance between metabolic requirements during growth and available extrinsic resources will be investigated as the major physiological driver of migratory behaviour. Together these results will be used to develop a predictive model to explore the consequences of rapid environmental change, accounting for the effects of genetics and environment on phenotype and on population demographics. In addition to their value for conservation and management of an iconic and key species in European freshwaters and coastal seas, these results will generate novel insight into the evolution of migratory behaviour generally, providing a text book example of how alternative life histories are shaped and maintained in wild populations.

Project End Date: **4/30/2020**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
617457	**PHYLOCANCER**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. David Posada** dposada@uvigo.es
Host Institution:	Universidad De Vigo, ES

Phylogeography and somatic evolution of cancer tumor cells

By far, most evolutionary research has focused on the changes that occur in the germline of individuals across generations, within and between species. For different reasons, much less attention has been given to the process of change within the somatic line of a multicellular individual. The formation of cancer tumors due to uncontrolled cell proliferation is one of the most prominent forms of somatic evolution. The evolution of cancer tumors in a body can be likened with the evolution of populations in more or less fragmented habitats. The tumor is usually a expanding population of clonal cells, which may differentiate to a bigger or lesser extent (population structure) and disperse to contiguous (range expansion) or more distant tissues (long distance colonization). During tumor progression, this population of cells is subject to distinct somatic evolutionary processes like mutation, drift, selection or migration, which can act at different points in time and geographical space. Very recently, the discovery of extensive intratumor heterogeneity, together with the rise of single cell genomics, has created an unique opportunity to study the phylogeography of cancer tumor cells. So far evolutionary inferences drawn from cancer genomes have been mostly qualitative. Here we propose to study a thousand single cell genomes from different regions in primary tumors and matched metastases. We will develop and apply state-of-the-art statistical and computational techniques from phylogenetics, phylogeography and population genomics to understand the tempo and mode of evolution of cell lineages within and between cancer tumors. By doing so we aim to construct a robust theoretical and methodological evolutionary framework that can contribute to a better understanding of the process of somatic evolution and shed light into the biology of cancer.

Project End Date: **9/30/2019**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
724805	**MultiLevelLandscape**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator: **Dr. Avigdor Eldar**
avigdor@gmail.com

Host Institution: Tel Aviv University, IL

Multilevel Selection for Specificity and Divergence in Bacteria

The evolution of specificity between interacting biological molecules underlies the diversification and expansion of biological pathways. A shift in specificity poses a serious theoretical problem; it requires coordinated mutations in the interacting partners, but mutation in one partner may lead to loss of interaction and functional failure. While some theoretical suggestions were proposed to solve this 'specificity valley crossing' problem, it remains a challenge to study this problem empirically at the molecular level. In bacteria, there are numerous divergent evolving pathways. Many of these pathways are involved in mediating conflicts between selfish genes, cells and populations. We and others have speculated that such multilevel selection can facilitate pathway divergence. Here we propose to study this link using the Rap-Phr cell-cell communication system, which has diversified to ~100 specific systems in the B. subtilis lineage. These systems consist of a receptor (Rap) and its cognate peptide pheromone (Phr) that influence multiple levels of selection. They promote their own horizontal transfer, modulate core cellular pathways, and manipulate cooperation between cells. Combining modelling with deep mutational scanning, competition assays and time-lapse microscopy we will quantitatively study all these levels of selection and their implication for diversification on a large fitness landscape. Specifically, we will (1) map the Rap-Phr interaction landscape at unprecedented resolution, constructing and screening libraries of ~106 Phr peptide variants and ~104 Rap variants. (2) Quantify the fitness effects of these systems at multiple levels of selection in biofilms. (3) Theoretically generate and experimentally verify predictions about how Rap-Phr co-evolve and diversify. Our work will pioneer the study of fitness landscapes under multilevel selection and provide a direct, quantitative, and predictive framework for understanding the evolution of specificity.

Project End Date: **2/28/2022**

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

Principal Investigator:	**Dr. John Colin Murrell** j.c.murrell@uea.ac.uk
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: **10/31/2021**

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

Principal Investigator: **Dr. Alexandra Houssaye**
houssaye@mnhn.fr

Host Institution: Centre National De La Recherche Scientifique, 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.

Project End Date: **3/31/2022**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
742288	**EVOSOM**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. Pauline Schaap** p.schaap@dundee.ac.uk
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: **4/30/2022**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
669609	**Diversity6continents**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. Vojtech Novotny** novotny@entu.cas.cz
Host Institution:	Biologicke Centrum Av Cr, V. V. I., CZ

Ecological determinants of tropical-temperate trends in insect diversity

The study will examine one of the most fundamental, yet poorly understood patterns of global biodiversity distribution: How can so many species coexist in a tropical forest? This key question of current ecology will be studied using quantitative surveys of plant-herbivore-parasitoid food webs within paired sets of tropical and temperate forests from six continents, in Papua New Guinea (PNG), Gabon, Panama, the Czech Republic, Japan, and USA, sampled using canopy cranes, truck-mounted elevated platforms and forest felling. This novel type of data will be analysed using a new rarefaction method, developed to test mechanistic explanations for biodiversity patterns along ecological gradients. It will evaluate competing hypotheses explaining latitudinal trends in insect herbivore diversity by the variation in either phylogenetic or functional diversity of plants, the host specificity of herbivores, or the diversity and specificity of their parasitoids and predators. The study will thus examine the importance of bottom-up (plants) and top-down (enemies) drivers of latitudinal trends in herbivore food webs, central to ecological theory that postulates the role of specialized herbivores as density-dependent agents of mortality involved in maintaining high tropical plant diversity. The project builds upon prior research that produced one of the largest tropical food web data sets to expand it conceptually, methodologically and geographically. It will build a globally important research facility (a canopy crane in PNG) and link researchers and infrastructure from several countries in a major effort to draw together separate lines of tropical and temperate research. Study sites in the ILTER, NEON, CTFS/SIGEO, and Canopy Crane Network will participate. The internationally recognized paraecologist program will be expanded, PhD students from both European and developing countries will be trained, and conservation of rainforests by indigenous rainforest dwellers will be leveraged.

Project End Date: **9/30/2020**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
714623	**FunKeyGut**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. David Berry** berry@microbial-ecology.net
Host Institution:	Universitaet Wien, AT

Illuminating Functional Networks and Keystone Species in the Gut

We live in an intimate symbiosis with our gut microbiota, which provides us services such as vitamin production, breakdown of dietary compounds, and immune training. Sequencing-based approaches that have been applied to catalogue the gut microbiota have revealed intriguing discoveries associating the microbiome with diet and disease. The next outstanding challenge is to unravel the many activities and interactions that define gut microbiota function. The gut microbiota is a diverse community of cooperating and competing microbes. These interactions form a network that links organisms with each other and their environment. Interactions in such a “functional network” are based partially, though not exclusively, on food webs. Certain “keystone species”, such as Rumonicoccus bromii, are thought to play a major role in these networks. Though some evidence exists for the presence of keystone species, their identity and activity remains largely unknown. As keystone species are vital to networks they are ideal targets for manipulating the gut microbiota to improve metabolic health and protect against enteropathogen infection. Given the complexity of the gut microbiota, networks can only be elucidated directly in the native community. This project aims to identify functional networks and keystone species in the human gut using novel approaches that are uniquely and ideally suited for studying microbial activity in complex communities. Using state-of-the-art methods such as stable isotope labeling, Raman microspectroscopy, and secondary ion mass spectrometry (NanoSIMS) we will illuminate functional networks in situ. This will allow us to identify what factors shape gut microbiota activity, reveal important food webs, and ultimately use network knowledge to target the microbiota with prebiotic/probiotic treatments rationally designed to promote health.

Project End Date: **3/31/2022**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
339347	**SpaceRadarPollinator**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. Lars Chittka** l.chittka@qmul.ac.uk
Host Institution:	Queen Mary University Of London, UK

Space use by bees– radar tracking of spatial movement patterns of key pollinators

Current radar tracking technology to monitor insect movements in space allows us to catch only glimpses of their spatial movements – it is severely constrained by the restricted range that can be covered, the fact that individuals can only be tracked one at a time, and the lack of a height dimension. Here we propose ground-breaking technology advances to make insect telemetry fit for the 21st century, to answer multiple fundamental questions in pollinator space use and its implications for the plants they pollinate. We will work towards transponder miniaturisation to make application to a large number of insect species viable; we will develop radar technology to allow coverage of areas of up to 10km2 and the exploration of the 3rd dimension of insect flight, and we will adapt the equipment so that multiple individuals can be traced simultaneously. We will identify the rules of bee movements at the landscape scale, and the extent to which they use familiar landmarks and learnt vectors to link multiple locations. We will explore whether speed-accuracy tradeoffs are relevant in landmark navigation. Natural resource exploration and exploitation will be monitored over the entire foraging career of select individuals, and we will quantify individual differences in space use. Tracking bees in three dimensions will allow us to ask whether looking at the landscape from above aids efficient navigation. The tracking of multiple bees simultaneously will allow us to monitor competitive interactions as well as the possibility of social learning in space use. For the first time we will also track the spatial movement strategies of queens and males to see how they interface the search for mates with the need to forage efficiently. Our findings will have wide-ranging applications not just for the understanding of pollinator space use, but also for the conservation, management, and the understanding of mating patterns in the plants they pollinate.

Project End Date: **3/31/2019**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
715097	**EVOMICROCOMM**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. Sara Mitri** sara.mitri@unil.ch
Host Institution:	Universite De Lausanne, CH

Evolving interactions in microbial communities

Microbes play an important role in various aspects of our lives, from our own health to the health of our environment. In almost all of their natural habitats, microbes live in dense communities composed of different strains and species that interact with each other. As these microbes evolve, so do the interactions between them, which alters the functioning of the community as a whole. In this project, I propose to develop theoretical and experimental tools to study and control evolving interactions between cells and species living in microbial ecosystems. This will involve three main research objectives: first, we will couple theory and experiments to disentangle and characterise the social interactions between five bacterial species that make up an ecosystem used to degrade pollutants. Our second objective will be to use this knowledge to control this same ecosystem, by directing it toward increased productivity and stability. Finally, our third objective will be to "breed" novel communities from scratch using experimental evolution to promote cooperative interactions between community members and thereby increase productivity. This interdisciplinary and ambitious research will allow us to improve existing methods in pollution degradation, and to design new microbial communities for this and other purposes. More generally, our model system will provide an in-depth conceptual understanding of microbial ecosystems and their evolution, and the tools to investigate more complex microbial communities. My ultimate vision is to possess the technology to use microbial communities to degrade waste, generate efficient biofuels, and design customised treatments for intestinal diseases. This project promises to create the foundations needed to develop this technology, and open many exciting avenues for future research.

Project End Date: **4/30/2022**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
647292	**MathModExp**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. Ivana Gudelj** I.Gudelj@exeter.ac.uk
Host Institution:	The University Of Exeter, UK

The Evolution of Competition and Cooperation: how polymorphisms in microbial populations optimise virulence and mediate drug resistance

Microbes form intricate communities where multiple strains and species communicate cooperate and compete, they can cause life-threatening diseases and destroy our food sources. Metabolism is key to these interactions, yet the way microbes acquire and utilise nutrients is often overlooked in evolutionary studies of pathogenicity, virulence and antibiotic resistance. I will address this by quantifying how microbial community composition is determined by the metabolism, genetics and physiology of individual players, establishing principles by which microbial composition affects virulence and antimicrobial resistance. Competition for resources is the most basic of ecological interactions, fundamental because one cell directly impacts the fitness of others. It is only by incorporating nutrient acquisition and utilisation into studies of virulence and antibiotic resistance that we can predict, and ultimately control, the evolutionary response of microbes to resource stresses, antimicrobials and host defences. I will address two outstanding problems:Challenge one: Pathogens must acquire nutrients from their hosts, but what combination of different resource acquisition and utilisation strategies maximise population success and, therefore, virulence?Challenge two: Antibiotics can perturb the composition of polymicrobial communities from susceptible to resistant species but how is this shift mediated by resource utilisation strategies?Fully integrating empirical data and theory, concepts from ecology and evolutionary dynamics will be key. We will formulate new theoretical tools that allow us to make predictions that will be fully challenged by data, both in vitro and in vivo. This research will exploit advances in the molecular genetics of important plant and human pathogens and we will use them to synthesise polymorphic microbial populations and polymicrobial communities. We will dissect these to understand what makes microbials so resilient to the challenges they face.

Project End Date: **8/31/2020**

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** matteo.campioli@uantwerpen.be
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: **1/31/2022**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
337023	**EcoStress**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. Dror Hawlena** dror.hawlena@mail.huji.ac.il
Host Institution:	The Hebrew University Of Jerusalem., IL

Physiological Reaction to Predation- A General Way to Link Individuals to Ecosystems

This proposal aims to advance a new general theory that links plasticity in prey responses to predation and biogeochemical processes to explain context-dependent variations in ecosystem functioning. The physiological reaction of prey to predation involves allocating resources from production to support emergency functions. An example of such a reaction is an increase in maintenance respiration concomitant with higher carbohydrate and lower N demand. Such changes in prey energy and elemental budget should alter the role prey play in regulating the quality of detrital inputs to soils. Nutrient content of detritus is an important determinant of the way soil communities regulate ecosystem processes. Thus, the physiological reaction of prey to predation can potentially explicate changes in ecosystem functioning. My first empirical examination of a few selected mechanisms of this theory has yielded very promising insights.

The main objectives of this proposal are: (1) To systematically test whether prey reactions to predation are consistent with the proposed theory's predictions across species and ecosystems; (2) to examine the interface between stress physiology and anti-predatory behaviors in explaining predator induced diet shift, and (3) to evaluate how predator induced responses at the individual level regulate ecosystem processes. To address these objectives, I propose combining manipulative field experiments, highly controlled laboratory and garden experiments, and stable-isotopes pulse chase approaches. I will examine individual prey responses and the emerging patterns across five food-chains that represent phylogenetically distant taxa and disparate ecosystems. The proposed study is expected to revolutionize our understanding of the mechanisms by which aboveground predators regulate ecosystem processes. Promoting such a mechanistic understanding is crucial to predict how human-induced changes in biodiversity will affect life-supporting ecosystem services.

Project End Date: **1/31/2019**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
616346	**WaterWalking**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. Abderrahman Khila** abderrahman.khila@ens-lyon.fr
Host Institution:	Centre National De La Recherche Scientifique, FR

Water-walking insects: marrying evo-devo with ecology for a better understanding of morphological evolution

Understanding the origin of the remarkable biodiversity in nature is an important goal in biological studies. Despite recent advances in evolutionary developmental biology, our understanding of the interaction between developmental genetic processes and the ecological environment in shaping the phenotype remains largely fragmented. This is mainly because of the difficulty to transfer molecular genetic tools to natural systems where we have a good understanding of the ecology. In this proposal, we combine original natural systems, water-walking insects, with state of the art tools of functional and developmental genetics, to study the interplay between developmental genetic pathways and the ecological environment, and how this interaction can shape adaptive phenotypic change. About 200 million years ago, the common ancestor of water-walking insects (Heteroptera, Gerromorpha) invaded water surface and radiated into a diverse array of niches, from shorelines to open oceans. This ecological transition and specialization is associated with an array of adaptive changes that enabled these insects to support their body weight and generate efficient propulsion on the water surface.

In this project, we aim to develop a multilevel functional approach that combines developmental and evolutionary genetics, ecology, and comparative genomics and transcriptomics, to study a set of key morphological traits directly associated with the initial event of transition to water surface life, and the diversification that followed. To achieve this, we chose three water-walking insects, along with a terrestrial and under-water outgroups, based on their morphology, ecology, and amenability for laboratory culturing and functional experiments. We will identify the genes and genetic changes responsible for the development and evolution of the hydrophobic bristles –a key trait that was instrumental in the transition from terrestrial to water surface life. In addition, we will identify the geneti

Project End Date: **2/28/2019**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
681715	**Virocellsphere**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. Assaf Vardi** assaf.vardi@weizmann.ac.il
Host Institution:	Weizmann Institute Of Science, IL

Host-virus chemical arms race during algal bloom in the ocean at a single cell resolution

Phytoplankton blooms are ephemeral events of exceptionally high primary productivity that regulate the flux of carbon across marine food webs. The cosmopolitan coccolithophore Emiliania huxleyi (Haptophyta) is a unicellular eukaryotic alga responsible for the largest oceanic algal blooms covering thousands of square kilometers. These annual blooms are frequently terminated by a specific large dsDNA E. huxleyi virus (EhV).

Despite the huge ecological importance of host-virus interactions, the ability to assess their ecological impact is limited to current approaches, which focus mainly on quantification of viral abundance and diversity. On the molecular basis, a major challenge in the current understanding of host-virus interactions in the marine environment is the ability to decode the wealth of “omics” data and translate it into cellular mechanisms that mediate host susceptibility and resistance to viral infection.

In the current proposal we intend to provide novel functional insights into molecular mechanisms that regulate host-virus interactions at the single-cell level by unravelling phenotypic heterogeneity within infected populations. By using physiological markers and single-cell transcriptomics, we propose to discern between host subpopulations and define their different “metabolic states”, in order to map them into different modes of susceptibility and resistance. By using advanced metabolomic approaches, we also aim to define the infochemical microenvironment generated during viral infection and examine how it can shape host phenotypic plasticity. Mapping the transcriptomic and metabolic footprints of viral infection will provide a meaningful tool to assess the dynamics of active viral infection during natural E. huxleyi blooms. Our novel approaches will pave the way for unprecedented quantification of the “viral shunt” that drives nutrient fluxes in marine food webs, from a single-cell level to a population and eventually ecosystem levels.

Project End Date: **10/31/2021**

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** m.bonizzoni@unipv.it
Host Institution:	Universita Degli Studi Di Pavia, IT

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

Recent discoveries clearly show that non-retroviral RNA viruses, despite not coding for reverse transcriptase and integrase, can transfer genetic material to their hosts, similarly to DNA viruses and retroviruses. The distribution of non-retroviral integrated RNA viruses (NIRVs) in host populations, mechanisms of NIRVs formation and effects on hosts are unclear. The main objective of this proposal is to uncover the complex biological interactions between non-retroviral RNA viruses and their hosts using the model system “Aedes albopictus and Flavivirus”. This system is ideal because Ae. albopictus is a known vector of non-retroviral RNA viruses, including several highly relevant for public health such as dengue viruses (Flaviviridae, Flavivirus) and NIRVs phylogenetically related to Flaviviruses have been identified in its genome. First, a population genomic approach will be used to interrogate the genome of Ae. albopictus from different geographic populations at their DNA and RNA levels. This approach will permit the systematic characterization of the distributions of NIRVs in natural host populations, the analyses of correlations between the presence of NIRVs and viral infections and the description of NIRVs genomic context, from which insights on mechanisms of NIRVs formation can be derived. Secondly, tissue-specificity of the NIRVs, their trans-generational stability and impact on mosquito biology will be analysed in a controlled laboratory environment. Somatic integrations could contribute to acquired immunity to their respective viruses or establishment of persistent viral infection. Germ-line integrations could have an evolutionary impact. If NIRVs affect Ae. albopictus vector competence or the genome of emerging viral populations, they could be manipulated for vector control purposes. Additionally, results on NIRV distribution in natural host populations and mechanisms of NIRVs formation will have implications in medicine because several non-retroviral RNA viruses are emerging as delivery systems for gene therapy applications.

Project End Date: **4/30/2021**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
715874	**FLIGHT**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. Emily Shepard** e.l.c.shepard@swansea.ac.uk
Host Institution:	Swansea University, UK

The true costs of bird flight: From the laboratory to the field

Flight is thought to be one of the most energetically costly of bird activities. These costs matter by virtue of their magnitude, as factors affecting flight costs can have a disproportionate impact on the overall energy balance. Flight costs are fundamentally linked to airflows, as well as behavioural responses to them, because birds react to horizontal and vertical currents by changing flight mode (i.e. flapping/ gliding), speed and route. Even minor route adjustments can radically affect the flow conditions that birds experience due to the uniquely dynamic and heterogeneous nature of the aerial environment. Yet our understanding of how airflows impact birds is in its infancy, being constrained by a lack of information on the metabolic costs of flight. Currently, the main methods for measuring flight costs in the laboratory either restrain the bird (thereby increasing energy expenditure) or suffer from low resolution, and field methods do not allow costs to be resolved in relation to fine scale movement paths. FLIGHT will use interdisciplinary approaches, integrating laboratory and field techniques, to address these grand challenges. Breakthrough methodologies will be used to (1) measure the costs of unrestrained bird flight in the laboratory and (2) derive a new proxy for power use in flight that is linked to flight performance, using accelerometry measurements from cutting-edge data loggers. Loggers will then be (3) deployed on wild birds to quantify their responses to airflows and the energetic consequences over fine scales. This will provide completely novel, mechanistic insight into the way the physical environment impacts flight costs, and (4) enable variation in flight–related energy expenditure to be modelled geographically and seasonally in model species. Overall, FLIGHT will provide new macro-ecological insight into relationships between bird distributions and flow conditions and inform assessments of how birds may be affected by changing wind regimes.

Project End Date: **3/31/2022**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
647787	**LocalAdaptation**	**LS8 - Evolutionary, Population and Environmental Biology**

Principal Investigator:	**Dr. Andrea Manica** am315@cam.ac.uk
Host Institution:	The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

Detecting Local Adaptation with Climate-Informed Spatial Genetic Models

Local adaptation, whereby individuals of a population exhibit higher fitness in their local environment compared to that experienced by other populations, has the potential to shape the distribution of genetic diversity and influence speciation. However, detecting and quantifying the extent of local adaptation is challenging, since neutral demographic processes can leave signatures which are hard to distinguish from those of local selection. In this project, I propose to quantify the extent of local adaptation in Anatomically Modern Humans by using climate-informed spatial genetic models (CISGeM) to reconstruct past population sizes, local movements, and range expansions, and thus provide a null model against which the signature of geographically-localised selection can be detected.In CISGeM, demography is affected by local resource availability, which in turn is defined by paleoclimate and paleovegetation reconstructions. By using these additional lines of evidence, it is possible to generate accurate demographic reconstructions for any number of populations, as well as integrating information from both modern and ancient genomes. Such spatially-explicit reconstructions are key for defining the expected neutral patterns due to complex demography, and thus allow us to isolate the signals of selection from this noisy background with high fidelity. The availability of paleoclimate reconstructions also enables formally testing hypotheses about the drivers of selection, integrating the changes in the strength of selection through space and time.While this project will be focused on Anatomically Modern Humans, the framework that I will develop will be applicable to the investigation of local adaptation from genomic data in any species. Such tools are very timely, given the ever-increasing availability of large genetic datasets thanks to the decreasing cost of genotyping and sequencing in both model and non-model organisms.

Project End Date: **8/31/2020**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
615217	**PS3**	**LS9 - Applied life Sciences and Non-Medical Biotechnology**

Principal Investigator:	**Dr. Dror Noy** Drorn@migal.org.il
Host Institution:	Migal Galilee Technology Center, Ltd, IL

An artificial water-soluble photosystem by protein design

This project aims at producing a fully functional light energy conversion system that is inspired by, but does not necessarily mimic, the fundamental solar energy conversion unit of natural photosynthesis – the photosystem. This is a formidable challenge that can be met with thorough understanding of biological energy and electron transfer processes, and the growing capabilities of computational protein design. Here, this knowledge and capabilities will be further developed and utilized for the design and construction of multi-cofactor, multi-subunit protein complexes with photosystem functionality. These will be designed to efficiently capture light in the visible and near infrared range, exploit it for driving the oxidation of a molecular redox carrier at one end, and providing highly reducing electrons at the other end.

Our general goal will be achieved by designing protein-cofactor complexes that will facilitate light-driven electron- and excitation energy-transfer that will make up the reaction center, and light harvesting modules, respectively. Constructing protein scaffolds that will assemble and organize arrays of multiple pigments, and chains of redox cofactors are significant challenges at the forefront of the field of protein de novo design, and current theories of biological energy and electron transfer. Success will set a new standard, well beyond the current state of the art, for our ability to use computational protein design methods for assembling functional protein-cofactor complexes. These can be used as benchmarks to test and validate the engineering principles of biological energy conversion systems, as well as new ideas about their evolution. Practically, it will open new and exciting technological possibilities for constructing artificial solar energy conversion systems from biological building blocks, which may enable their introduction into living systems and the construction of novel bioreactors for light driven fuel production.

Project End Date: **5/31/2019**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
341076	**SEXYPARTH**	**LS9 - Applied life Sciences and Non-Medical Biotechnology**

Principal Investigator:	**Dr. Abdelhafid Bendahmane** abdelhafid.bendahmane@inra.fr
Host Institution:	Institut National De La Recherche Agronomique, FR

Unraveling sex determination and parthenocarpy mechanisms to improve crops

In the last century, the use of high-yielding F1-hybrid varieties, mechanization and irrigation have insured yield improvement for major crops. In the post-genomic era, one would expect that the discovery and the optimization of the gene networks controlling key agronomic traits could contribute to another level of yield improvement. In this scenario, leader alleles will be identified and combined to produce new plant prototypes. Our proposal aims to investigate unisexual flowers development and parthenocarpy in Cucurbitaceae species and to produce new plant prototypes adapted to specific growing conditions. The rationale behind choosing plants from this family as a model system is justified by the widespread of sex morphs and the major role of many species of this family in food security. Our recent work on sex determination which led to the isolation of the first naturally occurring sex determination genes in plants, has set the ground for this project. The proposal relies on integrative analyses of datasets that will be obtained from the combination of different “omics” and genetic tools. Specific objectives include the (i) Determination of the gene networks controlling unisexual flower development and fruit shape, (ii) Comparative analysis of the sex genes in Cucurbitaceae species of different sexual morphs (iii) Determination of the gene networks controlling parthenocarpy and (iv) Production of new plant prototypes of major and orphan cucurbits and detailed phenotyping for yield. Outcomes will be transferred to the major Cucurbitaceae, melon, watermelon, cucumber and zucchini, as well as the orphan crop, bottle gourd. Cucurbitaceae in this project are considered not only as plant to improve but also as a model system to bring new insights to two breeding traits, unisexual flower development and fruit setting.

Project End Date: **3/31/2019**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
336295	**miPDesign**	**LS9 - Applied life Sciences and Non-Medical Biotechnology**

Principal Investigator:	**Dr. Stephan Wenkel** wenkel@plen.ku.dk
Host Institution:	Københavns Universitet, DK

Designing microProteins to alter growth processes in crop plants

The directed control of protein activity plays a crucial role in the regulation of growth and development of multicellular organisms. Different post-translational control mechanisms are known to influence the activity of proteins. Here, I am proposing a novel way to control the activity of proteins that function as multimeric complexes. MicroProteins, are small single-domain protein species that can influence target proteins by sequestering them into non-productive protein complexes. I have developed the concept of microProtein function and subsequently started to identify novel microProtein regulators in the model plant Arabidopsis. The aim of this proposal is to use the microProtein concept and build synthetic microProtein modules in economical import crop plants. By combining synthetic biology approaches with modern plant breeding, we intent to re-wire plant development and alter the flowering behaviour of rice. In addition, we will use a combination of artificial microProteins and microProtein-resistant transcription factors to modify the inclination angle of leaves in rice and the bioenergy model species Brachypodium distachion. Modification of the leaf angle will allow us to grow crops at higher densities, thus having the potential to increase both biomass and seed production per acreage. Finally, we aim to identify novel, evolutionary conserved microProtein-modules and unravel the mechanism of microProtein function, to study their role in plant development and adaptation.

Project End Date: **11/30/2018**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
614839	**PASTFORWARD**	**LS9 - Applied life Sciences and Non-Medical Biotechnology**

Principal Investigator:	**Dr. Kris Verheyen** kris.verheyen@ugent.be
Host Institution:	Universiteit Gent, BE

Development trajectories of temperate forest plant communities under global change: combining hindsight and forecasting (PASTFORWARD)

The last decades are characterized by an upsurge of research on the impacts of global environmental changes on forests. Climate warming, atmospheric deposition of acidifying and eutrophying pollutants and land-use change are three of the most important threats to biodiversity in temperate forests. However, most studies focused on the effects of single factors over short time periods, such that our ability to predict the combined effects of multiple global change drivers over longer time periods remains rudimentary. The lack of knowledge on effects of global change drivers on forest herb layer communities is particularly striking, since the herb layer contains the largest part of vascular plant diversity in temperate forests and provides key ecosystem services. Therefore PASTFORWARD will build an integrative understanding of the interactive effects of land-use change, atmospheric deposition and climate warming on forest herb layer communities, starting from the insight that changes in herb layer communities are driven primarily by past land use, but can be modulated by atmospheric deposition, climate warming and forest management. Indeed, it is still largely ignored that sensible predictions of herb layer development trajectories under global change can only be made by taking the forest's land-use history into account, as legacies of past land use can leave century-long imprints on forest herb layer communities. Three complementary data sources (a database with resurveyed vegetation plots, field measurements in a pan-European network of resurvey plots, and a multi-factor experiment) combined with an ecosystem model will be used. Furthermore, concepts and tools from different disciplines, ranging from history over sylviculture to community and ecosystem ecology will be applied. The results of PASTFORWARD will help forest managers and policy makers in taking more informed decisions on how to combine resource extraction with biodiversity conservation.

Project End Date: **5/31/2019**

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** arbely@bgu.ac.il
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: **6/30/2021**

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** eniko.kubinyi@ttk.elte.hu
Host Institution:	Eotvos Lorand Tudomanyegyetem, 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: **5/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
340469	**ADREEM**	**LS9 - Applied life Sciences and Non-Medical Biotechnology**

Principal Investigator:	**Dr. Mark Bradley** Mark.Bradley@ed.ac.uk
Host Institution:	The University Of Edinburgh, UK

Adding Another Dimension – Arrays of 3D Bio-Responsive Materials

This proposal is focused in the areas of chemical medicine and chemical biology with the key drivers being the discovery and development of new materials that have practical functionality and application. The project will enable the fabrication of thousands of three-dimensional "smart-polymers" that will allow: (i). The precise and controlled release of drugs upon the addition of either a small molecule trigger or in response to disease, (ii). The discovery of materials that control and manipulate cells with the identification of scaffolds that provide the necessary biochemical cues for directing cell fate and drive tissue regeneration and (iii). The development of new classes of "smart-polymers" able, in real-time, to sense and report bacterial contamination. The newly discovered materials will find multiple biomedical applications in regenerative medicine and biotechnology ranging from 3D cell culture, bone repair and niche stabilisation to bacterial sensing/removal, while offering a new paradigm in drug delivery with biomarker triggered drug release.

Project End Date: **10/31/2019**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
648026	**BioAqua**	**LS9 - Applied life Sciences and Non-Medical Biotechnology**

Principal Investigator: **Dr. Frank Hollmann**
f.hollmann@tudelft.nl

Host Institution: Technische Universiteit Delft, NL

Water as cosubstrate for biocatalytic redox reactions

The research proposed in BioAqua aims at breaking new ground in the area of catalysis by enabling water-driven biocatalytic redox reactions.Oxidoreductases are a class of enzymes with a very high potential for preparative organic synthesis, which is why they are increasingly used also on industrial scale. The current state-of-the-art, however, utilises valuable high-energy cosubstrates (such as glucose and alcohols) to promote oxidoreductases. Thereby valuable (and edible) building blocks are wasted as sacrificial electron donors which will have significant ethical (food for chemistry), economic and environmental consequences once redox biocatalysis is applied at scale.I envision utilizing water as sacrificial electron donor. Hence, a simple and abundant cosubstrate will be used instead of the valuable cosubstrates mentioned above. This will be a completely new approach in (bio)catalysis.However, activating water for this purpose water is extremely difficult due to its kinetic and thermodynamic inertness. To solve this problem, I propose using visible light as external energy source and advanced chemical catalysts to facilitate water oxidation. The electrons liberated in this process will be made available (for the first time) to promote oxidoreductases-catalysed transformations.BioAqua represents an entirely new paradigm in catalysis as I will bridge the gap between photocatalysis and biocatalysis enabling cleaner and more efficient reaction schemes.

Project End Date: **6/30/2020**

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** ehudg@post.tau.ac.il
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: **5/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
646603	**METALS**	**LS9 - Applied life Sciences and Non-Medical Biotechnology**

Principal Investigator:	**Dr. Frank Kjeldsen** frankk@bmb.sdu.dk
Host Institution:	Syddansk Universitet, DK

Formation and Characterization of Protein Post-Translational Modifications and Assessment of Cellular Responses by Application of Metals in Biological Systems

The chemistry of metals is rich and viewed in a biological context its diversity is crucial for a multitude of molecular functions in the living cell. Many of these reactions are very attractive to both academia and industry. In this proposal, I plan to develop novel applications of metal compounds to solve immediate challenges in mass spectrometry-based proteome research, but also will assess the potential risks of using nano-sized metals in our society. First, it is important to develop an efficient enzyme-independent method to synthesize large amounts of biologically relevant C-terminal amidated peptides. Presently, C-terminal peptide amidation poses a challenge in pharmaceutical production due to limitations of the two enzymes used for this purpose. The suggested approach in METALS will examine the specific binding of uranyl to artificially phosphorylated recombinant peptides. Data reveal that subsequent UV irradiation produces C-terminal amidated peptides. I will attempt to minimize the bias inherent in current phosphopeptide analysis, which comes from inefficient inhibition of phosphatases during cell lysis. Application of a recently developed gallium complex during cell lysis should limit the extent of this bias by binding phosphorylated proteins. The neutral conditions involved with the gallium complex reaction should also facilitate the possibility of enrichment of acid labile phospho-histidine peptides of which only a handful have been characterized. Finally, humans are now exposed to increasing amounts of artificially nano-metals applied via consumer products, food packages, and cosmetics. I will investigate this problem using advanced mass spectrometry, confocal microscopy, and biochemical assays of the response of human neural cells to nano-metal particles. The particular focus area will be to elucidate whether the action of nanoparticles in human neural cells may shed new light on understanding of diseases like Parkinson´s disease.

Project End Date: **2/29/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
311705	**CUMTAS**	**LS9 - Applied life Sciences and Non-Medical Biotechnology**

Principal Investigator:	**Dr. Tiina Sikanen** tiina.sikanen@helsinki.fi
Host Institution:	Helsingin Yliopisto, FI

Customized Micro Total Analysis Systems to Study Human Phase I Metabolism

The goal of this project is to develop inexpensive, high-throughput technology to screen the thus far unexplored metabolic interactions between environmental and household chemicals and clinically relevant drugs. The main influential focus will be on human phase I metabolism (redox reactions) of common toxicants like agrochemicals and plasticizers. On the basis of their structural resemblance to pharmaceuticals and endogenous compounds, many of these chemicals are suspected to have critical effects on cytochrome P450 metabolism which is the main detoxification route of pharmaceuticals in man. However, with the current analytical instrumentation, screening of such large chemical pool would take several years, and new chemicals would be introduced faster than the old ones are screened. Thus, the main technological goal of this project is to develop novel, practically zero-cost analytical instruments that enable characterization of a compound's metabolic profile at very high speed (<1 min/sample). This goal is achieved through miniaturization and high degree of integration of analytical instrumentation by microfabrication means, an approach often called lab(oratory)-on-a-chip. The microfabricated arrays are envisioned to incorporate all analytical key functions required (i.e., sample pretreatment, metabolic reaction, separation of the reaction products, detection) on a single chip. Thanks to the reduced dimensions, the amount of chemical waste and consumption of expensive reagents are significantly reduced. In this project, several different microfabrication techniques, from delicate cleanroom processes to extremely simple printing techniques, will be exploited to produce smart microfluidic designs and multifunctional surfaces. Towards the end of the project, more focus will be put on "printable microfluidics" which provides a truly low-cost approach for fabrication of highly customized microfluidic assays. Numerical modelling is also an integral part of the work.

Project End Date: **2/28/2019**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
335724	**VecSyn**	**LS9 - Applied life Sciences and Non-Medical Biotechnology**

Principal Investigator:	**Dr. Nikolai Windbichler** nikolai.windbichler@imperial.ac.uk
Host Institution:	Imperial College Of Science, Technology And Medicine, UK

Synthetic species of the mosquito vectors of human disease: from hybrid genetics to a new type of vector control

In this project I aim to generate the first synthetic species of mosquitoes derived from Anopheles gambiae, the main vector of malaria, and also from Aedes albopictus, a vector of several viral diseases, that has recently invaded Europe. The experimental generation of artificial species will prove invaluable to shed light on major biological questions concerning reproductive isolation. Furthermore, I propose a novel strategy to reduce the incidence of disease transmitted by these vectors based on the release of synthetic strains. Mathematical modelling indicates this to be a highly effective way to simultaneously suppress and replace a wild disease transmitting vector population with disease-refractory insects.

In Objective 1, I will identify genes that constitute the natural reproductive barriers in mosquitoes by analyzing the genetic makeup of progeny arising from crosses of related mosquito species. Such genes can be drawn upon for the construction of artificial barriers and help to reveal the mechanisms underlying speciation in mosquitoes.

In Objective 2, I will introduce, into the mosquito genome, artificial reproductive barriers that cause post-zygotic lethality in hybrids but that will not otherwise affect the mating propensity of parent and synthetic species. I propose a generalizable approach for the construction of artificial species barriers utilizing synthetic transcriptional activators.

In Objective 3, synthetic strains will be transformed with genes that interfere with the replication of malaria or viral pathogens and their transmission to humans and tested in cage experiments to validate their efficacy for vector control.

To carry out these experimental activities I will utilize cutting-edge next generation genetic mapping and site-specific genome-editing technologies. Knowledge arising from the development of synthetic mosquito strains will be applicable to beneficial species with a range of applications in biosafety, agriculture and biotechnology.

Project End Date: **1/31/2019**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
683163	**IDRICA**	**LS9 - Applied life Sciences and Non-Medical Biotechnology**

Principal Investigator:	**Dr. Ana Cano Delgado** ana.cano@cragenomica.es
Host Institution:	Centre De Recerca En Agrigenomica Csic-Irta-Uab-Ub, ES

Improving Drought Resistance in Crops and Arabidopsis

Drought is the first cause of agricultural losses globally, and represents a major threat to food security. Currently, plant biotechnology stands as the most promising strategy to produce crops capable of producing high yields in fed rain conditions. From the study of whole-plants, the main underlying mechanism for responses to drought stress has been uncovered, and multiple drought resistance genes have been engineered into crops. So far, plants with enhanced drought resistance displayed reduced crop yield, which imposes the search of novel approaches to uncouple drought resistance from plant growth. Our laboratory has recently shown, for the first time, that the receptors of Brassinosteroid hormones use cell-specific pathways to allocate different developmental responses during root growth. In particular, we have found that cell-specific components of the stem cell niche have the ability to control cellular responses to stress to promote stem renewal to ensure root growth. Additionally, we have also found that BR mutants are resistant to drought, together opening an exceptional opportunity to investigate the mechanisms that confer drought resistance with cellular specificity in plants. In this project, we will use Brassinosteroid signaling in the Arabidopsis root to investigate the mechanism for drought stress resistance in plant and to design novel molecules able to confer resistance to the drought stress. Finally, we will translate our research results and tools into Sorghum bicolor (Sorghum), a crop cereal of paramount importance in fed rain regions of the planet. Our research will impact in science, providing new avenues for the study of hormone signaling in plants, and in society, by providing sustainable solutions for enhance crop production in limiting water environments.

Project End Date: **10/31/2021**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
648925	**BHIVE**	**LS9 - Applied life Sciences and Non-Medical Biotechnology**

Principal Investigator:	**Dr. Emma Master** emma.master@utoronto.ca
Host Institution:	Aalto-Korkeakoulusaatio, FI

Bio-derived HIgh Value polymers through novel Enzyme function

Recent advances in systems-level study of cells and organisms have revealed the enormous potential to live more sustainably through better use of biological processes. Plants sustainably synthesize the most abundant and diverse materials on Earth. By applying recent advances in life science technology, we can better harness renewable plant resources and bioconversion processes, to develop environmentally and politically sustainable human enterprise and lifestyles. At the same time, the global market for high-value biochemicals and bioplastics from forest and agricultural sources is rapidly increasing, which presents new opportunities for forest and agricultural sectors. The overall aim of BHIVE is to illuminate uncharted regions of genome and metagenome sequences to discover entirely new protein families that can be used to sustainably synthesize novel, high-value biomaterials from renewable plant resources. The approach will include three parallel research thrusts: 1) strategic analysis of transcriptome and metagenome sequences to identify proteins with entirely unknown function relevant to biomass (lignocellulose) transformation, 2) mapping of uncharted regions within phylogenetic trees of poorly characterized enzyme families with recognized potential to modify the chemistry and biophysical properties of plant polysaccharides, and 3) the design and development of novel enzyme screens to directly address the increasing limitations of existing assays to uncover entirely new protein functions. BHIVE will be unique in its undivided focus on characterizing lignocellulose-active proteins encoded by the 30-40% of un-annotated sequence, or genomic “dark matter”, typical of nearly all genome sequences. In this way, BHIVE tackles a key constraint to fully realizing the societal and environmental benefits of the genomics era.

Project End Date: **8/31/2020**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
725061	**TEMUBLYM**	**LS9 - Applied life Sciences and Non-Medical Biotechnology**

Principal Investigator:	**Dr. Carolina Tafalla** tafalla@inia.es
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: **3/31/2022**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
726396	**OXIDISE**	**LS9 - Applied life Sciences and Non-Medical Biotechnology**

Principal Investigator:	**Dr. Roland Ludwig** roland.ludwig@boku.ac.at
Host Institution:	Universitaet Fuer Bodenkultur Wien, AT

Interaction and Kinetics of Oxidative Biomass Degrading Enzymes Resolved by High-Resolution Techniques

Current processes for lignocellulose deconstruction are unspecific and produce some constituents in poor quality. Specific biocatalysts could achieve optimal segregation together with minimal damage to cellulose and lignin and provide high-quality feedstocks for industry. Naturally occurring fungal oxidoreductases perform this task, but their characterisation – and hence their optimisation for industrial application – is difficult because of the experimental challenges. The mission of OXIDISE to develop appropriate methods to characterise lignocellulose degrading oxidoreductases, i.e. elucidate their conversions rates and to resolve their distribution and interaction in vicinity of their polymeric substrates. High-resolution techniques will be adapted to specifically detect fungal oxidoreductases like lytic polysaccharide monooxygenase, cellobiose dehydrogenase, laccase, lignin peroxidase, or members of the GMC oxidoreductase superfamily. These enzymes are all involved in the oxidative attack of recalcitrant biopolymers and are present in over 90% of fungal genomes. To overcome problems of current assaying techniques such as their low spatial and temporal resolution, OXIDISE will develop and apply techniques based on microelectrodes, scanning electron microscopy, surface plasmon resonance and fluorescence microscopy thereby pursuing three objectives: 1) study the interaction of all major oxidoreductases secreted by fungi in regard to electron transfer, regeneration of redox species and substrate cascading; 2) resolve the distribution of secreted oxidoreductases on cellulosic and lignocellulosic substrates at high resolution; 3) transfer the developed techniques to natural lignocellulose samples with growing fungal hyphae and study the secreted oxidoreductase activities. OXIDISE strives to establish new techniques to elucidate the kinetics and interactions of oxidoreductases – a long neglected enzyme class for lignocellulose depolymerisation.

Project End Date: **2/28/2022**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714239	**PERVOL**	**LS9 - Applied life Sciences and Non-Medical Biotechnology**

Principal Investigator:	**Dr. Matthias Erb** matthias.erb@ips.unibe.ch
Host Institution:	Universitaet Bern, CH

Perception of Plant Volatiles

The capacity to produce and perceive organic chemicals is essential for most cellular organisms. Plant leaves that are attacked by insect herbivores for instance start releasing distinct blends of herbivore-induced plant volatiles, which in turn can be perceived by non-attacked tissues. These tissues then respond more rapidly and more strongly to herbivore attack. One major question that constrains the current understanding of plant volatile communication is how plants perceive herbivore induced volatiles. Can plants smell danger by detecting certain volatiles with specific receptors? Or are other mechanisms at play? Answering these questions would push the boundaries of plant signaling research, as it would allow for the creation of perception impaired mutants to perform detailed analyses of the biological functions and potential agricultural benefits of plant volatile perception.
My recent work identified indole as a key herbivore induced volatile priming signal in maize. As indole is produced by many different plant species and has been well studied as a bacterial volatile, it is an ideal candidate to study the mechanisms and biological functions of plant volatile perception. The key objectives of PERVOL are 1) to develop a new high-throughput plant volatile sampling system for genetic screens of indole perception, 2) to use the system to identify molecular mechanisms of indole perception and 3) to create indole perception mutants to uncover novel biological functions of volatile priming. If successful, PERVOL will set technological standards by providing the community with an innovative and powerful volatile sampling system. Furthermore, it will push the field of plant volatile research by elucidating mechanisms of herbivore induced volatile perception, generating new genetic resources for functional investigations of plant volatile signaling and testing new potential biological functions of the perception of herbivore induced volatiles.

Project End Date: **2/28/2022**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
670216	**MYCOCHASSIS**	**LS9 - Applied life Sciences and Non-Medical Biotechnology**

Principal Investigator:	**Dr. Luis Serrano** luis.serrano@crg.eu
Host Institution:	Fundacio Centre De Regulacio Genomica, ES

Engineering of a minimal bacterial therapeutic chassis

Engineering bacteria to deliver therapeutic agents or to present antigens for vaccination is an emerging area of research with great clinical potential. The most challenging issue in this field is the selection of the right bacteria to engineer, commonly known as “chassis”. The best chassis depends on the application but there is a common drawback in bacteria used nowadays: their complexity and the lack of quantitative information for many reactions which limits genome engineering to classical trial and error approaches. In this project, we want to engineer the genome-reduced bacterium M. pneumoniae using a whole-cell model that will drive the rational to create a chassis for human and animal therapy. Its small size (816 Kbases), the lack of cell wall, and the vast amount of comprehensive quantitative –omics datasets makes this bacterium one of the best candidates for chassis design. By combining bioinformatics, -omics, and biochemistry approaches with genome engineering tools, systems biology analyses, and computational whole-cell models, MYCOCHASSIS aims to: i) develop a whole cell-model based on organism-specific experimental data that will be validated experimentally and that can predict the impact of genome modifications; ii) implement genome engineering tools to delete non-essential pathogenic and virulent elements predicted by the whole-cell model to engineer a therapeutical chassis; iii) using the whole-cell model design and engineer genes and circuits to improve growth rate in a defined medium. iv) as a proof of concept introduce orthogonal gene circuits to secrete peptides and enzymes capable of dissolving in vitro biofilms made by the lung pathogens Pseudomonas aeruginosa and Staphylococus aureus. This project will validate the usefulness of whole-cell models for synthetic biology by modelling multiple genomic modifications orientated to facilitate engineering of biological systems.

Project End Date: **10/31/2020**

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 Cecília Roque** cecilia.roque@fct.unl.pt
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: **11/30/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682387	**REVOLINC**	**LS9 - Applied life Sciences and Non-Medical Biotechnology**

Principal Investigator:	**Dr. Jérémy BOUYER** bouyer@cirad.fr
Host Institution:	Centre De Cooperation Internationale En Recherche Agronomique Pour Ledeveloppement - C.I.R.A.D. Epic, FR

Revolutionizing Insect Control

EFSA recently prohibited 75% of insecticides to account for their toxicity and ecotoxicity. Moreover, the spread of insecticide resistance and invasion of Europe by new tropical vectors and pests require the development of alternative biological techniques.

Recently, we hypothesized that shifting the vision of the sterile male from a sexual competitor only to a specific transporter of active biocides to the targeted female might boost the impact of the sterile insect technique (SIT). Here we want to demonstrate this concept using three biocides: Pyriproxifen, Bacillus thuringiensis and a Densovirus against the Tiger mosquito (Aedes albopictus). Pyriproxifen will also be tested against tsetse and fruit flies.

We will test the technology both in the laboratory and at an operational scale and model the relative impacts of SIT and boosted-SIT on the dynamics of the targeted population. Moreover, we will compare the evolutionary response of the target population to these different control pressures (multiple lethal mutations, multiple lethal mutations + biocides), for three different biocides and three demographic strategies. This will generate breakthrough knowledge on the transmission of biocides and pathogens in insects and the sustainability of genetic control, provide a new control technique for mosquitoes, and improve the cost-effectiveness of SIT in tsetse and fruit flies.

We will have to address technical issues associated to mass rearing, sterilization, sex separation and aerial release of mosquitoes as well as regulatory issues required for releasing sterile males coated with bioicides.

Project End Date: **8/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
678071	**ProNeurons**	**LS9 - Applied life Sciences and Non-Medical Biotechnology**

Principal Investigator:	**Dr. Volker Busskamp** volker.busskamp@tu-dresden.de
Host Institution:	Technische Universitaet Dresden, DE

Transcription Factor-mediated Neuronal Cell Fate Programming in Human Stem Cells

The discovery of pluripotent stem cells has expanded the working modes in biology towards the reverse engineering of specific cell types. Unlike studying developmental phenomena in vivo, we are now theoretically able to mimic some of these processes in a dish. The use of human induced pluripotent stem (iPS) cells facilitates studying the genesis of human cell types in an ethically approved setting. However, exploiting the full potency of stem cells is only possible with very few differentiated cell types. In particular, the generation of neurons is in its infancy: of the many neuronal types present in the brain, only a few types have been generated in vitro. So far, neuronal differentiation protocols are multifaceted and tailored to individual cell types. The molecular events that occur during reprogramming remain enigmatic. Hence, we cannot confer these protocols easily on producing different neurons of interest. Therefore, we plan to induce transcription factors as differentiation control buttons in human iPS cells in order to explore in vitro neurogenesis systematically. First, we will apply a human transcription factor library to conditional fluorescent iPS reporter lines, facilitating high-throughput isolation and analysis of induced neurons. Second, the underlying gene regulatory networks will be revealed using RNA-sequencing over the entire differentiation period to identify the biological rules of in vitro neuronal differentiation. We will combine these in-depth transcriptomic analyses with morphological, anatomical, and functional characterizations. Finally, based on our discoveries, we will engineer human photoreceptors that can be applied to cell transplantation experiments in retinal degeneration diseases. Conceptually, our approach paves the way for targeted “forward” programming of human iPS cells to neurons.

Project End Date: **2/28/2021**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
637675	**SYBORG**	**LS9 - Applied life Sciences and Non-Medical Biotechnology**

Principal Investigator:	**Dr. Tobias Erb** toerb@mpi-marburg.mpg.de
Host Institution:	Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

combining SYnthetic Biology and chemistry to create novel CO2-fixing enzymes, ORGanelles and ORGanisms

Carbon dioxide (CO2) is a potent greenhouse gas whose presence in the atmosphere is a critical factor for global warming. At the same time atmospheric CO2 is a cheap and readily available carbon source that can in principle be used for the synthesis of biomass/biofuels and value-added products. However, as synthetic chemistry lacks suitable catalysts to functionalize the CO2-molecule, there is an increasing need to exploit the CO2-fixing mechanisms offered by Nature for applications at the interface of chemistry and biology. This proposal is centered on reductive carboxylation, a completely novel principle of enzymatic CO2-fixation that we discovered only recently and that is one of the most efficient CO2-fixation reactions described in biology so far. First, we will focus on understanding the novel principle of reductive carboxylation, by studying its catalysis at molecular scale and single step resolution. This will allow us to derive the first detailed catalytic framework for highly efficient CO2-fixation and enable us to engineer novel carboxylation reactions and products. Second, we will establish a new in vitro platform for the assembly and optimization of artificial ("synthetic") CO2-fixation pathways that are based on reductive carboxylation and that have been calculated to be kinetically and bioenergetically favored compared with naturally existing CO2-fixation pathways. This platform closes a long-standing gap between the theory and practice of synthetic pathway design, and will be used to develop the first functional in vitro module for CO2-fixation, a "synthetic organelle". Finally, we will realize synthetic CO2-fixation in selected biological model systems. To that end, we will implement the optimized in vitro pathways in isolated chloroplasts, as well as alpha-proteobacterial hosts to create novel CO2-fixing organelles and organisms, breaking new grounds in understanding and engineering biological systems for efficient CO2-fixation.

Project End Date: **4/30/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647928	**MIMESIS**	**LS9 - Applied life Sciences and Non-Medical Biotechnology**

Principal Investigator:	**Dr. Cristina Silva Pereira** spereira@itqb.unl.pt
Host Institution:	Instituto De Tecnologia Quimica E Biologica - Universidade Nova De Lisboa, PT

Development of biomaterials through mimesis of plant defensive interfaces to fight wound infections

Fighting microbial infection of wounds, especially in immunocompromised patients, is a major challenge in the 21st century. The skin barrier is the primary defence against microbial (opportunistic) pathogens. When this barrier is breached even non-pathogenic fungi may cause devastating infections, most of which provoked by crossover fungi able to infect both plant and humans. Hence, diabetic patients (ca. 6.4% of the world population), who are prone to develop chronic non-healing wounds, constitute a major risk group. My research is driven by the vision of mimicking the functionality of plant polyesters to develop wound dressing biomaterials that combine antimicrobial and skin regeneration properties.Land plants have evolved through more than 400 million years, developing defence polyester barriers that limit pathogen adhesion and invasion. Biopolyesters are ubiquitous in plants and are the third most abundant plant polymer. The unique chemical composition of the plant polyester and its macromolecular assembly determines its physiological roles. This lipid-based polymer shows important similarities to the epidermal skin layer; hence it is an excellent candidate for a wound-dressing material. While evidences of their skin regeneration properties exist in cosmetics formulations and in traditional medicine, extracting polyesters from plants results in the loss of both native structure and inherent barrier properties hampering progress in this area.We have developed a biocompatible extraction method that preserves the plant polyester film forming abilities and their inherent biological properties. The ex-situ reconstituted polyester films display the native barrier properties, including potentially broad antimicrobial and anti-biofouling effect. This, combined with our established record in fungal biochemistry/genetics, places us in a unique position to push the development of plant polyester materials to be applied in wounds, in particular diabetic chronic wounds.

Project End Date: **8/31/2020**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
647275	**ProFF**	**LS9 - Applied life Sciences and Non-Medical Biotechnology**

Principal Investigator:	**Dr. yannick rondelez** yannick.rondelez@espci.fr
Host Institution:	Centre National De La Recherche Scientifique, FR

Programming in vitro evolution using molecular fitness functions

Natural enzymes are awesome catalysts, in terms of their catalytic efficiency, selectivity, control mechanisms, etc. Revamped as laboratory or industrial tools, they have allowed more than a few breakthroughs, such as PCR, next generation sequencing or green chemistry. The next revolution will be brought by a new generation of extensively modified “enzymatic” catalysts working in non-natural environments, possibly build from non-natural chemistries and targeting an unlimited range of non-natural functions. However, their design is still an arduous process; computational design lacks precision while the combinatorial approach, directed evolution, is limited by labor-intensive or ad hoc selection stages.We will remove the selection bottleneck in directed evolution by introducing biochemical computers able to perform this step autonomously. Based on recent developments in DNA-based molecular programming, these molecular scouts will be co-compartmentalized with genetic libraries into billions of individual compartments in micrometric emulsions. At each generation and in each droplet, after expression of the genotype, these molecular programs will autonomously: i- evaluate the phenotypic signature of a candidate, ii- integrate this information into a predefined scoring function and iii- propagate the relevant genetic information according to this score.The programmability of this approach will make directed evolution versatile, faster, and able to address more challenging problems. The evolution dynamics itself become tunable, offering new perspectives on the fitness landscape of biopolymer catalysts. A quantitative in silico model will be built and integrated in a computer-assisted tool for the fast set-up of in vitro experiments and tuning of the various experimental knobs. Overall, we will close a virtuous circle by evolving the molecular tools enabling the programmable selection of the next generation of catalytic tools.

Project End Date: **8/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
615112	**HAPDEGMT**	**PE1 - Mathematics**

Principal Investigator: **Dr. Jose Maria Martell**
chema.martell@icmat.es

Host Institution: Agencia Estatal Consejo Superior Deinvestigaciones Cientificas, ES

Harmonic Analysis, Partial Differential Equations and Geometric Measure Theory

The origin of Harmonic Analysis goes back to the study of the heat diffusion, modeled by a differential equation, and the claim made by Fourier that every periodic function can be represented as a series of sines and cosines. In this statement we can find the motivation to many of the advances that have been made in this field. Partial Differential Equations model many phenomena from the natural, economic and social sciences. Existence, uniqueness, convergence to the boundary data, regularity of solutions, a priori estimates, etc., can be studied for a given PDE. Often, Harmonic Analysis plays an important role in such problems and, when the scenarios are not very friendly, Harmonic Analysis turns out to be fundamental. Not very friendly scenarios are those where one lacks of smoothness either in the coefficients of the PDE and/or in the domains where the PDE is solved. Some of these problems lead to obtain the boundedness of certain singular integral operators and this drives one to the classical and modern Calderón-Zygmund theory, the paradigm of Harmonic Analysis. When studying the behavior of the solutions of the given PDE near the boundary, one needs to understand the geometrical features of the domains and then Geometric Measure Theory jumps into the picture. This ambitious project lies between the interface of three areas: Harmonic Analysis, PDE and Geometric Measure theory. It seeks deep results motivated by elliptic PDE using techniques from Harmonic Analysis and Geometric Measure Theory.This project is built upon results obtained by the applicant in these three areas. Some of them are very recent and have gone significantly beyond the state of the art. The methods to be used have been shown to be very robust and therefore they might be useful towards its applicability in other regimes. Crucial to this project is the use of Harmonic Analysis where the applicant has already obtained important contributions.

Project End Date: **12/31/2018**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
614195	**RIGIDITY**	**PE1 - Mathematics**

Principal Investigator: **Dr. Stefaan Vaes**
stefaan.vaes@kuleuven.be

Host Institution: Katholieke Universiteit Leuven, BE

Rigidity and classification of von Neumann algebras

Sorin Popa's deformation/rigidity theory has lead to an enormous progress in our understanding of von Neumann algebras coming from discrete groups and their actions on probability spaces. In a five year long collaboration with Sorin Popa, we solved many long-standing open problems in this area, including superrigidity theorems for group measure space II_1 factors, results on the possible fundamental groups of II_1 factors, and uniqueness theorems for Cartan subalgebras. In the first part of the project, we want to establish new unique Cartan decomposition theorems for II_1 factors coming from hitherto intractable groups. Using methods coming from Lie groups, ergodic theory and geometric group theory, we want to reach such results for lattices in higher rank simple Lie groups, and for countable groups with nonvanishing L^2-Betti numbers. An important intermediate step will be the unique Cartan decomposition of Bernoulli crossed products. Secondly we want to prove classification theorems for type III factors that are equally strong as the existing results for the type II_1 case. This includes a complete classification of the noncommutative Bernoulli shifts of the free groups and will require an intricate combination of Tomita/Takesaki and deformation/rigidity theory. The methods developed so far bring within reach an attack on two of the most important open problems in operator algebras and functional analysis: the free group factor problem and Connes's rigidity conjecture. The exact progress on these problems is of course unforeseeable, but it is sure that the research on these problems will lead to an even deeper interaction between diverse areas of mathematics as operator algebras, group theory, functional analysis, ergodic theory, and descriptive set theory. Intermediate goals are the classification of natural classes of group von Neumann algebras, including those coming from Baumslag-Solitar groups, wreath product groups, and other families of discrete groups.

Project End Date: **6/30/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724298	**DIFFINCL**	**PE1 - Mathematics**

Principal Investigator: **Dr. László Székelyhidi Jr.**
szekelyhidi@math.uni-leipzig.de

Host Institution: Universitaet Leipzig, DE

Differential Inclusions and Fluid Mechanics

Important problems in science often involve structures on several distinct length scales. Two typical examples are fine phase mixtures in solid-solid phase transitions and the complex mixing patterns in turbulent or multiphase flows. The microstructures in such situations influence in a crucial way the macroscopic behavior of the system, and understanding the formation, interaction and overall effect of these structures is a great scientific challenge. Although there is a large variety of models and descriptions for such phenomena, a recurring issue in the mathematical analysis is that one has to deal with very complex and highly non-smooth structures in solutions of the associated partial differential equations. A common ground is provided by the analysis of differential inclusions, a theory whose development was strongly influenced by the influx of ideas from the work of Gromov on partial differential relations, building on celebrated constructions of Nash for isometric immersions, and the work of Tartar in the study of oscillation phenomena in nonlinear partial differential equations. A recent success of this approach is provided by my work on the h-principle in fluid mechanics and Onsager's conjecture. Against this background my aim in this project is to go significantly beyond the state of the art, both in terms of the methods and in terms of applications of differential inclusions. One part of the project is to continue my work on fluid mechanics with the ultimate goal to address important challenges in the field: providing an analytic foundation for the K41 statistical theory of turbulence and for the behavior of turbulent flows near instabilities and boundaries. A further aim is to explore rigidity phenomena and to attack several outstanding open problems in the context of differential inclusions, most prominently Morrey's conjecture on quasiconvexity and rank-one convexity.

Project End Date: **3/31/2022**

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**
dierk@jacobs-university.de

Host Institution: Jacobs University Bremen Ggmbh, 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: **9/30/2021**

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**
d.kral@warwick.ac.uk

Host Institution: The University Of Warwick, UK

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: **11/30/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
614492	**MSMath**	**PE1 - Mathematics**

Principal Investigator: **Dr. Tony LELIEVRE**
lelievre@cermics.enpc.fr

Host Institution: Ecole Nationale Des Ponts Et Chaussees, FR

Molecular Simulation: modeling, algorithms and mathematical analysis

Many models for materials rely on a microscopic description. In a classical regime and for a fixed temperature, atoms are described by particles that interact through a force field and evolve according to Newton's equations of motion, with additional stochastic terms to model thermostating. This simulation technique is called molecular dynamics. Applications are ubiquitous, ranging from biology to materials science. The direct numerical simulation of these models is extremely computationally expensive, since the typical timescale at the microscopic level is orders of magnitude smaller than the macroscopic timescales of interest. Many algorithms used by practitioners have not yet been investigated by applied mathematicians. The aim of this proposal is to further develop the mathematical analysis of these methods and to build new and more efficient algorithms, validated by precise error estimates. The underlying theoretical questions are related to the mathematical definition and quantification of metastability for stochastic processes. Metastability refers to the fact that the stochastic process remains trapped in some regions of the configuration space for very long times. Using naive simulations, transitions between these states are very rarely observed, whereas these transition events are actually those which matter at the macroscopic level. Metastability is one of the major bottlenecks in making molecular simulations predictive for real life test cases. The main challenges motivating this proposal are: the design of efficient techniques to sample high-dimensional multimodal measures, the development and analysis of algorithms to sample metastable dynamics and the construction of coarse-graining techniques for high-dimensional problems. This project relies on strong collaborations with practitioners (biologists and physicists) in order to propose common benchmarks, to identify the methodological bottlenecks and to apply new algorithms to real life test cases.

Project End Date: **5/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
615216	**LifeInverse**	**PE1 - Mathematics**

Principal Investigator: **Dr. Martin Burger**
martin.burger@wwu.de

Host Institution: Westfaelische Wilhelms-Universitaet Muenster, DE

Variational Methods for Dynamic Inverse Problems in the Life Sciences

This project will develop novel techniques for solving inverse problems in life sciences, in particular related to dynamic imaging. Major challenges in this area are efficient four- dimensional image reconstruction under low SNR conditions and further the quantification of image series as obtained from molecular imaging or life microscopy techniques. We will tackle both of them in a rather unified framework as inverse problems for time-dependent (systems of) partial differential equations.
In the solution of these inverse problems we will investigate novel approaches for the following aspects specific to the above-mentioned problems in the life sciences: 1. Solution of inverse problems for PDEs in complex time-varying geometries
2. Development of appropriate variational regularization models for dynamic images, including noise and motion models
3. Improved forward and inverse modelling of cellular and intracellular dynamics leading to novel inverse problems for nonlinear partial differential equations
4. Construction and implementation of efficient iterative solution methods for the arising 4D inverse problems and their variational formulation All tasks will be driven by concrete applications in biology and medicine and their success will be evaluated in applications to real problems and data. This is based on interdisciplinary work related to electrocardiology and developmental biology. The overall development of methods will however be carried out in a flexible and modular way, so that they become accessible for larger problem classes.

Project End Date: **2/28/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714892	**Waterscales**	**PE1 - Mathematics**

Principal Investigator: **Dr. Marie Rognes**
meg@simula.no

Host Institution: Simula Research Laboratory As, NO

Mathematical and computational foundations for modeling cerebral fluid flow.

Your brain has its own waterscape: whether you are reading or sleeping, fluid flows through the brain tissue and clears waste in the process. These physiological processes are crucial for the well-being of the brain. In spite of their importance we understand them but little. Mathematics and numerics could play a crucial role in gaining new insight. Indeed, medical doctors express an urgent need for multiscale modeling of water transport through the brain, to overcome limitations in traditional techniques. Surprisingly little attention has been paid to the numerics of the brain's waterscape however, and fundamental knowledge is missing. In response, the Waterscales ambition is to establish the mathematical and computational foundations for predictively modeling fluid flow and solute transport through the brain across scales -- from the cellular to the organ level. The project aims to bridge multiscale fluid mechanics and cellular electrophysiology to pioneer new families of mathematical models that couple macroscale, mesoscale and microscale flow with glial cell dynamics. For these models, we will design numerical discretizations that preserve key properties and that allow for whole organ simulations. To evaluate predictability, we will develop a new computational platform for model adaptivity and calibration. The project is multidisciplinary combining mathematics, mechanics, scientific computing, and physiology. If successful, this project enables the first in silico studies of the brain's waterscape across scales. The new models would open up a new research field within computational neuroscience with ample opportunities for further mathematical and more applied study. The processes at hand are associated with neurodegenerative diseases e.g. dementia and with brain swelling caused by e.g. stroke. The Waterscales project will provide the field with a sorely needed, new avenue of investigation to understand these conditions, with tremendous long-term impact.

Project End Date: **3/31/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
646649	**SymplecticEinstein**	**PE1 - Mathematics**

Principal Investigator: **Dr. Joel Fine**
joel.fine@ulb.ac.be

Host Institution: Universite Libre De Bruxelles, BE

The symplectic geometry of anti-self-dual Einstein metrics

This project is founded on a new formulation of Einstein's equations in dimension 4, which I developed together with my co-authors. This new approach reveals a surprising link between four-dimensional Einstein manifolds and six-dimensional symplectic geometry. My project will exploit this interplay in both directions: using Riemannian geometry to prove results about symplectic manifolds and using symplectic geometry to prove results about Reimannian manifolds.Our new idea is to rewrite Einstein's equations using the language of gauge theory. The fundamental objects are no longer Riemannian metrics, but instead certain connections over a 4-manifold M. A connection A defines a metric g_A via its curvature, analogous to the relationship between the electromagnetic potential and field in Maxwell's theory. The total volume of (M,g_A) is an action S(A) for the theory, whose critical points give Einstein metrics. At the same time, the connection A also determines a symplectic structure \omega_A on an associated 6-manifold Z which fibres over M.My project has two main goals. The first is to classify the symplectic manifolds which arise this way. Classification of general symplectic 6-manifolds is beyond current techniques of symplectic geometry, making my aims here very ambitious. My second goal is to provide an existence theory both for anti-self-dual Poincaré--Einstein metrics and for minimal surfaces in such manifolds. Again, my aims here go decisively beyond the state of the art. In all of these situations, a fundamental problem is the formation of singularities in degenerating families. What makes new progress possible is the fresh input coming from the symplectic manifold Z. I will combine this with techniques from Riemannian geometry and gauge theory to control the singularities which can occur.

Project End Date: **8/31/2020**

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**
andreas.thom@tu-dresden.de

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 methods from 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
The theory of `2-homology and `2-torsion of groups has provided a fruitful context to study global properties of infinite groups. The relationship of these homological invariants with ergodic theory of group actions will be part of the content of Part (i). In Part (ii) we seek for generalizations of `2-methods to a context of locally compact groups and study the asymptotic invariants of sequences of lattices (or more generally invariant random subgroups). Part (iii) tries to lay the foundation of a padic
analogue of the `2-theory, where we study novel aspects of p-adic functional analysis which help to clarify the approximation properties of (Z/pZ)-Betti numbers. Finally, in Part (iv), we try to attack various longstanding combinatorial problems in group theory with tools from algebraic topology and p-local homotopy theory.

Project End Date: **9/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715734	**HyLEF**	**PE1 - Mathematics**

Principal Investigator: **Dr. Ana Patrícia Gonçalves**
patricia.goncalves@math.tecnico.ulisboa.pt

Host Institution: Instituto Superior Tecnico, PT

Hydrodynamic Limits and Equilibrium Fluctuations: universality from stochastic systems

A classical problem in the field of interacting particle systems (IPS) is to derive the macroscopic laws of the thermodynamical quantities of a physical system by considering an underlying microscopic dynamics which is composed of particles that move according to some prescribed stochastic, or deterministic, law. The macroscopic laws can be partial differential equations (PDE) or stochastic PDE (SPDE) depending on whether one is looking at the convergence to the mean or to the fluctuations around that mean. One of the purposes of this research project is to give a mathematically rigorous description of the derivation of SPDE from different IPS. We will focus on the derivation of the stochastic Burgers equation (SBE) and its integrated counterpart, namely, the KPZ equation, as well as their fractional versions. The KPZ equation is conjectured to be a universal SPDE describing the fluctuations of randomly growing interfaces of 1d stochastic dynamics close to a stationary state. With this study we want to characterize what is known as the KPZ universality class: the weak and strong conjectures. The latter states that there exists a universal process, namely the KPZ fixed point, which is a fixed point of the renormalization group operator of space-time scaling 1:2:3, for which the KPZ is also invariant. The former states that the fluctuations of a large class of 1d conservative microscopic dynamics are ruled by stationary solutions of the KPZ. Our goal is threefold: first, to derive the KPZ equation from general weakly asymmetric systems, showing its universality; second, to derive new SPDE, which are less studied in the literature, as the fractional KPZ from IPS which allow long jumps, the KPZ with boundary conditions from IPS in contact with reservoirs or with defects, and coupled KPZ from IPS with more than one conserved quantity. Finally, we will analyze the fluctuations of purely strong asymmetric systems, which are conjectured to be given by the KPZ fixed point.

Project End Date: **11/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
337039	**WallXBirGeom**	**PE1 - Mathematics**

Principal Investigator: **Dr. Arend Bayer**
arend.bayer@ed.ac.uk

Host Institution: The University Of Edinburgh, UK

Wall-crossing and Birational Geometry

We will use modern techniques in algebraic geometry, originating from string theory and mirror symmetry, to study fundamental problems of classical flavour. More concretely, we apply wall-crossing in the derived category to the birational geometry of moduli spaces. Bridgeland stability is a notion of stability for complexes in the derived category. Wall-crossing describes how moduli spaces of stable complexes change under deformation of the stability condition, often via a birational surgery occurring in its minimal model program (MMP). This relates wall-crossing to the most basic question of algebraic geometry, the classification of algebraic varieties. Our previous results additionally provide a very direct connection between Bridgeland stability conditions and positivity of divisors, the main tool of modern birational geometry. This makes the above link significantly more effective, precise and useful. We will exploit this in the following long-term projects: 1. Prove a Bogomolov-Gieseker type inequality for threefolds that we conjectured previously. This would provide a solution in dimension three to well-known open problems of seemingly completely different nature: the existence of Bridgeland stability conditions, Fujita's conjecture on very ampleness of adjoint line bundles, and projective normality of toric varieties. 2. Study the birational geometry of moduli space of sheaves via wall-crossing, adding more geometric meaning to their MMP. 3. Prove that the MMP for local Calabi-Yau threefolds is completely induced by deformation of Bridgeland stability conditions. The motivation is a derived version of the Kawamata-Morrison cone conjecture, classical questions on Chern classes of stable bundles, and mirror symmetry. 4. Answer major open questions on the birational geometry of the moduli space of genus zero curves (for example, the F-conjecture) using exceptional collections in the derived category and wall-crossing.

Project End Date: **11/30/2018**

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**
pnowak@impan.pl

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: **7/31/2021**

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**
erik.wahlen@maths.lu.se

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: **2/28/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
335421	**ROBUSTFINMATH**	**PE1 - Mathematics**

Principal Investigator: **Dr. Jan Obloj**
jan.obloj@maths.ox.ac.uk

Host Institution: The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Robust Financial Mathematics: model-ambiguous framework for valuation and risk management

The last forty years have seen a remarkable interplay between Mathematics and contemporary Finance. At the heart of the successful growth of Mathematical Finance was a perfect fit between its dominant model--specific framework and the tools of stochastic analysis. However, this approach has always had important limitations, and the dangers of overreach have been illustrated by the dramatic events of the recent financial crisis.

I set out to create a coherent mathematical framework for valuation, hedging and risk management, which starts with the market information and not an a priori probabilistic setup. The main objectives are: (i) to incorporate both historical data and current option prices as inputs of the proposed robust framework, and (ii) to establish pricing-hedging duality, define the concept of no-arbitrage and prove a Fundamental Theorem of Asset Pricing, all in a constrained setting where the market information, and not a probability space, is fixed from the outset. Further, I will test the performance of robust valuation and hedging methods.

The project proposes a genuine change of paradigm. It requires building novel mathematical tools combining pathwise stochastic calculus, embedding problems, martingale optimal transport, variation inequalities as well as numerical methods.

Significant research efforts have focused on introducing and investigating a form of model uncertainty in Financial Mathematics. This project makes an important next step. Motivated by recent contributions, it builds a framework which consistently combines model ambiguity with a comprehensive use of market information. Further, it has built-in flexibility to interpolate between the model-specific and model-independent settings. It offers a new theoretical foundation opening horizons for future research. Moreover, it provides novel tools which could be applied by the financial industry.

Project End Date: **12/31/2018**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694920	**CHROMIUM**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator:	**Dr. Jennifer Thomas** jennifer.thomas@ucl.ac.uk
Host Institution:	University College London, UK

CHROMIUM

Why the Universe is void of anti-matter is one of the remaining Big Questions in Science.One explanation is provided within the Standard Model by violation of Charge Parity (CP) symmetry, producing differences between the behavior of particles and their anti-particles.CP violation in the neutrino sector could allow a mechanism by which the matter-anti matter asymmetry arose.The objective of this proposal is to enable a step change in our sensitivity to CP violation in the neutrino sector. I have pioneered the concepts and led the deployment of a small prototype using a novel approach which could eventually lead to the construction of a revolutionary Mega-ton scale Water Cherenkov (WC) neutrino detector.The goal of my research program is to demonstrate the feasibility of this approach via the construction of an intermediate sized prototype with an expandable fiducial mass of up to 10-20kt. It will use a low-cost and lightweight structure, filled with purified water and submerged for mechanical strength and cosmic ray shielding in a 60m deep flooded mine pit in the path of Fermilab's NuMI neutrino beam in N. Minnesota.The European contribution to this experiment will be profound and definitive.Applying the idea of fast timing and good position resolution of small photodetectors, already pioneered in Europe, in place of large-area photodetector, we will revolutionize WC design.The game-changing nature of this philosophy will be demonstrated via the proof of the detector construction and the observation of electron neutrino events form the NuMI beam.The successful completion of this R&D program will demonstrate a factor of up to 100 decrease in cost compared to conventional detectors and the proof that precision neutrino measurements could be made inside a few years rather than the presently needed decades.The project describes a five year program of work amounting to a total funding request of €3.5M, including an extra €1M of equipment funds.

Project End Date: **9/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724473	**SMARTIES**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator:	**Dr. Sylvain Gigan** sylvain.gigan@lkb.ens.fr
Host Institution:	Centre National De La Recherche Scientifique, FR

Scattering Media as a Resource Towards Information Processing and Sensing

Scattering of light in complex environments has long been considered a nuisance and an inescapable limitation to imaging and sensing alike, ranging from astronomical observation, biomedical imaging, spectroscopy, etc. In the last decade, wavefront shaping techniques have revolutionized this view, by allowing light focusing and imaging even deep in the multiple scattering regime. This principle is embodied in the possibility—that I pioneered—to access the transmission matrix of a complex medium.

In SMARTIES, I will go one major conceptual step further, by exploiting directly the inherent property of a complex medium to mix perfectly and deterministically the information carried by the light. This mixing is actually a processing step. Along this general idea, SMARTIES will explore two synergistic directions:

—Classical and quantum optical computing: Thanks to the highly multimode nature and the strong mixing properties of complex material, I will aim at demonstrating high performance classical computing tasks in the context of randomized algorithms. As a platform for quantum information processing, this will be relevant for high dimension quantum computing algorithms, and quantum machine learning.

—Generalized imaging and sensing: Rather than tediously focusing and imaging through a scattering material, computational approaches can significantly improve and simplify the imaging process. I also aim to show that the relevant information can be directly and optimally extracted from the scattered light without imaging, using machine-learning algorithms.

From a methodological standpoint, SMARTIES will require bridging knowledge from mesoscopic physics, light-matter interaction, linear and non-linear optics, with algorithms and signal processing concepts. It will deliver a whole new class of optical methods and devices, based on disorder. Its applications range from big data analysis, quantum technologies, to sensors and deep imaging for biology and neuroscience.

Project End Date: **3/31/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714005	**Q-DIM-SIM**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator:	**Dr. Nir Bar-Gill** bargill@phys.huji.ac.il
Host Institution:	The Hebrew University Of Jerusalem., IL

Quantum spin simulators in diamond

Quantum interacting systems are at the forefront of contemporary physics, and pose challenges to our understanding of quantum phases, many-body dynamics, and a variety of condensed matter phenomena. Advances in quantum applications, including quantum computation and metrology, rely on interactions to create entanglement and to improve sensitivity beyond the standard quantum limit. In recent years tremendous effort has been invested in developing precision experimental tools to study and simulate complicated many-body Hamiltonians. So far, such tools have been mostly realized in cold atomic systems, trapped ions and photonic networks. I propose a novel experimental approach using Nitrogen-Vacancy (NV) color centers in diamond, superconducting couplers, super-resolution addressing and cryogenic cooling, as a many-body quantum spin simulator. The NV center is a unique spin defect in a robust solid, with remarkable optical properties and a long electronic spin coherence lifetime (~3 ms at room temperature). We have recently demonstrated that this coherence time can be extended to almost 1 second at low temperature, paving the way for interaction-dominated NV-based experiments. The goal of this project is to develop a paradigm of atom-like spin defects in the solid-state as a platform for studying elaborate quantum many-body spin physics (e.g. the Haldane phase in 2D) and quantum information systems (e.g. one-way quantum computing). I intend to combine a low temperature environment with a novel optical super-resolution system and nanofabricated superconducting structures on the diamond surface to produce a unique experimental setup capable of achieving this goal. The ability to engineer and control interacting NV systems in the solid-state diamond lattice has far-reaching applications for studying fundamental problems in many-body physics and in quantum information science.

Project End Date: **12/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
335739	**Fields-Knots**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator:	**Dr. Piotr Sułkowski** psulkows@fuw.edu.pl
Host Institution:	Uniwersytet Warszawski, PL

Quantum fields and knot homologies

This project is concerned with fundamental problems arising at the interface of quantum field theory, knot theory, and the theory of random matrices. The main aim of the project is to understand two of the most profound phenomena in physics and mathematics, namely quantization and categorification, and to establish an explicit and rigorous framework where they come into play in an interrelated fashion. The project and its aims focus on the following areas: - Knot homologies and superpolynomials. The aim of the project in this area is to determine homological knot invariants and to derive an explicit form of colored superpolynomials for a large class of knots and links. - Super-A-polynomial. The aim of the project in this area is to develop a theory of the super-A-polynomial, to find an explicit form of the super-A-polynomial for a large class of knots, and to understand its properties. - Three-dimensional supersymmetric N=2 theories. This project aims to find and understand dualities between theories in this class, in particular theories related to knots by 3d-3d duality, and to generalize this duality to the level of homological knot invariants. - Topological recursion and quantization. The project aims to develop a quantization procedure based on the topological recursion, to demonstrate its consistency with knot-theoretic quantization of A-polynomials, and to generalize this quantization scheme to super-A-polynomials. All these research areas are connected via remarkable dualities unraveled very recently by physicists and mathematicians. The project is interdisciplinary and aims to reach the above goals by taking advantage of these dualities, and through simultaneous and complementary development in quantum field theory, knot theory, and random matrix theory, in collaboration with renowned experts in each of those fields.

Project End Date: **11/30/2018**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714118	**TRAPLAB**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator: **Dr. Guy Ron**
gron@phys.huji.ac.il

Host Institution: The Hebrew University Of Jerusalem., IL

Lab Based Searches for Beyond Standard Model Physics Using Traps

In this project I will measure a critical constant (beta-nu correlation) of the standard model to a precision of at least 0.1%, an order of magnitude improvement over the state of the art. The project will provide a platform for beyond standard-model (BSM) explorations, based on modern atom/ion trapping and a new accelerator facility. High precision measurements of beta decay correlations in trapped radioactive atoms and ions are one of the most precise tools with which to search for BSM physics. The recently published US National Science Advisory Council 2015 Long Range Plan states: ``Measurements of the decays of neutrons and nuclei provide the most precise and sensitive characterization of the charge-changing weak force of quarks and are a very sensitive probe of yet undiscovered new forces. In fact, weak decay measurements with an accuracy of 0.1% or better provide a unique probe of new physics at the TeV energy scale``. Ne and He isotopes are particularly attractive due to calculable SM values, high sensitivity to several manifestations of BSM physics, ease of production, and lifetimes in the useful range for such experiments. This program combines a Magneto-Optical Trap (MOT) and an Electrostatic Ion Beam Trap (EIBT) to perform a high-precision, competitive, measurement of correlations in the decay of such nuclei. The MOT program focuses on the neon isotopes, where existing measurements are of insufficient quality, and have unique sensitivities to aspects of BSM physics. The EIBT program focuses on measurements using 6He (where a comparison with existing measurements is of great import) and the aforementioned neon isotopes, allowing a direct comparison between the two systems within the same facility (a unique worldwide capability). The combination of these methods will allow an extraction of the beta-nu coefficient to the 0.1% level, making this proposal a forerunner in the field, which will provide a leap-step in the current set of world data.

Project End Date: **11/30/2021**

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 Gühne**
otfried.guehne@uni-siegen.de

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: **4/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
637352	**GQCOP**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator:	**Dr. Gerardo Adesso** gerardo.adesso@nottingham.ac.uk
Host Institution:	The University Of Nottingham, UK

Genuine Quantumness in Cooperative Phenomena

The proposed research programme addresses issues of fundamental and technological importance in quantum information science and its interplay with complexity. The main aim of this project is to provide a new paradigmatic foundation for the characterisation of quantumness in cooperative phenomena and to develop novel platforms for its practical utilisation in quantum technology applications.To reach its main goal, this programme will target five specific objectives:O1. Constructing a quantitative theory of quantumness in composite systems;O2. Benchmarking genuine quantumness in information and communication protocols;O3. Devising practical solutions for quantum-enhanced metrology in noisy conditions;O4. Developing quantum thermal engineering for refrigerators and heat engines;O5. Establishing a cybernetics framework for regulative phenomena in the quantum domain.This project is deeply driven by the scientific curiosity to explore the ultimate range of applicability of quantum mechanics. Along the route to satisfying such curiosity, this project will fulfill a crucial two-fold mission. On the fundamental side, it will lead to a radically new level of understanding of quantumness, in its various manifestations, and the functional role it plays for natural and artificial complex systems traditionally confined to a classical domain of investigation. On the practical side, it will deliver novel concrete recipes for communication, sensing and cooling technologies in realistic conditions, rigorously assessing in which ways and to which extent these can be enhanced by engineering and harnessing quantumness.Along with a skillful team which this grant will allow to assemble, benefitting from the vivid research environment at Nottingham, and mainly thanks to his creativity, broad mathematical and physical preparation and relevant inter-disciplinary expertise, the applicant is in a unique position to accomplish this timely and ambitious mission.

Project End Date: **4/30/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681208	**SIRPOL**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator:	**Dr. Hans Peter Büchler** buechler@theo3.physik.uni-stuttgart.de
Host Institution:	Universitaet Stuttgart, DE

Strongly interacting Rydberg slow light polaritons

A fundamental property of optical photons is their extremely weak interactions, which can be ignored for all practical purposes and applications. This phenomena forms the basis for our understanding of light and is at the heart for the rich variety of tools available to manipulate and control optical beams. On the other hand, a controlled and strong interaction between individual photons would be ideal to generate non-classical states of light, prepare correlated quantum states of photons, and harvest quantum mechanics as a new resource for future technology. Rydberg slow light polaritons have recently emerged as a promising candidate towards this goal, and first experiments have demonstrated a strong interaction between individual photons. The aim of this project is to develop and advance the research field of Rydberg slow light polaritons with the ultimate goal to generate strongly interacting quantum many-body states with photons. The theoretical analysis is based on a microscopic description of the Rydberg polaritons in an atomic ensemble, and combines well established tools from condensed matter physics for solving quantum many-body systems, as well as the inclusion of dissipation in this non-equilibrium problem. The goals of the present project addresses questions on the optimal generation of non-classical states of light such as deterministic single photon sources and Schrödinger cat states of photons, as well as assess their potential for application in quantum information and quantum technology. In addition, we will shed light on the role of dissipation in this quantum many-body system, and analyze potential problems and fundamental limitations of Rydberg polaritons, as well as address questions on equilibration and non-equilibrium dynamics. A special focus will be on the generation of quantum many-body states of photons with topological properties, and explore novel applications of photonic states with topological properties.

Project End Date: **5/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695188	**DG-PESP-CS**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator:	**Dr. David Gershoni** dg@physics.technion.ac.il
Host Institution:	Technion - Israel Institute Of Technology., IL

Deterministic Generation of Polarization Entangled single Photons Cluster States

Measurement based quantum computing is one of the most fault-tolerant architectures proposed for quantum information processing. It opens the possibility of performing quantum computing tasks using linear optical systems. An efficient route for measurement based quantum computing utilizes highly entangled states of photons, called cluster states. Propagation and processing quantum information is made possible this way using only single qubit measurements. It is highly resilient to qubit losses. In addition, single qubit measurements of polarization qubits is easily performed with high fidelity using standard optical tools. These features make photonic clusters excellent platforms for quantum information processing.

Constructing photonic cluster states, however, is a formidable challenge, attracting vast amounts of research efforts. While in principle it is possible to build up cluster states using interferometry, such a method is of a probabilistic nature and entails a large overhead of resources. The use of entangled photon pairs reduces this overhead by a small factor only.

We outline a novel route for constructing a deterministic source of photonic cluster states using a device based on semiconductor quantum dot. Our proposal follows a suggestion by Lindner and Rudolph. We use repeated optical excitations of a long lived coherent spin confined in a single semiconductor quantum dot and demonstrate for the first time practical realization of their proposal. Our preliminary demonstration presents a breakthrough in quantum technology since deterministic source of photonic cluster, reduces the resources needed quantum information processing. It may have revolutionary prospects for technological applications as well as to our fundamental understanding of quantum systems.

We propose to capitalize on this recent breakthrough and concentrate on R&D which will further advance this forefront field of science and technology by utilizing the horizons that it opens.

Project End Date: **5/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724707	**PINQS**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator:	**Dr. Wolfram Pernice** wolfram.pernice@uni-muenster.de
Host Institution:	Westfaelische Wilhelms-Universitaet Muenster, DE

Photonic integrated quantum transceivers

Quantum processors are envisioned to conquer ultimate challenges in information processing and to enable simulations of complex physical processes that are intractable with classical computers. Among the various experimental approaches to implement such devices, scalable technologies are particularly promising because they allow for the realization of large numbers of quantum components in circuit form. For upscaling towards functional applications distributed systems will be needed to overcome stringent limitations in quantum control, provided that high-bandwidth quantum links can be established between the individual nodes. For this purpose the use of single photons is especially attractive due to compatibility with existing fibre-optical infrastructure. However, their use in replicable, integrated optical circuits remains largely unexplored for non-classical applications.

In this project nanophotonic circuits, heterogeneously integrated with superconducting nanostructures and carbon nanotubes, will be used to realize scalable quantum photonic chips that overcome major barriers in linear quantum optics and quantum communication. By relying on electro-optomechanical and electro-optical interactions, reconfigurable single photon transceivers will be devised that can act as broadband and high bandwidth nodes in future quantum optical networks. A hybrid integration approach will allow for the realization of fully functional quantum photonic modules which are interconnected with optical fiber links. By implementing quantum wavelength division multiplexing, the communication rates between individual transceiver nodes will be boosted by orders of magnitude, thus allowing for high-speed and remote quantum information processing and quantum simulation. Further exploiting recent advances in three-dimensional distributed nanophotonics will lead to a paradigm shift in nanoscale quantum optics, providing a key step towards optical quantum computing and the quantum internet.

Project End Date: **4/30/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
639560	**MECTRL**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator:	**Dr. Jacob Friis Sherson** sherson@phys.au.dk
Host Institution:	Aarhus Universitet, DK

Measurement-based dynamic control of mesoscopic many-body systems

Quantum control is an ambitious framework for steering dynamics from initial states to arbitrary desired final states. It has over the past decade been used extensively with immense success for control of low- dimensional systems in as varied fields as molecular dynamics and quantum computation. Only recently have efforts been initiated to extend this to higher-dimensional many-body systems. Most generic quantum control schemes to date, however, put quite heavy requirements on the controllability of either the system Hamiltonian or a set of measurement operators. This will in many realistic scenarios prohibit an efficient realization. Within this proposal, I will develop a new quantum control scheme, which is minimalistic on system requirements and therefore ideally suited for the efficient and reliable optimization of many-body control problems. The fundamentally new ingredient is the total quantum evolution dictated by a combination of fixed many-body time evolution and the precise knowledge of the quantum back-action due to repeated quantum non-destruction (QND) measurements of a single projection operator.

The main focus of this proposal is theoretical and experimental quantum engineering of the dynamics in systems, which are sufficiently small to calculate the measurement back-action exactly and sufficiently large to have interesting many-body properties.

Recent experimental advances in single site manipulation of bosons in optical lattices have enabled the high fidelity preparation exactly such mesoscopic samples of atoms (5-50). This forms an ideal starting point for many-body quantum control, and we will i.a. demonstrate engineering of quantum phase transitions and preparation of highly non-classical Schödinger cat states. Finally, using the results from an online graphical interface allowing users of the internet to solve quantum problems we will attempt to build next-generation optimization computer algorithms with a higher level of cognition built in.

Project End Date: **4/30/2020**

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** luis.silva@tecnico.ulisboa.pt
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: **8/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
639022	**NewNGR**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator:	**Dr. Pau Figueras** p.figueras@qmul.ac.uk
Host Institution:	Queen Mary University Of London, UK

New frontiers in numerical general relativity

In recent years general relativity (GR) has become an increasingly important new tool in areas of physics beyond its traditional playground in astrophysics. The main motivation for this comes from the AdS/CFT correspondence which conjectures an equivalence between gravity in anti-de Sitter (AdS) spaces and certain conformal field theories (CFT's). Via this correspondence, GR now plays a key role in improving our understanding of non-gravitational physics at strong coupling. The AdS/CFT correspondence naturally leads to the study of GR in dimensions greater than four and/or in AdS spaces. Our current understanding of GR in these new settings is rather limited but it has been realized that the physics of gravity can be significantly different than in the 4d asymptotically flat case. Moreover, to access these new gravitational phenomena numerical methods have been and will be essential. However, the use of numerical GR beyond the traditional 4d asymptotically flat case is still in its infancy. The goal of this project is to improve our understanding of GR in higher dimensions and/or AdS spaces using numerical techniques. To achieve this goal, we will focus on the study of the following topics: 1. Develop stable codes for doing numerical GR in AdS and higher dimensions. We will use numerical GR and the AdS/CFT correspondence to study out of equilibrium phenomena in strongly coupled CFT's. We will also use numerical GR to understand the endpoint of the various black hole instabilities and thereby address long standing conjectures in GR. 2. New types of stationary black holes. We will use numerical GR to numerically construct new types of black holes in higher dimensions and in AdS, with novel topologies and fewer symmetries than the known ones. We shall apply them to the study of equilibrium configurations in strongly coupled gauge theories at finite temperature.

Project End Date: **8/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
648615	**VIBRA**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator:	**Dr. Dario Polli** dario.polli@polimi.it
Host Institution:	Politecnico Di Milano, IT

Very fast Imaging by Broadband coherent RAman

The VIBRA project aims at developing an innovative microscope for real-time non-invasive imaging of cells and tissues, which promises to have a revolutionary impact on several fields of biology and medicine. Chemically specific vibrational signatures of molecules enable their direct structural characterization. Reliable and quantitative endogenous bio-markers can be established, e.g., to follow cell differentiation and to identify crucial properties of tissues (malignant vs benign phenotype of a tumour). In this way neoplasms can be located and their borders with normal tissue traced for surgery. Spontaneous Raman spectroscopy demonstrated this capability, but it is intrinsically too slow for imaging. Coherent Raman microscopy, on the other hand, can reach extremely high speed (up to the video rate) but at the expense of poor chemical selectivity, being limited to a single vibrational frequency.The ground-breaking goal of VIBRA is to combine the most detailed molecular information over the entire vibrational spectrum with the highest acquisition speed. The PI will develop a complete coherent Raman microscope for near-video-rate broadband vibrational imaging. This high risk/high gain goal will be achieved by the combination of four key developments: improved pulsed laser source; optimized non-linear interaction, enhancing the signal; increase in acquisition speed, thanks to innovative spectrometers; parallel on-board data processing.In the final application phase, the VIBRA project will validate the performances of the novel vibrational imaging system studying two important bio-medical problems: cancerous cell differentiation and detection of neuronal tumours. This will pave the way towards future “virtual histopathology”: intraoperative non-invasive evaluation of cancerous tissue. My vision is to allow researchers and doctors without a specific knowledge in lasers and optics to routinely visualize functional properties of cells and tissues in vivo.

Project End Date: **5/31/2020**

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** h.stroeher@fz-juelich.de
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 thereforeowe 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: **9/30/2021**

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** manuela.cavallaro@lns.infn.it
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: **3/31/2022**

European Research Council
Executive Agency

Established by the European Commission

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

Principal Investigator:	**Dr. Dmitry Budker** budker@uni-mainz.de
Host Institution:	Johannes Gutenberg Universitaet 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: **7/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
617156	**SpecMAT**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator:	**Dr. Riccardo Raabe** riccardo.raabe@kuleuven.be
Host Institution:	Katholieke Universiteit Leuven, BE

Spectroscopy of exotic nuclei in a Magnetic Active Target

SpecMAT aims at providing crucial experimental information to answer key questions about the structure of atomic nuclei: - What are the forces driving the shell structure in nuclei and how do they change in nuclei far from stability?
- What remains of the Z = 28 and N = 50 “magic numbers” in 78Ni?
- Do we understand shape coexistence in nuclei, and what are the mechanisms controlling its appearance? The position of natural and “intruder” shells will be mapped in two critical regions, the neutron-rich nuclei around Z = 28 and the neutron-deficient nuclei around Z = 82. The centroids of the shell strength are derived from the complete spectroscopy of those systems in nucleon-transfer measurements. This method will be applied for the first time in the region of neutron-deficient Pb nuclei. In SpecMAT (Spectroscopy of exotic nuclei in a Magnetic Active Target) a novel instrument will overcome the present challenges in performing such measurements with very weak beams of unstable nuclei. It combines high luminosity, high efficiency and a very large dynamic range and allows detection of both charged-particle and gamma-ray radiation. The instrument owns its remarkable performances to a number of advanced technologies concerning the use of electronics, gaseous detectors and gamma-ray detectors in a magnetic field. The SpecMAT detector will be coupled to the HIE-ISOLDE facility for the production and post-acceleration of radioactive ion beams in construction at CERN in Geneva. HIE-ISOLDE will provide world-unique beams thanks to the use of the proton injector of the CERN complex. If successful, SpecMAT at HIE-ISOLDE will produce specific results in nuclear structure which cannot be reached by other programmes elsewhere. Such results will have a significant impact on the present theories and models of the atomic nucleus.

Project End Date: **5/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
640645	**BetaDropNMR**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator:	**Dr. Magdalena Kowalska** kowalska@cern.ch
Host Institution:	European Organization For Nuclear Research, CH

Ultra-sensitive NMR in liquids

The nuclear magnetic resonance spectroscopy (NMR) is a versatile and powerful tool, especially in chemistry and in biology. However, its limited sensitivity and small amount of suitable probe nuclei pose severe constraints on the systems that may be explored.This project aims at overcoming the above limitations by giving NMR an ultra-high sensitivity and by enlarging the NMR "toolbox" to dozens of nuclei across the periodic table. This will be achieved by applying the β-NMR method to the soft matter samples. The method relies on anisotropic emission of β particles in the decay of highly spin-polarized nuclei. This feature results in 10 orders of magnitude more sensitivity compared to conventional NMR and makes it applicable to elements which are otherwise difficult to investigate spectroscopically. β-NMR has been successfully applied in nuclear physics and material science in solid samples and high-vacuum environments, but never before to liquid samples placed in atmospheric pressure. With this novel approach I want to create a new universal and extremely sensitive tool to study various problems in biochemistry.The first questions which I envisage addressing with this ground-breaking and versatile method concern the interaction of essential metal ions, which are spectroscopically silent in most techniques, Mg2+, Cu+, and Zn2+, with proteins and nucleic acids. The importance of these studies is well motivated by the fact that half of the proteins in our human body contain metal ions, but their interaction mechanism and factors influencing it are still not fully understood. In this respect NMR spectroscopy is of great help: it provides information on the structure, dynamics, and chemical properties of the metal complexes, by revealing the coordination number, oxidation state, bonding situation and electronic configuration of the interacting metal.My long-term aim is to establish a firm basis for β-NMR in soft matter studies in biology, chemistry and physics.

Project End Date: **9/30/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
339106	**OSYRIS**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator:	**Dr. Maciej Lewenstein** maciej.lewenstein@icfo.es
Host Institution:	Fundacio Institut De Ciencies Fotoniques, ES

Open SYstems RevISited: From Brownian motion to quantum simulators

This proposal concerns open systems, i.e. systems interacting with the environment, and their fundamental role in natural sciences. The main objectives are: i) to develop theory of Brownian motion for molecules in biological environments; ii) to adapt classical many-body open systems such as kinetic or/and diffusion-aggregation models to the quantum domain; iii) to develop theory of open systems as quantum simulators; finally iv) to develop theory of quantum Brownian motion in inhomogeneous media. Although all these objectives may seem to be quite unrelated, our main goal will be to connect them in order to unambiguously asses the relevance of open systems in specific areas of physics, biology and beyond. Accordingly, objective i) will be explored in close collaboration with experimentalists in which the diffusion of biomolecules on cell membranes requires a description in terms of Brownian motion in correlated disordered potentials. In ii) we will search for many-body kinetic and growth models that provide the configurations that may serve as samples of random potentials desired in i). These models can be regarded as quantum models with non-Hermitian generators of evolution; in some situations they can be generalized to genuine quantum ones, described by a quantum master equation, linking ii) and iii). In iii) we will look for applications of quantum open systems as quantum simulators of condensed matter/high energy physics. We will also look at single particle interactions with quantum many body environment, linking the objectives iii) with iv) and i). Expected results are: a) understanding the relationship between biological function and the spatiotemporal dynamics of single molecules in living cells; b) understanding of the structure of classical many body stochastic models and their relation to quantum ones; c) concrete proposals for open systems quantum simulators; and d) development of tools to characterize and observe quantum Brownian motion.

Project End Date: **12/31/2018**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
341222	**INTEGRAL**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator:	**Dr. Konstantin Zarembo** zarembo@nordita.org
Host Institution:	Stockholms Universitet, SE

Integrable Systems in Gauge and String Theory

The project is aimed at uncovering new links between integrable systems, string theory and quantum field theory. The goal is to study non-perturbative phenomena in strongly-coupled field theories, and to understand relationship between gauge fields and strings at a deeper level.

Project End Date: **2/28/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
617337	**QITBOX**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator:	**Dr. Antonio Acin** antonio.acin@icfo.eu
Host Institution:	Fundacio Institut De Ciencies Fotoniques, ES

Quantum Information Theory with black BOXes

With QITBOX we aim to develop a novel device-independent framework for quantum information processing. In this framework, devices are seen as black boxes that only receive inputs and produce outputs. Our main objective is to understand what can and cannot be done for information processing using only the observed correlations among the devices. We will structure our effort along three main research lines: (i) Characterization of quantum correlations: the general objective will be to characterize those correlations that are possible among quantum devices; (ii) Protocols based on correlations: the general objective will be to understand how quantum correlations can be exploited in order to construct relevant information protocols and (iii) Applications to physical setups: here the previous results to concrete physical setups will be applied, such as the quantum-optical realizations of the protocols or the study of the non-local properties of many-body systems. The expected results of QITBOX are: (i) Novel methods for the characterization of quantum correlations, (ii) Improved or novel device-independent protocols, (iii) Proposals for feasible experimental implementations of these protocols and (iv) Novel methods for the study of many-body systems based on correlations. QITBOX is a highly-interdisciplinary project with implications in Physics, Mathematics, Computer Science and Engineering. The execution of the planned research work will provide a unifying framework for a Quantum Information Theory with black BOXes (hence the acronym). Such a framework will bring quantum information processing to an unprecedented level of abstraction, in which information protocols and primitives are defined without any reference to the internal physical working of the devices. This, in turn, will lead to much more robust practical implementations of quantum information protocols, closing the mismatch between theoretical requirements and experimental realisations.

Project End Date: **12/31/2018**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
670557	**MIMAS**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator:	**Dr. Andreas Tünnermann** andreas.tuennermann@uni-jena.de
Host Institution:	Friedrich-Schiller-Universitat Jena, DE

Multi-dimensional interferometric amplification of ultrashort laser pulses

Ultrafast lasers, which allow the concentration of light in space and time, have been instrumental in revolutionizing industrial production technologies, medical applications and cutting-edge fundamental research. A common demand for many applications is the combination of maximum pulse peak powers with maximum average powers, in extreme cases involving petawatt (PW) peak powers and megawatt (MW) average powers. Additionally, these parameters must be achieved together with an optimum beam quality and high efficiency. The MIMAS project aims to address these demands and enable new realms of performance for ultrafast lasers. The basic idea is spatially and temporally separated amplification of ultrashort laser pulses followed by coherent combination. This overcomes all the scaling limitations known in single-emitter systems. Moreover, the spatially separated amplification will be developed to an integrated and highly compact configuration: an ytterbium-doped multicore fiber. In addition, it is proposed that a sequence of pulses be amplified with an encoded phase pattern, causing a coherent pulse stacking at the system output. The targeted laser pulse parameters are completely beyond the scope of current laser technology and therefore able to revolutionize many applications. The target is to generate a pulse energy of >1J at 10kHz repetition rate, i.e. an average power of >10 kW, with a wall-plug efficiency of >10%. Together with a pulse duration of <200fs, such performance results in a pulse peak power of >5 TW in a scalable architecture. This outstanding performance, which is three orders of magnitude above the capabilities of today's laser systems, is emitted from only two fibers and features excellent beam quality.I am deeply convinced that such an ultrafast laser source will be the key element in a number of experiments in modern sciences; not only in fundamental physics but also in biology and medicine, it will stimulate seminal discoveries and breakthroughs.

Project End Date: **8/31/2020**

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** pignol@lpsc.in2p3.fr
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: **3/31/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
339253	**PALP**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator: **Dr. Anne L'Huillier**
anne.lhuillier@fysik.lth.se

Host Institution: Lunds Universitet, SE

Physics of Atoms with Attosecond Light Pulses

The field of attosecond science is now entering the second decade of its existence, with good prospects for breakthroughs in a number of areas. We want to take the next step in this development: from mastering the generation and control of attosecond pulses to breaking new marks starting with the simplest systems, atoms. The aim of the present application is to advance the emerging new research field “Ultrafast Atomic Physics”, where one- or two-electron wave packets are created by absorption of attosecond pulse(s) and analyzed or controlled by another short pulse. Our project can be divided into three parts: 1. Interferometric measurements using tunable attosecond pulses

How long time does it take for an electron to escape its potential?

We will measure photoemission time delays for several atomic systems, using a tunable attosecond pulse source. This type of measurements will be extended to multiple ionization and excitation processes, using coincidence measurements to disentangle the different channels and infrared ionization for analysis. 2. XUV pump/XUV probe experiments using intense attosecond pulses

How long does it take for an atom to become an ion once a hole has been created?

Using intense attosecond pulses and the possibility to do XUV pump/ XUV probe experiments, we will study the transition between nonsequential double ionization, where the photons are absorbed simultaneously and all electrons emitted at the same time and sequential ionization where electrons are emitted one at a time. 3. "Complete" attosecond experiments using high-repetition rate attosecond pulses

We foresee a paradigm shift in attosecond science with the new high repetition rate systems based on optical parametric chirped pulse amplification which are coming to age. We want to combine coincidence measurement with angular detection, allowing us to characterize (two-particle) electronic wave packets both in time and in momentum and to study their quantum-mechanical properties.

Project End Date: **2/28/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647981	**3DSPIN**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator:	**Dr. Alessandro Bacchetta** alessandro.bacchetta@unipv.it
Host Institution:	Universita Degli Studi Di Pavia, IT

3-Dimensional Maps of the Spinning Nucleon

How does the inside of the proton look like? What generates its spin? 3DSPIN will deliver essential information to answer these questions at the frontier of subnuclear physics.At present, we have detailed maps of the distribution of quarks and gluons in the nucleon in 1D (as a function of their momentum in a single direction). We also know that quark spins account for only about 1/3 of the spin of the nucleon.3DSPIN will lead the way into a new stage of nucleon mapping, explore the distribution of quarks in full 3D momentum space and obtain unprecedented information on orbital angular momentum. Goals1. extract from experimental data the 3D distribution of quarks (in momentum space), as described by Transverse-Momentum Distributions (TMDs);2. obtain from TMDs information on quark Orbital Angular Momentum (OAM).Methodology3DSPIN will implement state-of-the-art fitting procedures to analyze relevant experimental data and extract quark TMDs, similarly to global fits of standard parton distribution functions. Information about quark angular momentum will be obtained through assumptions based on theoretical considerations. The next five years represent an ideal time window to accomplish our goals, thanks to the wealth of expected data from deep-inelastic scattering experiments (COMPASS, Jefferson Lab), hadronic colliders (Fermilab, BNL, LHC), and electron-positron colliders (BELLE, BABAR). The PI has a strong reputation in this field. The group will operate in partnership with the Italian National Institute of Nuclear Physics and in close interaction with leading experts and experimental collaborations worldwide.ImpactMapping the 3D structure of chemical compounds has revolutionized chemistry. Similarly, mapping the 3D structure of the nucleon will have a deep impact on our understanding of the fundamental constituents of matter. We will open new perspectives on the dynamics of quarks and gluons and sharpen our view of high-energy processes involving nucleons.

Project End Date: **6/30/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694561	**EntangleGen**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator:	**Dr. Markus Oberthaler** markus.oberthaler@kip.uni-heidelberg.de
Host Institution:	Ruprecht-Karls-Universitaet Heidelberg, DE

Entanglement Generation in Universal Quantum Dynamics

A paradigm example of precise predictions in complex systems is the universal scaling of correlation functions close to phase transitions, with their associated critical exponents. The extension of this concept to time dependent problems has been studied in the classical regime as well as in the quantum regime. A clean experimental confirmation of this prediction in a quantum system as well as of its connection to non-local entanglement generation is the defined goal of this project.The experimental system builds on atomic Bose-Einstein condensates with precisely controlled internal degrees of freedom. Their physics can be mapped onto extensively studied spin systems in the large-collective-spin limit. While the mean evolution of these large spins is well captured by classical descriptions, the detailed study of the fluctuations can reveal particle entanglement. The technology for such high-precision measurements has been pioneered by the PI, demonstrating entanglement in spin-squeezed as well as non-gaussian entangled states.In this project one-dimensional gases will be realized allowing for the implementation of a spin system revealing a quantum phase transition. While the spatial spin-spin correlation functions can already be detected, the future experimental development concerns the implementation of non-demolition/weak measurements of the spin degree of freedom. This makes time-time and time-space correlation functions for the first time accessible, as a necessary prerequisite for the envisaged studies of universal dynamics out of equilibrium and the experimental confirmation of non-local entanglement. Observation of scale invariance in the then available full correlation landscape will allow the verification of the presence of a non-thermal fixed point.The successful demonstration will lead to a paradigm shift in the description of quantum dynamics in complex systems and will also open up new routes for generating quantum resources for quantum metrology.

Project End Date: **9/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
340507	**TWISTS**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator: **Dr. Miles Padgett**
miles.padgett@glasgow.ac.uk

Host Institution: University Of Glasgow, UK

Twists & more: the complex shape of light

My scientific career to date has centered around the phase and intensity shaping of light beams, specifically for the pioneering studies of Orbital angular momentum. I wish to build upon this foundation applying twisted and shaped light to sensing and imaging in both the classical and quantum domains. I will use orbital angular momentum as a new imaging modality and as the basis as a remote sensor of rotational motion. I will used randomly shaped light beam as a new approach to 3D vision. I will use the quantum correlations of orbital angular momentum and other spatial states to explore new demonstrations of quantum behaviour and deliver imaging performance beyond the classical limit. To realize this project, funding is sought for 2 FTE postdoctoral research assistants for 5 years and 3 PhD students who will work in close conjunction with myself. I will devote myself to this project, both technically in the laboratory and in promoting the results of the program to international scientific, industrial and political peers.

Project End Date: **3/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
648723	**NPTEV-TQP2020**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator: **Dr. Lucio Cerrito**
lucio.cerrito@cern.ch

Host Institution: Universita Degli Studi Di Roma Tor Vergata, IT

Uncovering New Phenomena at the TeV Scale With Top Quarks

Our understanding of the subatomic world and of the very fabric of the space-time is encompassed in a theory which is the result of all past experimental observations and theoretical developments: the Standard Model of Particle Physics. Yet cosmological observations and theoretical arguments lead us to conclude that new phenomenology,new particles, forces, or a new space-time structure is waiting to be uncovered. Naturalness of the recently discovered Higgs boson suggests that new phenomena should appear at the tera-electronvolt (TeV) scale, and will be accompanied by modifications to the dynamics of the heaviest elementary particle known: the top quark.The aim of this proposal is to perform five measurements involving topquarks with the data that will be collected by the ATLAS experiment at the upcoming Run II (2015-18) of the Large Hadron Collider (LHC): the top quark mass, the CP violation in B hadron decays from the top, the top-Z boson couplings, the search for the top's Flavour Changing Neutral decays, and the search for heavy resonances decaying to top pairs. While measuring these properties is nothing new, the measurements are performed coherently using novel techniques beyond state-of-the-art to push the boundaries on the sensitivity of the limited Run II data, hence allowing the discovery of new phenomena at the LHC before 2020.

Project End Date: **8/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716378	**Quasicrystal**	**PE2 - Fundamental Constituents of Matter**

Principal Investigator:	**Dr. Ulrich Schneider** uws20@cam.ac.uk
Host Institution:	The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

An Optical Quasicrystal for ultracold atoms

During the last fifteen years, ultracold atoms in optical lattices have emerged as a powerful model system to study the many-body physics of interacting particles in periodic potentials. The main objective of this proposal is to extend this level of control to quasiperiodic potentials by realizing an optical quasicrystal. Quasicrystals are a novel form of condensed matter that is non-periodic, but long-range ordered. They have first been observed in the 1980s by Dan Shechtman in diffraction experiments. Quasicrystals give rise to a pattern of sharp Bragg peaks, similar to periodic crystals, but with rotational symmetries that are impossible for periodic structures. Their structure was found to be given by aperiodic tilings with more than one unit cell, such as the celebrated Penrose tiling.

Even though quasicrystals are long-range ordered, many foundational concepts of periodic condensed matter systems such as Blochwaves or Brillouin zones are not applicable. This places them on an interesting middle ground between periodic and disordered systems and highlights their potential for novel many-body physics. We will first characterize the optical quasicrystal using Kapitza-Dirac diffraction, and then study their unusual transport properties and relaxation dynamics after quantum quenches in the presence of interactions. We will additionally look for interesting novel phases at strong interactions and investigate the topological properties of quasiperiodic potentials. Building on my substantial expertise with optical lattices, I thus plan to build a versatile quantum simulator for the physics of quasicrystals by combining a non-periodic optical potential with ultracold Rubidium and Potassium gases.

Project End Date: **12/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715496	**2DNANOPTICA**	**PE3 - Condensed Matter Physics**

Principal Investigator: **Dr. Pablo Alonso González**
pabloalonso@uniovi.es

Host Institution: Universidad De Oviedo, ES

Nano-optics on flatland: from quantum nanotechnology to nano-bio-photonics

Ubiquitous in nature, light-matter interactions are of fundamental importance in science and all optical technologies. Understanding and controlling them has been a long-pursued objective in modern physics. However, so far, related experiments have relied on traditional optical schemes where, owing to the classical diffraction limit, control of optical fields to length scales below the wavelength of light is prevented. Importantly, this limitation impedes to exploit the extraordinary fundamental and scaling potentials of nanoscience and nanotechnology. A solution to concentrate optical fields into sub-diffracting volumes is the excitation of surface polaritons –coupled excitations of photons and mobile/bound charges in metals/polar materials (plasmons/phonons)-. However, their initial promises have been hindered by either strong optical losses or lack of electrical control in metals, and difficulties to fabricate high optical quality nanostructures in polar materials.

With the advent of two-dimensional (2D) materials and their extraordinary optical properties, during the last 2-3 years the visualization of both low-loss and electrically tunable (active) plasmons in graphene and high optical quality phonons in monolayer and multilayer h-BN nanostructures have been demonstrated in the mid-infrared spectral range, thus introducing a very encouraging arena for scientifically ground-breaking discoveries in nano-optics. Inspired by these extraordinary prospects, this ERC project aims to make use of our knowledge and unique expertise in 2D nanoplasmonics, and the recent advances in nanophononics, to establish a technological platform that, including coherent sources, waveguides, routers, and efficient detectors, permits an unprecedented active control and manipulation (at room temperature) of light and light-matter interactions on the nanoscale, thus laying experimentally the foundations of a 2D nano-optics field.

Project End Date: **12/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724103	**MODMAT**	**PE3 - Condensed Matter Physics**

Principal Investigator:	**Dr. Philipp Werner** philipp.werner@unifr.ch
Host Institution:	Universite De Fribourg, CH

Nonequilibrium dynamical mean-field theory: From models to materials

Pump-probe techniques are a powerful experimental tool for the study of strongly correlated electron systems. The strategy is to drive a material out of its equilibrium state by a laser pulse, and to measure the subsequent dynamics on the intrinsic timescale of the electron, spin and lattice degrees of freedom. This allows to disentangle competing low-energy processes along the time axis and to gain new insights into correlation phenomena. Pump-probe experiments have also shown that external stimulation can induce novel transient states, which raises the exciting prospect of nonequilibrium control of material properties.

The ab-initio simulation of correlated materials is challenging, and the prediction of a material's behavior under nonequilibrium conditions is an even more ambitious task. In the equilibrium context, a significant recent advance is the implementation of dynamical mean field theory (DMFT) schemes capable of treating dynamically screened interactions. These techniques have enabled the combination of the GW ab-initio method and DMFT in realistic contexts. Another recent development is the nonequilibrium extension of DMFT, which has been established as a flexible tool for the simulation of time-dependent phenomena in correlated lattice systems. The goal of this research project is to combine these two recently developed computational techniques into a GW and nonequilibrium DMFT based ab-initio framework capable of delivering quantitative and material-specific predictions of the nonequilibrium properties of correlated compounds. The new formalism will be used to study photoinduced phasetransitions, unconventional superconductors with driven phonons, and strongly correlated devices such as Mott insulating solar cells.

Project End Date: **4/30/2022**

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** stefano.bonetti@fysik.su.se
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: **1/31/2022**

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**
johan.christensen@gmail.com

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: **11/30/2021**

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** martin.lenz@u-psud.fr
Host Institution:	Centre National De La Recherche Scientifique, 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: **5/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677458	**AlterMateria**	**PE3 - Condensed Matter Physics**

Principal Investigator: **Dr. Andrea Caviglia**
a.caviglia@tudelft.nl

Host Institution: Technische Universiteit Delft, NL

Designer Quantum Materials Out of Equilibrium

Recently, 'designer' quantum materials, synthesised layer by layer, have been realised, sparking ground-breaking new scientific insights. These artificial materials, such as oxide heterostructures, are interesting building blocks for a new generation of technologies, provided that one is able to access, study and ultimately control their quantum phases in practical conditions such as at room temperature and high speeds.
On the other hand, an independent research area is emerging that uses ultra-short bursts of light to stimulate changes in the macroscopic electronic properties of solids at unprecedented speeds.

Here I propose to bridge the gap between material design and ultrafast control of solids. This new synergy will allow us to explore fundamental research questions on the non-equilibrium dynamics of quantum materials with competing ground states. Specifically, I will utilize intense THz and mid-infrared electromagnetic fields to manipulate the electronic properties of artificial quantum materials on pico- to femto-second time scales. Beyond the development of novel techniques to generate THz electric fields of unprecedented intensity, I will investigate metal-insulator and magnetic transitions in oxide heterostructures as they unfold in time. This research programme takes oxide electronics in a new direction and establishes a new methodology for the control of quantum phases at high temperature and high speed.

Project End Date: **5/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682843	**FLATLAND**	**PE3 - Condensed Matter Physics**

Principal Investigator:	**Dr. Ralph Ernstorfer** ernstorfer@fhi-berlin.mpg.de
Host Institution:	Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Electron-lattice-spin correlations and many-body phenomena in 2D semiconductors and related heterostructures

Two-dimensional crystalline materials exhibit exceptional physical properties and offer fascinating potential as fundamental building blocks for future two-dimensional electronic and optoelectronic devices. Transition metal dichalcogenides (TMDCs) are of particular interest as they show a variety of many-body phenomena and correlation effects. Key properties are: i) additional internal degrees of freedom of the electrons, described as valley pseudospin and layer pseudospin, ii) electronic many-body effects like strongly-bound excitons and trions, and iii) electron-lattice correlations like polarons. While these phenomena represent intriguing fundamental solid state physics problems, they are of great practical importance in view of the envisioned nanoscopic devices based on two-dimensional materials. The experimental research project FLATLAND will address the exotic spin-valley-layer correlations in few-layer thick TMDC crystals and TMDC-based heterostructures. The latter comprise other 2D materials, organic crystals, metals and phase change materials as second constituent. Microscopic coupling and correlation effects, both within pure materials as well as across the interface of heterostructures, will be accessed by time- and angle-resolved extreme ultraviolet-photoelectron spectroscopy, femtosecond electron diffraction, and time-resolved optical spectroscopies. The project promises unprecedented insight into the microscopic coupling mechanisms governing the performance of van der Waals-bonded devices.

Project End Date: **9/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
648589	**SUPER-2D**	**PE3 - Condensed Matter Physics**

Principal Investigator:	**Dr. Alexander Grüneis** grueneis@ph2.uni-koeln.de
Host Institution:	Universitaet Zu Koeln, DE

Many-body physics and superconductivity in 2D materials

The goal of this project is to prepare and functionalize layered materials and then to characterize them in-situ using a novel combination of electrical transport, photoelectron and optical spectroscopy. This approach provides a solution to the intense research efforts in trying to engineer, probe and unravel many-body physics and the superconducting coupling mechanism in layered solids. The materials under investigation are based on the families of graphene, dichalcogenides and iron based superconductors. Chemical functionalization using dopants and strain allows for an unprecedented control over their physical properties. The proposed material systems provide a new arena to explore diverse condensed matter phenomena such as electron correlation, electron-phonon coupling and superconductivity. The groundbreaking aspects of this proposal are as follows: (1) development of a unique setup where electrical transport, angle-resolved photoemission (ARPES) and optical spectroscopy is measured in-situ on the same sample, (2) large-area deterministic layer-by-layer growth by chemical vapour deposition (CVD) and molecular beam epitaxy, (3) the effects of mechanical strain and hence large pseudomagnetic fields on the electronic band structure will be investigated using ARPES, (4) the effects of alkali metal doping on the superconducting transition temperature and the spectral function will be investigated using transport, ARPES and optical spectroscopies shining light onto the superconducting pairing mechanisms in different classes of materials. The proposal's feasibility is firmly grounded on the pioneering work of the PI's group on superconducting coupling in functionalized graphene and the in-situ ARPES measurements of a CVD grown graphene/BN heterostructure.

Project End Date: **5/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
648011	**QuantumMagnonics**	**PE3 - Condensed Matter Physics**

Principal Investigator: **Dr. Martin Weides**
martin.weides@kit.edu

Host Institution: Karlsruher Institut Fuer Technologie, DE

Interfacing spin waves with superconducting quantum circuits for single magnon creation and detection

The proposed project will experimentally interface ferromagnets with superconducting quantum circuits to study dynamics within the magnet. To this end, magnonic elements made up by thin, structured magnetic films will be strongly coupled to the qubit. Superconducting qubits are ideal detectors due to their quantum limited back-action on the measured object and energy resolution. Spectroscopy and coherence measurements on the hybrid system will be made in order to address fundamental aspects such as spin wave generation, detection, coherence, or wave propagation down to mK temperatures and at ultra-low power (atto-watts). Amplitude and phase noise of spin wave resonators will be determined. At the final stage of the project, the quantum limited resolution of qubits will facilitate single magnon creation and detection. Quantum states are swapped between qubit and magnon, and superpositioned and entangled states will be explored. Monitoring the qubit response to its magnetic environment the low and high-frequency flux noise spectrum of spin waves will be inferred. The research methodology employs junctions, resonators, and qubits as research objects and detectors. The samples will be characterized at cryogenic temperatures by transport, magnetometry, resonator and qubit setups. Magnetic materials will be deposited and structured beneath or ontop the superconducting quantum circuits. Exploring spin wave dynamics in thin films by coupling to a superconducting qubit complements conventional measurement techniques based on photon, electron or neutron scattering methods, which require highly populated excitations. The project connects to and extends research objects of ground-breaking nature to open up new horizons for quantum, magnon and spin electronics. Magnetic material physics is enhanced by new research concepts such as quantum resolved spectroscopy and coherence measurements on intrinsic dynamic states.

Project End Date: **5/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647413	**See-1D-Qmatter**	**PE3 - Condensed Matter Physics**

Principal Investigator:	**Dr. shahal ilani** shahal.ilani@weizmann.ac.il
Host Institution:	Weizmann Institute Of Science, IL

Unravelling Fragile 1D Quantum States of Matter Through Ultra-sensitive Imaging

In condensed matter physics there are several iconic predictions that have evaded experimental discovery for many decades. Well-known examples include the proposed fractionally-charged quasiparticles in one-dimension, the theorized quantum crystal of electrons, and the elusive Kondo cloud. These sought-after many-body states all share two key aspects underscoring why they are so hard to discover: They each involve a fragile quantum state of matter that is destroyed easily by disorder or elevated temperatures, and in each case the distinguishing fingerprint is encoded in their real-space structure, which is often difficult to probe directly. The discovery of such phases therefore requires two challenging experimental components: A superb material system in which these phases can be generated, and a novel real-space probe that can image their spatial structure, yet is minimally invasive as not to destroy them.

Recently, we have developed a radically new approach for creating the state-of-the-art in both material systems and scanning probes, based on carbon nanotube devices of unprecedented complexity and cleanliness. With these components in place, we are poised to make the next quantum leap in technology by building a conceptually new experimental platform in which fragile quantum states of matter can be realized and studied microscopically: We will use a nanotube single-electron-transistor as a high-resolution, ultrasensitive scanning charge detector to non-invasively image an exotic quantum state within a second pristine nanotube. With this new platform we will thus be able to address several foundational questions in condensed matter physics (including those mentioned above) and unravel their underlying physics.

Project End Date: **12/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679288	**unLiMIt-2D**	**PE3 - Condensed Matter Physics**

Principal Investigator: **Dr. Christian Schneider**
cnschnei@physik.uni-wuerzburg.de

Host Institution: Julius-Maximilians Universitaet Wuerzburg, DE

Unique Light-Matter Interactions with Two-Dimensional Materials

Controlling light- and matter excitations down to the microscopic scale is one major challenge in modern optics. Applications arising from this field, such as novel coherent- and quantum light sources have the potential to affect our daily life. One particularly appealing material platform in quantum physics consists of monolayer crystals. The most prominent species, graphene, however remains rather unappealing for photonic applications due to the lack of an electronic bandgap in its pristine form. Monolayers of transition metal dichalcogenides and group III-VI compounds comprise such a direct bandgap, and additionally feature intriguing spinor properties, making them almost ideal candidates to study optics and excitonic effects in two-dimensional systems.

unLiMIt-2D aims to establish these materials as a new platform in solid-state cavity quantum electrodynamics. The targeted experiments will be based on thin layers embedded in high quality photonic heterostructures providing optical confinement.

Firstly, I will exploit the combination of ultra-large exciton binding energies, giant absorption and unique spin properties of such materials to form microcavity exciton polaritons. These composite bosons provide the unique possibility to study coherent quantum fluids up to room temperature. Due to the possibility of fabricating such structures by relatively simple means, establishing bosonic condensation effects in atomic monolayers can lead to a paradigm shift in polaritonics.

Secondly, I will study exciton localization in layered materials, with the perspective to establish a new generation of microcavity-based quantum light sources. Light-matter coupling effects will greatly improve the performance of such sources. I will investigate possibilities of tuning the spectral properties of these localizations via external electric and strain-fields, to gain position control and make use of them as sources of single, indistinguishable photons.

Project End Date: **4/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
321305	**EXCITON**	**PE3 - Condensed Matter Physics**

Principal Investigator:	**Dr. Ifor Samuel** idws@st-and.ac.uk
Host Institution:	The University Court Of The University Of St Andrews, UK

Advanced Measurement and Control of Exciton Diffusion for Next Generation Organic Semiconductor Optoelectronics

There is great interest in organic materials with semiconducting electronic properties. This arises from both a scientific point of view (how can a plastic be a semiconductor?) and a technological point of view as these materials can be used to make light-emitting diodes, lasers and solar cells. The performance of all these devices is strongly affected by exciton diffusion, a process that is little studied or understood (particularly compared with charge transport) largely because of the lack of reliable measurement techniques. The purpose of this proposal is to make a breakthrough in the measurement, understanding and control of exciton diffusion in organic semiconductors, and so create a new generation of materials and devices with enhanced performance due to control of exciton diffusion. The key elements of the study are first to develop and validate advanced measurements of exciton diffusion. This will open up the whole topic of exciton "transport" and provide the tools for us (and others) to explore the physics of exciton diffusion and how it is affected by a range of factors relating to the structure of the materials and how they are processed. The following phase of work will use information about the main factors affecting exciton diffusion to develop strategies for controlling it. A particular challenge is to increase exciton diffusion which will then lead to improved efficiency of organic solar cells. We aim to address this both by applying the structure-property relations we develop and by developing directional exciton transfer, including quantum coherent energy transfer. This is an unconventional approach to improving organic solar cells, which could not only improve their efficiency, but also greatly simplify their structure, leading to a breakthrough in their manufacturability. Control of exciton diffusion arising from the proposed research will also lead to strategies for increasing the efficiency of organic light-emitting diodes and lasers.

Project End Date: **3/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
669598	**SynDiv**	**PE3 - Condensed Matter Physics**

Principal Investigator:	**Dr. Cees Dekker** c.dekker@tudelft.nl
Host Institution:	Technische Universiteit Delft, NL

A nanophysics approach to synthetic cell division

Imagine building a living cell from basic components, a vesicle filled with biomolecules that can sustain itself and reproduce into similar offspring. Can this be done?This proposal addresses the most tantalizing aspect: synthetic cell division. We aim to build liposomes (lipid vesicles enclosing an aqueous solution with proteins and DNA) that can spontaneously divide through a contractile protein ring at the vesicle perimeter. To realize this, we employ an experimental biophysics approach that addresses both the actual division and the prerequisite spatial control, with:1. Cells in nanofabricated shapes. We will study cell-division proteins and DNA in live E.coli bacteria that are molded into user-defined arbitrary shapes and sizes. Clarifying the effects of cell shape will elucidate the guiding principles for the spatiotemporal organization of the cell-division machinery.2. Proteins and DNA in nanofabricated chambers. We will use a bottom up approach to study the basic divisome components in vitro exploiting the full control provided by nanochambers. This will resolve the spatial organization of the fascinating patterns of Min proteins and chromatin that dictate the localization of the division ring.3. Liposomes on chip. We will develop a chip-based technology to generate liposomes for exploring synthetic cell division. We will use both microfluidic constrictions and a biomimetic approach (encapsulation of divisome proteins such as FtsZ) to induce autonomous liposome splitting, thus enabling a simplified but tightly controlled form of synthetic cell division.To our knowledge, this nanofabrication-based approach to synthetic division is unique. We expect to be able to make important contributions to understanding cell division, and anticipate that on a 5-year scale we indeed can master synthetic division. We believe that our mix of nanophysics and synthetic biology is bound to yield deep insight into the biophysical underpinnings of cellular reproduction.

Project End Date: **6/30/2020**

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** daniele.fausti@elettra.eu
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: **5/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724813	**SmartCells**	**PE3 - Condensed Matter Physics**

Principal Investigator:	**Dr. Pascal Hersen** pascal.hersen@univ-paris-diderot.fr
Host Institution:	Universite Paris Diderot - Paris 7, FR

Smart Lab-On-Chips for the Real -Time Control of Cells

Cells are complex, autonomous genetic machines with rich information processing capabilities. Synthetic Biology builds on these properties to design novel, synthetic genetic programs in cells with the aim of benefiting humans. Yet, safety and efficiency issues require creation of synthetic circuits that are reliable over a large range of operating conditions and stable to all sorts of perturbations. This is a tremendous challenge for synthetic biologists, as the robustness of any circuit is limited by their high dependence on the cellular host machinery and the fundamental stochastic nature of gene expression. Taking inspiration from physics and engineering we have imagined a computer-based feedback loop that can remotely, in real-time, control the state of a synthetic genetic program running in cells. Here, we will combine microfluidics, optogenetics, structured illumination, inference methods and control algorithm into such a real time control device of gene expression for yeast cells. We will then study how cells can be controlled at different scales and with increasing levels of complexity from a simple circuit to a simple multicellular ecosystem. Specifically, we aim at: (1) Understanding the potential and limits of such a control method. We will ask to what extent robust control can be achieved at the single cell level over a broad range of operating conditions.
(2) Taking control of complex circuits. In particular, we will take control of key genes of the large regulatory network in charge of yeast adaptation to osmotic stress and dissect their roles in setting the mechano-biology properties of yeast.
(3) Taking control of multicellular systems. We will control the collective dynamics of a population of cells via single cell control at selected locations. This framework will establish solid scientific and technological foundations of a novel research area combining physics, engineering and synthetic biology to take control of living systems.

Project End Date: **3/31/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647073	**FORCASTER**	**PE3 - Condensed Matter Physics**

Principal Investigator: **Dr. Nicolas Minc**
nicolas.minc@ijm.fr

Host Institution: Centre National De La Recherche Scientifique, FR

Force, Motion and Positioning of Microtubule Asters

Cells must move and position internal components to perform their function. We here focus on the physical designs which allow microtubule (MT) asters to exert forces in order to move and position themselves in vivo. These are arrays of MTs radiating from the centrosome, which fill up large portions of cells. They orchestrate nuclear positioning and spindle orientation for polarity, division and development. Forces that move asters are generated at nanometer and second scales by MT-associated motors from sites in the cytoplasm or at the cell surface. How MTs and force-generators self-organize to control aster motion and position at millimeter and hour scales is not known. We will use a suit of biophysical experiments and models to address how aster micro-mechanics contribute to aster migration, centration, de-centration and orientation in a single in vivo system, using the early stages of Sea urchin development as a quantitative model.

We aim to: 1) Elucidate mechanisms that drive aster large-scale motion, using sperm aster migration after fertilization during which asters grow and move rapidly and persistently to the large-egg center. We will investigate how speeds and trajectories depend on boundary conditions and on the dynamic spatial organization of force-generators.

2) Implement magnetic-based subcellular force measurements of MT asters. We will use this to understand how single force-events are integrated at the scale of asters, how global forces may evolve will aster size, shape, in centration and de-centration processes, using various stages of development, and cell manipulation; and to compute aster friction.

3) Couple computational models and 3D imaging to understand and predict stereotyped division patterns driven by subsequent aster positioning and aster-pairs orientation in the early divisions of Sea urchin embryos and in other tissues.

This framework bridging multiple scales will bring unprecedented insights on the physics of living active matter.

Project End Date: **6/30/2020**

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** rosalind.allen@ed.ac.uk
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: **5/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
336749	**QuantumCANDI**	**PE3 - Condensed Matter Physics**

Principal Investigator: **Dr. Alexander Högele**
alexander.hoegele@lmu.de

Host Institution: Ludwig-Maximilians-Universitaet Muenchen, DE

Interfacing quantum states in carbon nanotube devices

Coherent control and sensitive detection of quantum states in condensed matter are among the most topical challenges of modern physics. They drive the development of novel materials, theoretical concepts, and experimental methods to advance our understanding of fundamental laws of quantum mechanics and to create transformative technologies for future applications. During the past decades carbon has emerged as a new material platform to address these challenges: graphene and carbon nanotubes have been created as paradigm systems with exceptional physical properties. As atomically-thin cylinders carbon nanotubes combine ultra-low mass with extreme mechanical stiffness. This identifies them as perfect candidates for the realization of ultra-high quality mechanical resonators with applications in quantum metrology and sensing. Their crystalline lattice can be made free of nuclear spins by material engineering to ensure ultra-long electron spin coherence times for quantum information processing and coherent spintronics. In addition, semiconducting single-wall carbon nanotubes exhibit optical resonances with unprecedented tunability in color for quantum communication and cryptography. These outstanding material properties form the basis for our scientific research proposal. Our vision is to realize up-conversion schemes interfacing light with spin, mechanical, and spin-mechanical degrees of freedom in carbon nanotube devices. In particular, we will study spin dynamics in carbon nanotubes with an isotopically engineered nuclear spin lattice and we will suspend individual carbon nanotubes in high-fidelity optical micro-cavities to detect and control mechanical motion down to the quantum ground state. Ultimately, our devices will realize entirely novel regimes of quantum states by hybridizing light with magnetic or mechanical excitations and explore the foundations of emerging technologies at the quantum limit.

Project End Date: **12/31/2018**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714235	**AQSuS**	**PE3 - Condensed Matter Physics**

Principal Investigator:	**Dr. Gerhard Kirchmair** gerhard.kirchmair@uibk.ac.at
Host Institution:	Universitaet Innsbruck, AT

Analog Quantum Simulation using Superconducting Qubits

AQSuS aims at experimentally implementing analogue quantum simulation of interacting spin models in two-dimensional geometries. The proposed experimental approach paves the way to investigate a broad range of currently inaccessible quantum phenomena, for which existing analytical and numerical methods reach their limitations. Developing precisely controlled interacting quantum systems in 2D is an important current goal well beyond the field of quantum simulation and has applications in e.g. solid state physics, computing and metrology.

To access these models, I propose to develop a novel circuit quantum-electrodynamics (cQED) platform based on the 3D transmon qubit architecture. This platform utilizes the highly engineerable properties and long coherence times of these qubits. A central novel idea behind AQSuS is to exploit the spatial dependence of the naturally occurring dipolar interactions between the qubits to engineer the desired spin-spin interactions. This approach avoids the complicated wiring, typical for other cQED experiments and reduces the complexity of the experimental setup. The scheme is therefore directly scalable to larger systems. The experimental goals are: 1) Demonstrate analogue quantum simulation of an interacting spin system in 1D & 2D.

2) Establish methods to precisely initialize the state of the system, control the interactions and readout single qubit states and multi-qubit correlations.

3) Investigate unobserved quantum phenomena on 2D geometries e.g. kagome and triangular lattices.

4) Study open system dynamics with interacting spin systems. AQSuS builds on my backgrounds in both superconducting qubits and quantum simulation with trapped-ions. With theory collaborators my young research group and I have recently published an article in PRB [9] describing and analysing the proposed platform. The ERC starting grant would allow me to open a big new research direction and capitalize on the foundations established over the last two years.

Project End Date: **3/31/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
639088	**SeSaMe**	**PE3 - Condensed Matter Physics**

Principal Investigator:	**Dr. silvia vignolini** sv319@cam.ac.uk
Host Institution:	The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

Sustainable routes for Smart photonic Materials

Structural colour arises from constructive interference of light that is reflected at interfaces within periodic arrays of transparent materials. Their optical response is well understood and widely described in various biological organisms. Despite the maturity of the research field, many important questions remain completely unsolved.

In order to elucidate the design principles that underlie the development of such structures in nature, I aim to study the assembly and optical response of both natural and bio-mimetic materials made by using the same materials as nature: cellulose and chitin. Bio-mimetic using natural building blocks will also reveal if disorder, always present in natural structures, is a direct consequence of intrinsic material limitations or if it has a biological significance.

Furthermore, understanding the assembly of natural materials will also allow the production of low cost, biodegradable photonic materials.

Project End Date: **9/30/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694544	**OMNES**	**PE3 - Condensed Matter Physics**

Principal Investigator:	**Dr. Tomaz Prosen** tomaz.prosen@fmf.uni-lj.si
Host Institution:	Univerza V Ljubljani, SI

Open Many-body Non-Equilibrium Systems

We shall study non-equilibrium many-body quantum systems, considering local interactions in one or two spatial dimensions in situations where the generator of time evolution in the bulk of the system is unitary whereas the incoherent processes are limited to the system's boundaries. We foresee a mathematical theory of dynamical quantum phases of matter with applications in the theory of quantum transport and nanoscale devices that manipulate heat, information, charge or magnetization. Our steady-state setup represents a fundamental paradigm of mathematical statistical physics which has been pioneered by the PI, who gave the first explicit solution for boundary driven/dissipative strongly interacting many-body problem (XXZ spin 1/2 chain) which answered a long debated question on strict positivity of the spin Drude weight at high temperature. The main focus of OMNES will be centered on exploring the following three interconnected pathways: Most importantly, we shall develop a general framework for exact solutions of non-equilibrium integrable quantum many-body models, in particular the steady states and relaxation modes, and develop quantum integrability methods for non-equilibrium many-body density operators. Fundamentally new concepts which are expected to emerge from these studies, relevant beyond the context of boundary-driven/dissipative systems, are novel quasilocal conservation laws of the bulk Hamiltonian dynamics. Second, we shall investigate relevance of exact solutions in physics of generic systems which are small perturbations of integrable models and explore the problem of stability of local and quasilocal conserved quantities under generic integrability-breaking perturbations. Third, we shall formulate and study the problem of quantum chaos in clean lattice systems, in particular to establish a link between random matrix theory of level statistics and kinematic and dynamical features of lattice models with sufficiently strong integrability breaking.

Project End Date: **9/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
340906	**MOLPROCOMP**	**PE3 - Condensed Matter Physics**

Principal Investigator: **Dr. Kurt Kremer**
kremer@mpip-mainz.mpg.de

Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

From Structure Property to Structure Process Property Relations in Soft Matter – a Computational Physics Approach

From cell biology to polymer photovoltaics, (self-)assembly processes that give rise to morphology and functionality result from non-equilibrium processes, which are driven by both, external forces, such as flow due to pressure gradients, inserting energy, or manipulation on a local molecular level, or internal forces, such as relaxation into a state of lower free energy. The resulting material is arrested in a metastable state. Most previous work has focused on the relationship between structure and properties, while insight into the guiding principles governing the formation of a (new) material, has been lacking. However, a comprehensive molecular level understanding of non-equilibrium assembly would allow for control and manipulation of material processes and their resulting properties. This lag of knowledge can be traced to the formidable challenge in obtaining a molecular picture of non-equilibrium assembly. Non-equilibrium processes have been studied extensively on a macroscopic level by non-equilibrium thermodynamics. We take a novel route approaching the challenge from a molecular point of view. Recent advances in experimental, but especially computational modeling, now allow to follow (supra-) molecular structural evolution across the range of length and time scales necessary to comprehend, and ultimately control and manipulate macroscopic functional properties of soft matter at the molecular level. Soft matter is particularly suited for that approach, as it is “slow” and easy to manipulate. We take the computational physics route, based on simulations on different levels of resolution (all atom, coarse grained, continuum) in combination with recent multiscale and adaptive resolution techniques. This work will initiate the way towards a paradigm change from conventional Structure Property Relations (SPR) to molecularly based Structure Process Property Relations (SPPR).

Project End Date: **1/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
639172	**TopFront**	**PE3 - Condensed Matter Physics**

Principal Investigator:	**Dr. Netanel Lindner** lindner@physics.technion.ac.il
Host Institution:	Technion - Israel Institute Of Technology., IL

Expanding the Topological Frontier in Quantum Matter: from Concepts to Future Applications

Topological phases arise from a fascinating interplay between quantum mechanics and many-body physics. They exhibit an abundance of extraordinary properties, such as protected edge and surface modes, exotic particle statistics, and non-local correlations. These make them not only scientifically stimulating, but also appealing for ground-breaking future applications, such as quantum computing using non-Abelian systems. Their subtle nature often renders them hard to study theoretically, and even more so to detect and control experimentally. To date, only a small subset of them has been accessed in experiments. The purpose of this research program is to expand the scope of possible realizations of topological quantum matter, and to develop methods to detect, control and manipulate them. Two main research directions will be considered. The first will focus on utilizing defects to synthesize new non-Abelian systems. We will study the mathematical theory describing the defects, starting from microscopic considerations and aiming to achieve a unifying mathematical framework. New non-Abelian phases arising in networks of coupled defects will be explored. Protocols for controlling non-Abelian anyons and zero modes will be developed and optimized, aiming to minimize errors arising from imperfections in physical implementations. The second direction will explore the exciting possibility of inducing topological behaviour in non-equilibrium systems. Periodically driven systems, such as matter interacting with light, can exhibit anomalous topological phenomena with no analogue in static systems, which we intend to reveal and classify. We will study the unique many body physics arising from the interplay of topological Bloch-Floquet band structures, inter-particle interactions, and coupling to the environment. Finally, for both research directions we will consider possible experimental realizations in a variety of solid state and cold atom systems along with designated probes.

Project End Date: **8/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647471	**SUPERNEMS**	**PE3 - Condensed Matter Physics**

Principal Investigator: **Dr. Oliver Williams**
williamso@cardiff.ac.uk

Host Institution: Cardiff University, UK

Superconducting Diamond Quantum Nano-Electro-Mechanical Systems

In this project, the fabrication and characterisation of all diamond superconducting Nano-Electro-Mechanical Systems (NEMS) is proposed for the investigation of macroscopic quantum states. This involves state of the art Chemical Vapour Deposition (CVD) of diamond, doping, nanofabrication and modelling of devices. The fundamental properties of superconducting diamond, the associated mechanical properties of diamond NEMS and the characterisation of low temperature and low dimensional quantum effects will be investigated. Critically, the unprecedented resonant frequencies of diamond cantilevers allow the possibility of cooling cantilever devices down to the ground state. Coupled with its superconducting-based read out possibilities, this material offers new opportunities for challenging the Standard Quantum Limit, the study of quantum entanglement and the fabrication of superconducting diamond Qubits. This work is highly ambitious, as it aims to manipulate systems by exploiting fundamental quantum limits. However, the applicant has already demonstrated the individual constituents of this approach and thus it is not reckless to propose to integrate them.

Project End Date: **6/30/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677513	**BioMNP**	**PE3 - Condensed Matter Physics**

Principal Investigator:	**Dr. Giulia Rossi** rossig@fisica.unige.it
Host Institution:	Universita Degli Studi Di Genova, IT

Understanding the interaction between metal nanoparticles and biological membranes

The BioMNP objective is the molecular-level understanding of the interactions between surface functionalized metal nanoparticles and biological membranes, by means of cutting-edge computational techniques and new molecular models.

Metal nanoparticles (NP) play more and more important roles in pharmaceutical and medical technology as diagnostic or therapeutic devices. Metal NPs can nowadays be engineered in a multitude of shapes, sizes and compositions, and they can be decorated with an almost infinite variety of functionalities. Despite such technological advances, there is still poor understanding of the molecular processes that drive the interactions of metal NPs with cells. Cell membranes are the first barrier encountered by NPs entering living organisms. The understanding and control of the interaction of nanoparticles with biological membranes is therefore of paramount importance to understand the molecular basis of the NP biological effects.

BioMNP will go beyond the state of the art by rationalizing the complex interplay of NP size, composition, functionalization and aggregation state during the interaction with model biomembranes. Membranes, in turn, will be modelled at an increasing level of complexity in terms of lipid composition and phase. BioMNP will rely on cutting-edge simulation techniques and facilities, and develop new coarse-grained models grounded on finer-level atomistic simulations, to study the NP-membrane interactions on an extremely large range of length and time scales.

BioMNP will benefit from important and complementary experimental collaborations, will propose interpretations of the available experimental data and make predictions to guide the design of functional, non-toxic metal nanoparticles for biomedical applications. BioMNP aims at answering fundamental questions at the crossroads of physics, biology and chemistry. Its results will have an impact on nanomedicine, toxicology, nanotechnology and material sciences.

Project End Date: **3/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694272	**HITSUPERJU**	**PE3 - Condensed Matter Physics**

Principal Investigator: **Dr. Yuli Nazarov**
y.v.nazarov@tudelft.nl

Host Institution: Technische Universiteit Delft, NL

Higher-dimensional topological solids realized with multiterminal superconducting junctions

Recently I revealed a deep operational analogy between an exotic material and an electronic device, i.e. between a 3-dimensional topological solid and a 4-terminal superconducting junction. Specifically, the 3d Weyl singularities revealed in the energy spectrum of this quantum device give rise to quantized trans-conductance in two leads that is typical for 2-dimensional topological Quantum Hall materials. The quantized value can be tuned with the third control phase. I propose to capitalize on this breakthrough by realizing artificial n-dimensional (topological) solid materials by (n+1)-terminal superconducting junctions. This seemed to be fundamentally forbidden so far. In particular, in the framework of one research direction I will address the realization of higher Chern numbers. The edges and interfaces are important in topological solids, they need to be structured. For the artificial topological materials made with multi-terminal superconducting junctions such structuring is impossible in geometric coordinate space. However, the fact that the charge and superconducting phase are quantum-conjugated quantities provide the unique possibility for the structuring in multi-dimensional charge space that I will access in the framework of another direction. These two research directions will be supplemented by a more technical effort devoted to computational (quantum) dynamics of multi-terminal superconducting junctions.The proposed way to "conquer" higher dimensions for condensed matter physics is of clear fundamental importance. Exciting applications are at the horizon, too. The exotic quantum states under consideration can be topologically protected and thus useful for quantum information processing. Quantized trans-resistance as well as other topological invariants may be important in metrology. More generally, the research proposed will boost the whole field of electronic devices wherever topology guarantees the discrete stability of device characteristics

Project End Date: **7/31/2021**

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** s.lounis@fz-juelich.de
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: **5/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
670918	**PICOPROP**	**PE3 - Condensed Matter Physics**

Principal Investigator:	**Dr. László Forró** laszlo.forro©epfl.ch
Host Institution:	Ecole Polytechnique Federale De Lausanne, CH

Photo Induced Collective Properties of Hybrid Halide Perovskites

The recent discovery of the organo-inorganic perovskite CH3NH3PbI3 as very efficient material in photoelectric conversion is multifaceted: it turns out that this compound is promising not only in photovoltaics, but it is lasing, it gives bright light emitting diodes, promising in water splitting and we are persuaded that it can play an important role in basic sciences, as well.

We have recently realized that under white light illumination the photoelectrons, due to their very long recombination time, stay in the conduction band and the resistivity of a single crystal shows a metallic behavior. If the lifetime is sufficiently long and the density of these excited carrier is high enough they could condense into a Fermi sea. The project's goal is to realize this highly unusual state and to document its properties by magneto-transport and spectroscopic techniques. We will check in our model compound the long-sought superconductivity of photo-excited carriers, extensively searched for in cuprates, if we could stabilize it by fine tuning the interactions by hydrostatic pressure under constant illumination.

The availability of high quality samples is primordial for this program. It turns out that CH3NH3PbI3 is ideal compound, it seems to be almost free of charged defects (its room temperature resistance is 5 orders of magnitude higher than that of Phosphorus doped Silicon at 1013 cm-3 doping concentration) and we can grow excellent single crystals of it. Furthermore, it has a flexibility in material design: one can vary all the constituents, and even the dimensionality by making layered materials with the main chemical motifs. A special effort will be devoted to tune the spin-orbit coupling by different elements, since this could be at the origin of the long recombination time of the photo-electrons.

We suspect that the highly tunable, clean and disorder-free doping obtained by shining light on these ionic crystals opens a new era in material discovery.

Project End Date: **8/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
338258	**OptoQMol**	**PE3 - Condensed Matter Physics**

Principal Investigator:	**Dr. Lapo Bogani** lapo.bogani@materials.ox.ac.uk
Host Institution:	The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Optical Quantum Control of Magnetic Molecules

A revolution is underway, as molecular magnets are establishing a fundamental link between spintronics, molecular electronics and quantum computation. On the other hand, we know almost nothing on how a magnetic molecule is affected by electrons flowing through it or by the excitation of a molecular group. OptoQMol will investigate these uncharted waters by developing innovative, ultra-clean methods that will provide information inaccessible to established procedures. This will allow an unprecedented study of the interplay of electronic and spin degrees of freedom in magnetic molecules and of its possible use for quantum logic. OptoQMol is a strongly multidisciplinary project, and makes use of an innovative mix of chemical and physical methods to overcome present experimental limitations, both in terms of time resolution and cleanliness. Instead of placing a magnetic molecule between bulk electrodes, we will directly grow photoactive groups on the molecule, so that electrons will flow through or close to the spin centers after a light pulse. This affords an ultra-clean system that can be studied in bulk, with a perfectly defined geometry of the magnetic and electronic elements. We will then combine optical and electron paramagnetic resonance techniques with ns time resolution, so as to observe the effect of electron flow on the spins in real time and measure the spin quantum coherence. Eventually we will use these innovative methods to control the interactions among spins and perform quantum logic operations. The success of OptoQMol will answer two fundamental questions: How do molecular spins interact with flowing electrons? How can we use electronic excitations to perform quantum logic operations between multiple electron spins? The results will open a totally new area of experimental and theoretical investigation. Moreover they will redefine the limits and possibilities of molecular spintronics and allow quantum logic operations among multiple electron spins.

Project End Date: **12/31/2018**

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** jensba@pks.mpg.de
Host Institution:	Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

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: **12/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
637815	**QUEST**	**PE3 - Condensed Matter Physics**

Principal Investigator: **Dr. Benjamin Sacépé**
benjamin.sacepe@neel.cnrs.fr

Host Institution: Centre National De La Recherche Scientifique, FR

QUantum Hall Edge State Tunnelling spectroscopy

The quantum nature of an electronic fluid is ubiquitous in many solid-state systems subjected to correlations or confinement. This is particularly true for two-dimensional electron gases (2DEGs) in which fascinating quantum states of matter, such as the integer and fractional quantum Hall (QH) states, arise under strong magnetic fields. The understanding of QH systems relies on the existence of one-dimensional (1D) conducting channels that propagate unidirectionally along the edges of the system, following the confining potential. Due to the buried nature of 2DEG commonly built in semiconducting heterostructures, the considerable real space structure of this 1D electronic fluid and its energy spectrum remain largely unexplored.This project consists in exploring at the local scale the intimate link between the spatial structure of QH edge states, coherent transport and the coupling with superconductivity at interfaces. We will use graphene as a surface-accessible 2DEG to perform a pioneering local investigation of normal and superconducting transport through QH edge states. A new and unique hybrid Atomic Force Microscope and Scanning Tunneling Microscope (STM) operating in the extreme conditions required for this physics, i.e. below 0.1 kelvin and up to 14 teslas, will be developed and will allow unprecedented access to the edge of a graphene flake where QH edge states propagate.Overall, the original combination of magnetotransport measurements with scanning tunnelling spectroscopy will solve fundamental questions on the considerable real-space structure of integer and fractional QH edge states impinged by either normal or superconducting electrodes. Our world-unique approach, which will provide the first STM imaging and spectroscopy of QH edge channels, promises to open a new field of investigation of the local scale physics of the QH effect.

Project End Date: **9/30/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
335040	**DynaMO**	**PE3 - Condensed Matter Physics**

Principal Investigator: **Dr. pietro tierno**
ptierno@ub.edu

Host Institution: Universitat De Barcelona, ES

Dynamics and assemblies of colloidal particles under Magnetic and Optical forces

Control of microscale matter through selective manipulation of colloidal building blocks will unveil novel scientific and technological avenues expanding current frontiers of knowledge in Soft Matter systems. I propose to combine state-of-the-art micromanipulation techniques based on magnetic and optical forces to transport, probe and assemble colloidal matter with single particle resolution in real time/space and otherwise unreachable capabilities. In the first part of the project, I will use paramagnetic colloids as externally controllable magnetic inclusions to probe the structural and rheological properties of optically assembled colloid crystals and glasses. In the second part, I will realize a new class of anisotropy patchy magnetic colloids, characterized by selective, directional and reversible interactions and employ these remotely addressable units to realize gels and frustrated crystals (static case), active jamming and synchronization via hydrodynamic coupling (dynamic case). DynaMO project will power a basic experimental research embracing a variety of apparently different systems ranging from deterministic ratchets, viscoelastic crystals, glasses, patchy colloidal gels, frustrated crystals, active jamming, and hydrodynamic waves. The ERC grant will allow me to establish a young and dynamic research group of interdisciplinary nature focused on these issues and aimed at performing high quality research and training/inspiring talented researchers in innovative and challenging scientific projects.

Project End Date: **12/31/2018**

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** fabrizio@sissa.it
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: **8/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
617266	**NANOPRS**	**PE3 - Condensed Matter Physics**

Principal Investigator:	**Dr. Christopher Royall** paddy.royall@bristol.ac.uk
Host Institution:	University Of Bristol, UK

Nano-Particle-Resolved Studies

Amorphous materials may be classified into three types – thermodynamically stable liquids, metastable (supercooled) liquids and solid glasses. The second type represents the meeting point of many of the great challenges of statistical physics and materials science. What is the mechanism of dynamical arrest, by which structural relaxation become progressively inhibited upon cooling from a liquid to a glass? Can we develop physical pictures of the sequence of fluctuations associated with irreversible relaxation in metastable liquids? How do crystals emerge from these fluctuations? Here we take a structural approach coupled with novel experiments and computer simulations to tackle two specific questions. Firstly, it has long been believed that there should be some structural mechanism underpinning the glass transition, where deeply supercooled liquids continuously transform into solid glasses. Secondly, the fate of the supercooled liquid – whether it crystallises on accessible timescales – should also be related to the local atomic arrangements in the liquid. Tackling the first will lead to insight into the nature of the glass transition - it is not known whether or not there is a true thermodynamic transition to a glass. As for crystallisation, predicted nucleation rates vary wildly with those obtained experimentally in the only system in which both have been compared, little is known beyond trial and error of means by which crystallisation in mixtures can be controlled. In short, our understanding of the fate of supercooled liquids is lacking in a variety of ways. Understanding the glass transition and nucleation is of fundamental importance, and both have important applications for example in metallic glasses and phase change materials. The former are prized for their superior mechanical properties such as extreme toughness while latter underpin emergent technologies such as optical data storage and phase change memory.

Project End Date: **4/30/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
337283	**MEMBRANESACT**	**PE3 - Condensed Matter Physics**

Principal Investigator: **Dr. Ana Suncana Smith**
smith@physik.fau.de

Host Institution: Friedrich-Alexander-Universitat Erlangen Nurnberg, DE

Biological Membranes in Action: A Unified Approach to Complexation, Scaffolding and Active Transport

In recent breakthrough publications, the effect of fluctuations on the affinity of membrane-confined molecules has been evaluated, and a quantitative model for the time evolution of small adhesion domains has been developed under my leadership. Now I propose to bring my research to a new level by tackling the problem of active and passive organisation of proteins into macromolecular structures on fluctuating fluid membranes, using a physicist's approach across established disciplinary boundaries. The formation and transport of supramolecular complexes in membranes is ubiquitous to nearly all functions of biological cells. Today, there is a variety of experiments suggesting that macromolecular complexes act as scaffolds for free proteins, overall yielding obstructed diffusion, counterbalanced by active transport by molecular motors. However, an integrative view connecting complexation and transport is largely missing. Furthermore, the effects of membrane mediated interactions and (non)-thermal fluctuations were so far overlooked. Gaining a quantitative insight into these processes is key to understanding the fundamental functioning of cells. Together with my carefully selected team, I will address these intrinsically biological problems, by means of theoretical physics. Phenomena such as active and anomalous transport, as well as complexation are also currently subject to intense research in the statistical and soft matter physics communities. In this context, the aim of this proposal is to bridge the divide between the two worlds and significantly contribute to both physics and the life sciences by developing general principles that can be applied to processes in cells. Resolving these issues is of fundamental importance since it would identify how interactions on the cell surface arise, and may translate directly into pharmaceutical applications.

Project End Date: **9/30/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679342	**SEQUNET**	**PE3 - Condensed Matter Physics**

Principal Investigator:	**Dr. Hendrik Bluhm** bluhm@physik.rwht-aachen.de
Host Institution:	Rheinisch-Westfaelische Technische Hochschule Aachen, DE

Semiconductor-based quantum network

Quantum networking would enable the connection of quantum processing nodes to increase computing power, long distance intrinsically secure communication, and the sharing of quantum resources over wide networks. Fully realizing these prospects requires local nodes with many coupled qubits connected by photonic links. Currently, qubits with good prospects for scaling to large numbers provide no optical interface, while optically addressable systems appear difficult to scale. This project aims to establish the fundamentals for quantum networks consisting of potentially scalable semiconductor spin qubits in gated GaAs quantum dots. These electrically controlled qubits have been proven viable for quantum computing, but so far have not been interfaced coherently with photons.

To achieve the latter, we plan to use local electric fields generated by gate electrodes on both sides of a quantum well to create bound exciton states in a semiconductor structure that also hosts quantum dot qubits. These hybrid devices will make results from semiconductor quantum optics and self-assembled quantum dots applicable to gate-defined quantum dots. Besides laying the foundations for our technological goal, such a connection of two very active subfields will open a broad range of new possibilities.

Building on the capability to optically address our qubits, we plan to implement a protocol to transfer their quantum state to a photon. In addition, we plan to implement exchange-based two-qubit gates for two-electron spin qubits, which promise a much higher fidelity than the demonstrated Coulomb-coupled gates. Such high fidelity entangling gates are essential for quantum information processing. We then aim to integrate a photon interface into a two-qubit device in order to entangle a photonic flying qubit and a scalable semiconductor qubit. Finally, two such devices will be used to entangle separate semiconductor qubits via a photonic link, thus demonstrating a minimal network.

Project End Date: **4/30/2021**

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** alexandre.tkatchenko@uni.lu
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: **2/28/2022**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
723106	**RetroNets**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Sebastian Maerkl** sebastisn.maerkl@epfl.ch
Host Institution:	Ecole Polytechnique Federale De Lausanne, CH

Reverse Engineering Gene Regulatory Networks

Gene regulatory networks (GRNs) are an important cellular signal processing mechanism for translating input signals into appropriate phenotypes by modulating expression of the genome. The quantitative details of how cells process information through GRNs are still poorly understood, but of central importance in a large number of biological processes. Considerable progress has been made in mapping the topology of GRNs and more recently in deciphering the relationship between promoter sequence and function. Nonetheless, it is not yet possible to computationally predict the output of most native promoters, nor is it trivial to build promoters that integrate signals in a novel and predictive manner. Developing a quantitative understanding of transcriptional regulation, ultimately leading to the ability to predict entire GRNs will be a significant achievement and a prerequisite for our ability to engineer biological systems.

I propose a multi-disciplinary approach incorporating biology, engineering, and computational modelling to improve our quantitative understanding by reverse engineering GRNs in S. cerevisiae. My research group has developed a powerful set of unique, high-throughput microfluidic technologies that enable the quantitative analysis of GRNs in vitro and in vivo.

Specifically I propose to quantitatively investigate the yeast phosphate regulatory network and to develop a master model capable of predicting output of the network under various inorganic phosphate concentrations, to develop novel approaches for modulating GRNs using engineered Zn-finger transcription factors (TF) and CRISPR/Cas, to link GRN output to fitness in order to develop an understanding of how networks are optimized and evolve, and to reverse engineer an exact functional copy of the native phosphate regulatory network with orthogonal components.

Project End Date: **3/31/2022**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716539	**HybridSolarFuels**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Csaba Janaky** janaky@chem.u-szeged.hu
Host Institution:	Szegedi Tudomanyegyetem, HU

Efficient Photoelectrochemical Transformation of CO2 to Useful Fuels on Nanostructured Hybrid Electrodes

Given that CO2 is a greenhouse gas, using the energy of sunlight to convert CO2 to transportation fuels (such as methanol) represents a value-added approach to the simultaneous generation of alternative fuels and environmental remediation of carbon emissions. Photoelectrochemistry has been proven to be a useful avenue for solar water splitting. CO2 reduction, however, is multi-electron in nature (e.g., 6 e- to methanol) with considerable kinetic barriers to electron transfer. It therefore requires the use of carefully designed electrode surfaces to accelerate e- transfer rates to levels that make practical sense. In addition, novel flow-cell configurations have to be designed to overcome mass transport limitations of this reaction.

We are going to design and assemble nanostructured hybrid materials to be simultaneously applied as both adsorber and cathode-material to photoelectrochemically convert CO2 to valuable liquid fuels. The three main goals of this project are to (i) gain fundamental understanding of morphological-, size-, and surface functional group effects on the photoelectrochemical (PEC) behavior at the nanoscale (ii) design and synthesize new functional hybrid materials for PEC CO2 reduction, (iii) develop flow-reactors for PEC CO2 reduction. Rationally designed hybrid nanostructures of large surface area p-type semiconductors (e.g., SiC, CuMO2, or CuPbI3) and N-containing conducting polymers (e.g., polyaniline-based custom designed polymers) will be responsible for: (i) higher photocurrents due to facile charge transfer and better light absorption (ii) higher selectivity towards the formation of liquid fuels due to the adsorption of CO2 on the photocathode (iii) better stability of the photocathode. The challenges are great, but the possible rewards are enormous: performing CO2 adsorption and reduction on the same system may lead to PEC cells which can be deployed directly at the source point of CO2, which would go well beyond the state-of-the-art.

Project End Date: **12/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
638258	**NanoChemBioVision**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Sumeet Mahajan** s.mahajan@soton.ac.uk
Host Institution:	University Of Southampton, UK

Next Generation Label-free Chemical Nanoscopy for Biomedical Applications

Imagine if one could simply use an optical microscope and see whether a particular virus has infected a biological specimen or not! Or if a single disease causing molecular structure could be detected, 20 years before the disease manifests itself! Conventional microscopy simply does not have such spatial resolution! The challenge is to image endogenous molecules and structures composed of them specifically, in real-time, without tampering and sample destruction. Non-Linear optical techniques such as vibrational sum frequency generation (vSFG) and coherent Raman scattering (CRS), which use the intrinsic properties of molecules for selectively imaging them, provide a solution. They are non-invasive, label-free, chemically selective and non-destructive with capability for video-rate imaging of biomolecules and biochemical structures. However, they need to overcome the frontier of spatial resolution to be able to provide information at <100 nm level, which is much below the limit for these techniques and conventional microscopy. The proposal addresses this challenge by developing and implementing a generic, simple optical ultra-high resolution technology using a novel approach based on super-oscillatory modulation of light coupled with wavelength mixing. We will uniquely apply this approach to the chemically selective vSFG and CRS techniques. Ultra-high spatial resolution with these techniques will allow unprecedented new insight into many biochemical phenomena. To demonstrate the utility of 'chemical nanoscopy' developed in this proposal vesicular transport in axons of neurons will be studied, which is highly relevant to cognitive decline observed in ageing and neurodegenerative disorders. The project outcomes have the potential to revolutionize research and biomedical understanding by opening doors to 'unseen biology', unravelling disease, viral infection and allergy mechanisms and ultimately, yielding better diagnostics and therapeutics.

Project End Date: **3/31/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
304980	**2D–SYNETRA**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Christian Klinke** klinke@chemie.uni-hamburg.de
Host Institution:	Universitaet Hamburg, DE

Two-dimensional colloidal nanostructures - Synthesis and electrical transport

We propose to develop truly two-dimensional continuous materials and two-dimensional monolayer films composed of individual nanocrystals by the comparatively fast, inexpensive, and scalable colloidal synthesis method. The materials' properties will be studied in detail, especially regarding their (photo-) electrical transport. This will allow developing new types of device structures, such as Coulomb blockade and field enhancement based transistors. Recently, we demonstrated the possibility to synthesize in a controlled manner truly two-dimensional colloidal nanostructures. We will investigate their formation mechanism, synthesize further materials as "nanosheets", develop methodologies to tune their geometrical properties, and study their (photo-) electrical properties. Furthermore, we will use the Langmuir-Blodgett method to deposit highly ordered monolayers of monodisperse nanoparticles. Such structures show interesting transport properties governed by Coulomb blockade effects known from individual nanoparticles. This leads to semiconductor-like behavior in metal nanoparticle films. The understanding of the electric transport in such "multi-tunnel devices" is still very limited. Thus, we will investigate this concept in detail and take it to its limits. Beside improvement of quality and exchange of material we will tune the nanoparticles' size and shape in order to gain a deeper understanding of the electrical properties of supercrystallographic assemblies. Furthermore, we will develop device concepts for diode and transistor structures which take into account the novel properties of the low-dimensional assemblies. Nanosheets and monolayers of nanoparticles truly follow the principle of building devices by the bottom-up approach and allow electric transport measurements in a 2D regime. Highly ordered nanomaterial systems possess easy and reliably to manipulate electronic properties what make them interesting for future (inexpensive) electronic devices.

Project End Date: **1/31/2019**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
616121	**HeteroIce**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. angelos michaelides** angelos.michaelides@ucl.ac.uk
Host Institution:	University College London, UK

Towards a molecular-level understanding of heterogeneous ice nucleation

Ice formation is one of the most common phase transitions on Earth. It is relevant to an enormous variety of phenomena such as weathering, cloud formation, airline safety, agriculture, and energy. However, despite having been studied since antiquity, our molecular level understanding of ice formation is largely incomplete. In particular, almost all ice formation in nature is aided by impurities or the surfaces of foreign materials, yet how surfaces act to facilitate ice formation (heterogeneous ice nucleation) is unclear. Given the ubiquity of ice nucleation, this is arguably one of the biggest unsolved problems in the physical sciences. Experiment provides insight into crystal nucleation and growth, but most nucleation events happen too quickly and involve too few particles to be rationalised purely by experiment. As a result, computer simulations play an important role and I believe we are now on the verge of using simulation to bring about major breakthroughs in understanding ice formation. Specifically, in this project we aim to perform the first full-on attack on heterogeneous ice nucleation so as to elucidate how the physiochemical properties of materials control their ability to nucleate ice. We will focus on nucleation on solid inorganic substrates and our approach will be to couple systematic studies on model systems with in-depth explorations of more realistic (and experimentally realisable) surfaces. We will improve existing computer simulation methods and develop new ones for accurate large- scale simulations of phase transitions in complex heterogeneous environments. In so doing we will help to make simulations of ice nucleation more routine, enabling us to establish what makes a good ice nucleating agent. The results from this multi-disciplinary project will not only shed light on an important everyday process but may also help to improve climate models and develop improved cloud seeding materials, or inhibitor coatings for industrial purposes.

Project End Date: **3/31/2019**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725686	**DeLiCAT**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Evgeny Pidko** e.a.pidko@tue.nl
Host Institution:	Technische Universiteit Eindhoven, NL

Death and Life of Catalysts: a Theory-Guided Unified Approach for Non-Critical Metal Catalyst Development

Most of the developments in catalyst are still based on serendipitous and trial-and-error approaches, in which potential systems can be overlooked simply because of the sub-optimal conditions of the initial activity assessment. Mechanistic and kinetic studies could provide a framework for a more adequate assessment of new catalysts, but such rigorous experiments are not practical for general catalyst discovery. Modern chemical theory and computations hold a promise to be employed in new efficient theory-guided approaches for rational catalyst and process development.

The main aim of DeLiCat is to formulate a hierarchical computational strategy for the design and synthesis of new non-critical metal-based catalysts for sustainable chemical transformations. New, durable and cheap, yet, highly active and selective tailor-made catalyst for hydrogenation of carboxylic acids and their esters as well as for acceptorless dehydrogenation of alcohols will be developed. The research will follow an innovative strategy combining advanced chemical theory, computational screening and experimental approaches from the fields of homogeneous and heterogeneous catalysis in an efficient knowledge exchange loop. Computer simulations will reveal complex reaction networks that determine the “death” and the “life” of catalyst systems. These insights will be used in targeted design of novel multifunctional catalyst systems to direct the selectivity of the reaction network and to prevent deactivation paths. Complementary experimental studies will guide and validate the theoretical predictions. DeLiCAT represents a leap forward in unified first principles-guided catalyst design for liquid phase chemical transformations. The new theoretical concepts, methodological advances as well as the novel superior catalyst systems developed here will be applicable in various areas including biomass valorization, homogeneous and heterogeneous catalysis as well as hydrogen technology.

Project End Date: **4/30/2022**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
635919	**SURFINK**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Dimas Garcia de Oteyza** d_g_oteyza@ehu.es
Host Institution:	Fundacion Donostia International Physics Center, ES

Functional materials from on-surface linkage of molecular precursors

With the advent of self-assembly, increasingly high hopes are being placed on supramolecular materials as future active components of a variety of devices. The main challenge remains the design and assembly of supramolecular structures with emerging functionalities tailored according to our needs. In this respect, the extensive research over the last decades has led to impressive progress in the self-assembly of molecular structures. However, self-assembly typically relies on non-covalent interactions, which are relatively weak and limit the structure's stability and often even their functionality. Only recently the first covalently bonded organic networks were synthesized directly on substrate surfaces under ultra-high-vacuum, whose structure could be defined by appropriate design of the molecular precursors. The potential of this approach was immediately recognized and has attracted great attention. However, the field is still in its infancy, and the aim of this project is to lift this new concept to higher levels of sophistication reaching real functionality. For optimum tunability of the material's properties, its structure must be controlled to the atomic level and allow great levels of complexity and perfection. Complexity can be reached e.g. with hybrid structures combining different types of precursors. In this project, this hardly explored approach will be applied to three families of materials of utmost timeliness and relevance: graphene nanoribbons, porous frameworks, and donor-acceptor networks. Along the pursuit of these objectives, side challenges that will be addressed are the extension of our currently available chemistry-on-surfaces toolbox by identification of new reactions, optimized reaction conditions, surfaces, and ultimately their combination strategies. A battery of tools, with special emphasis on scanning probe microscopies, will be used to visualize and characterize the reactions and physical-chemical properties of the resulting materials.

Project End Date: **8/31/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
678004	**DOPING-ON-DEMAND**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Arjan Houtepen** a.j.houtepen@tudelft.nl
Host Institution:	Technische Universiteit Delft, NL

Doping on Demand: precise and permanent control of the Fermi level in nanocrystal assemblies

The aim of the work proposed here is to develop a completely new method to electronically dope assemblies of semiconductor nanocrystals (a.k.a quantum dots, QDs), and porous semiconductors in general. External dopants are added on demand in the form of electrolyte ions in the voids between QDs. These ions will be introduced via electrochemical charge injection, and will subsequently be immobilized by (1) freezing the electrolyte solvent at room temperature or (2) chemically linking the ions to ligands on the QD surface, or by a combination of both. Encapsulating doped QD films using atomic layer deposition will provide further stability. This will result in stable doped nanocrystal assemblies with a constant Fermi level that is controlled by the potential set during electrochemical charging. QDs are small semiconductor crystals with size-tunable electronic properties that are considered promising materials for a range of opto-electronic applications. Electronic doping of QDs remains a big challenge even after two decades of research into this area. At the same time it is highly desired to dope QDs in a controlled way for applications such as LEDs, FETs and solar cells. This research project will provide unprecedented control over the doping level in QD films and will provided a major step in the optimization of optoelectronic devices based on QDs. The “Doping-on-Demand” approach will be exploited to develop degenerately doped, low-threshold QD lasers that can be operated under continuous wave excitation, and QD laser diodes that use electrical injection of charge carriers. The precise control of the Fermi-level will further be used to optimize pin junction QD solar cells and to develop, for the first time, QD pn junction solar cells with precise control over the Fermi levels.

Project End Date: **12/31/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
678169	**PhotoMutant**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Igor Schapiro** igor.schapiro@mail.huji.ac.il
Host Institution:	The Hebrew University Of Jerusalem., IL

Rational Design of Photoreceptor Mutants with Desired Photochemical Properties

From a technological viewpoint photoreceptor proteins, the light-sensitive proteins involved in the sensing and response to light in a variety of organisms, represent biological light converters. Hence they are successfully utilized in a number of technological applications, e.g. the green-fluorescent protein used to visualize spatial and temporal information in cells. However, despite the ground-breaking nature of this utilization in life science and other disciplines, the attempts to design a photoreceptor for a particular application by protein mutation remains an open challenge. This is exactly the scope of my research proposal: the application of multi-scale modelling for the systematic design of biological photoreceptor mutants. With this target in mind I will study representatives of two prominent photoreceptor proteins subfamilies which are of towering interest to experimentalists: proteorhodopsins and cyanobacteriochromes. Computer models of these proteins will be constructed using accurate multi-scale modeling. Their excitation energies and other properties (e.g. excited-state reactivity and efficiency) will be calculated using multireference methods that were shown to have an accuracy of <3 kcal/mol. The insights gained from simulations of the wild-type proteins will provide the basis for proposing mutations with altered photochemical properties: in essence to predict absorption and emission spectra, excited-state lifetime and quantum yields. This research requires interactions across the disciplines, as the best candidates will be synthesized and characterized experimentally by collaborators. The outcome of these experiments will provide feedback to improve both the properties of the mutants and the simulation methodology. Ultimately this high-risk/high gain project should derive a comprehensive understanding that would result in novel biotechnological applications, e.g. optogenetic tools, fluorescent probes and biosensors.

Project End Date: **1/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
614507	**COMOTION**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Jochen Küpper** jochen.kuepper@cfel.de
Host Institution:	Stiftung Deutsches Elektronen-Synchrotron Desy, DE

Controlling the Motion of Complex Molecules and Particles

The main objective of COMOTION is to enable novel experiments for the investigation of the intrinsic properties of large molecules, including biological samples like proteins, viruses, and small cells
-X-ray free-electron lasers have enabled the observation of near-atomic-resolution structures in diffraction- before-destruction experiments, for instance, of isolated mimiviruses and of proteins from microscopic crystals. The goal to record molecular movies with spatial and temporal atomic-resolution (femtoseconds and picometers) of individual molecules is near.
-The investigation of ultrafast, sub-femtosecond electron dynamics in small molecules is providing first results. Its extension to large molecules promises the unraveling of charge migration and energy transport in complex (bio)molecules.
-Matter-wave experiments of large molecules, with currently up to some hundred atoms, are testing the limits of quantum mechanics, particle-wave duality, and coherence. These metrology experiments also allow the precise measurement of molecular properties.
The principal obstacle for these and similar experiments in molecular sciences is the controlled production of samples of identical molecules in the gas phase. We will develop novel concepts and technologies for the manipulation of complex molecules, ranging from amino acids to proteins, viruses, nano-objects, and small cells: We will implement new methods to inject complex molecules into vacuum, to rapidly cool them, and to manipulate the motion of these cold gas-phase samples using combinations of external electric and electromagnetic fields. These external-field handles enable the spatial separation of molecules according to size, shape, and isomer.
The generated controlled samples are ideally suited for the envisioned precision experiments. We will exploit them to record atomic-resolution molecular movies using the European XFEL, as well as to investigate the limits of quantum mechanics using matter-wave interferometry.

Project End Date: **8/31/2019**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
646717	**TUNNELCHEM**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Johannes Kästner** kaestner@theochem.uni-stuttgart.de
Host Institution:	Universitaet Stuttgart, DE

Atom-Tunneling in Chemistry

Quantum mechanical tunneling of atoms is emerging as an ubiquitous phenomenon in chemistry. Every chemical reaction that includes a hydrogen transfer can be expected to be influenced by tunneling at room temperature. While simulations can monitor tunneling directly, experimental approaches can only detect the consequences. Theoretical investigations, as planned in TUNNELCHEM, have to keep up in order to aid the rational interpretation. We build on significant algorithmic breakthroughs recently achieved in the applicant's group, which allow accurate predictions of tunneling rates in larger systems than previously possible. These possibilities are to be exploited, which requires a big, combined project that can afford high-risk components.In TUNNELCHEM, we will investigate aspects of tunneling in several different areas of chemistry: biochemistry, astrochemistry, catalysis and algorithmic development. The investigation of tunneling contributions to enzymatic reactions will allow to plan modifications which increase the selectivity and efficiency. Several astrochemical processes can only be understood if their tunneling contributions are properly accounted for. Accurate tunneling rates will significantly improve the predictive power of models of the interstellar medium. Many processes in homogenous and heterogenous catalysis involve tunneling. A fundamental understanding of the principles involved allows for the design of improved catalysts. Further development of methods and algorithms in accordance with the demands of the applications is required. TUNNELCHEM will shift the present paradigm from descriptive investigations to a rational design of catalysts enabled by a mechanistic understanding of atom tunneling processes.Only such a combined effort may allow us to understand the principles of tunneling in chemistry and to develop concepts to exploit the tunnel effect for optimizing reactivity and selectivity of chemical reactions in biochemistry and catalysis.

Project End Date: **6/30/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
615834	**ESTYMA**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Alessandro Troisi** a.troisi@warwick.ac.uk
Host Institution:	The University Of Liverpool, UK

Excited state quantum dynamics in molecular aggregates: a unified description from biology to devices

The coherent dynamics of excitons in systems of biological interest and in organic materials can now be studied with advanced experimental techniques, including two dimensional electronic spectroscopy, with time resolution of few femtoseconds. The theory of open quantum systems, that should support the interpretation of these new experiments, has been developed in different contexts over the past 60 years but seems now very inadequate for the problems of current interest. First of all, the systems under investigation are extremely complex and the most common approach, based on the development of phenomenological models, is often not very informative. Many different models yield results in agreement with the experiments and there is no systematic way to derive these models or to select the best model among many. Secondly, the quantum dynamics of excitons is so fast that one cannot assume that the dynamics of environment is much faster than the dynamics of the system, an assumption crucial for most theories. A remedy to the current limitation is proposed here through the following research objectives.

(1) A general and automatic protocol will be developed to generate simple treatable models of the system from an accurate atomistic description of the same system based on computational chemistry methods.

(2) A professionally-written software will be developed to study the quantum dynamics of model Hamiltonians for excitons in molecular aggregates. This software will incorporate different methodologies and will be designed to be usable also by non-specialists in the theory of quantum open systems (e.g. spectroscopists, computational chemists).

(3) A broad number of problems will be studied with this methodology including (i) exciton dynamics in light harvesting complexes and artificial proteins and (ii) exciton dynamics in molecular aggregates of relevance for organic electronics devices.

Project End Date: **3/31/2019**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
694151	**STAMP**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Peter Schoenmakers** p.j.schoenmakers@uva.nl
Host Institution:	Universiteit Van Amsterdam, NL

Separation Technology for A Million Peaks

Extremely high separation powers are required to fully characterize complex mixtures that are of crucial importance in many fields, such as life science (including systems biology), food science, renewable energy sources and feedstocks, and high-tech materials. The STAMP project is aimed at obtaining a peak capacity of one million in liquid-phase analytical separations. Spatial three-dimensional liquid chromatography will be used to achieve this goal. The major advantage of this technique is that all second-dimension separations and – in a next step – all third-dimension separations are performed in parallel. This allows high-resolution separations to be performed in each dimension, while the total analysis time remains reasonable. Optical and mass-spectrometric imaging techniques are envisaged as detection methods after printing (STAMPing) the effluent from the 3D separation body on a suitable substrate. The STAMP project also has a number of sub-targets that will bring additional significant benefits to all the above application fields. The target and the sub-targets of the STAMP project may be summarized as follows.• Separations with a peak capacity of 1,000,000 (through the use of spatial 3D-LC)• Fast and efficient spatial 2D-LC separations• Devices for spatial 2D-LC and 3D-LC• Detection principles for spatial 2D-LC and 3D-LC• Suitable stationary-phase materials and mechanisms for orthogonal 2D and 3D separations• Relevant applications of all of the above in various fields of science.

Project End Date: **8/31/2021**

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** stienkemeier@uni-freiburg.de
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: **8/31/2021**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
681312	**CLUSTER**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Rolf Erni** rolf.erni@empa.ch
Host Institution:	Eidgenossische Materialprufungs- Und Forschungsanstalt, CH

Birth of solids: atomic-scale processes in crystal nucleation

The goal of this project is to explore the fundamental processes which trigger the nucleation and growth of solids. Condensed matter is formed by clustering of atoms, ions or molecules. This initial step is key for the onset of crystallization, condensation and precipitate formation. Yet, despite of the scientific and technological significance of these phenomena, on an atomistic level we merely have expectations on how atoms should behave rather than experimental evidence about how the growth of solid matter is initiated. The classical nucleation theory is commonly in agreement with experiments, provided the original and the final stages are inspected qualitatively. However, the classical theory does not define what fundamentally constitutes a pre-nucleation state or how a nucleus is formed at all. CLUSTER aims at investigating the very early stages of crystalline matter formation on an unprecedented length scale. It shall explore the atomic mechanisms which prompt the formation of solids. Complemented by density functional theory calculations and molecular dynamics simulations, in-situ high-resolution electron microscopy shall be used to investigate the formation, dynamics, stability and evolution of tiniest atomic clusters which represent the embryos of solid matter. Firstly, we investigate the 3D structure of clusters deposited on suspended graphene. Secondly, we focus on cluster formation, the evolution of sub-critical nuclei and the onset of particle growth by thermal activation. Thirdly, using a novel liquid-cell approach in the transmission electron microscope, we control and monitor in-situ cluster formation and precipitation in supersaturated solutions. The results of CLUSTER, which will advance the understanding of the birth of solid matter, are important for the controlled synthesis of (nano-)materials, for cluster science and catalysis and for the development of novel materials.

Project End Date: **5/31/2021**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
647755	**DYNPOR**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Veronique Van Speybroeck** veronique.vanspeybroeck@ugent.be
Host Institution:	Universiteit Gent, BE

First principle molecular dynamics simulations for complex chemical transformations in nanoporous materials

Chemical transformations in nanoporous materials are vital in many application domains, such as catalysis, molecular separations, sustainable chemistry,…. Model-guided design is indispensable to tailoring materials at the nanometer scale level. At real operating conditions, chemical transformations taking place at the nanometer scale have a very complex nature, due to the interplay of several factors such as the number of particles present in the pores of the material, framework flexibility, competitive pathways, entropy effects,… The textbook concept of a single transition state is far too simplistic in such cases. A restricted number of configurations of the potential energy surface is not sufficient to capture the complexity of the transformation. My objective is to simulate complex chemical transformations in nanoporous materials using first principle molecular dynamics methods at real operating conditions, capturing the full complexity of the free energy surface. To achieve these goals advanced sampling methods will be used to explore the interesting regions of the free energy surface. The number of guest molecules at real operating conditions will be derived and the diffusion of small molecules through pores with blocking molecules will be studied. New theoretical models will be developed to keep track of both the framework flexibility and entropy of the lattice. The selected applications are timely and rely on an extensive network with prominent experimental partners. The applications will encompass contemporary catalytic conversions in zeolites, active site engineering in metal organic frameworks and structural transitions in nanoporous materials, and the expected outcomes will have the potential to yield groundbreaking new insights. The results are expected to have impact far beyond the horizon of the current project as they will contribute to the transition from static to dynamically based modeling tools within heterogeneous catalysis

Project End Date: **7/31/2020**

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** wdemalsc@vub.ac.be
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: **2/28/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
648974	**P-MEM-NMR**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Guido Pintacuda** guido.pintacuda@ens-lyon.fr
Host Institution:	Centre National De La Recherche Scientifique, FR

Structure of paramagnetic integral membrane metalloproteins by MAS-NMR

Integral membrane metalloproteins are involved in the transport and homeostasis of metal ions, as well as in key redox reactions that have a tremendous impact on many fields within life sciences, environment, energy, and industry.

Most of our understanding of fine details of biochemical processes derives from atomic or molecular structures obtained by diffraction methods on single crystal samples. However, in the case of integral membrane systems, single crystals large enough for X-ray diffraction cannot be easily obtained, and the problem of structure elucidation is largely unsolved.

We have recently pioneered a breakthrough approach using Magic-Angle Spinning Nuclear Magnetic Resonance (MAS-NMR) for the atomic-level characterization of paramagnetic materials and complex biological macromolecules. The proposed project aims to leverage these new advances through a series of new concepts i) to improve the resolution and sensitivity of MAS-NMR from nuclei surrounding a paramagnetic metal ion, such as e.g. cobalt, nickel and iron, and ii) to extend its applicability to large integral membrane proteins in lipid membrane environments. With these methods, we will enable the determination of structure-activity relationships in integral membrane metalloenzymes and transporters, by combining the calculation of global structure and dynamics with measurement of the electronic features of metal ions.

These goals require a leap forward with respect to today's protocols, and we propose to achieve this through a combination of innovative NMR experiments and isotopic labeling, faster MAS rates and high magnetic fields. As outlined here, the approaches go well beyond the frontier of current research. The project will yield a broadly applicable method for the structural characterization of essential cellular processes and thereby will provide a powerful tool to solve challenges at the forefront of molecular and chemical sciences today.

Project End Date: **8/31/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716142	**GreenOnWaterCat**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Thomas Kühne** tkuehne@gmail.com
Host Institution:	Universitaet Paderborn, DE

Unravelling the Nature of Green Organic "On-Water" Catalysis via Novel Quantum Chemical Methods

The target of the research program, GreenOnWaterCat, is to revolutionize the understanding of green "on-water" catalysis and to unravel its microscopic origin. To enable these goals to be reached, several novel theoretical methods will be developed and implemented that will enable for unprecedented large-scale quantum molecular dynamics simulations, where both the electronic and nuclear Schrödinger equations are solved simultaneously. In addition, these methods will also allow the efficient computation of various state-of-the-art vibrational spectroscopies "on-the-fly", at essentially no additional computational cost. Furthermore, new analysis techniques permit to assign the spectra and explain their correlation with the atomic structure in order to gain invaluable insights and eventually grasp the relationships between the dynamics and structure of "on-water" catalysis and vibrational spectroscopies. Since the latter offers a convenient connection to experiment, the unique results are of utmost value in order to explain the experimental findings. In consequence, new synthetic processes based on the "on-water" phenomenon will be proposed and investigated. The expected results will be most helpful so that water will soon become not only a viable, but also very attractive solvent in the design of novel synthetic processes and to make it even more useful for industrial applications.

Beside the development and implementation of novel computational methods, which will be made publicly available, the additional outcomes expected are as follows: • To conclusively explain the underlying mechanism of the "on-water" rate phenomenon for the first time

• To elucidate the experimental measurements and characterize the corresponding atomic structure

• To propose novel synthetic processes which exploit the "on-water" concept, such as catalysis at the organic/metal oxide interface

• To investigate the possibility of "on-water" catalysis using two water-insoluble solid reactants

Project End Date: **12/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
638278	**SUPERFOAM**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Björn Braunschweig** braunschweig@uni-muenster.de
Host Institution:	Friedrich-Alexander-Universitat Erlangen Nurnberg, DE

Structure-Property Relations in Aqueous Foam and Their Control on a Molecular Level

Foams are of enormous importance as we find them in many technological relevant applications and food products. Foams as hierarchical materials are dominated by the arrangement and distri-bution of gas bubbles on a macroscopic scale, as well as by thickness and composition of lamella on a mesoscopic scale. Liquid-gas interfaces are, however, the building block of foam with over-whelming importance as their molecular properties easily dominate hierarchical elements on larger length scales. In order to formulate foam with specific properties, its structure must be controlled at the molecular level of a liquid-gas interface. Here, the molecular composition, molecular order and interactions such as electrostatics dominate, and thus must be addressed with molecular level probes that can provide access to both interfacial solvent and solute molecules. Specifically, molecular structures of aqueous interfaces can be modified by adding different mixtures of surface active molecules such as proteins, surfactants and polyelectrolytes, and by adjusting electrolyte properties. This is achieved by varying pH, introducing ions at different ionic strengths as well as by changing viscosities. Such model systems will be characterized with nonlinear optical spectroscopy amongst other surface sensitive probes. The gained information will be used to deduce properties of structures on larger length scales such as lamella, bubbles in a bulk liquid - as a precursor of foam - and finally macroscopic foam. For each length scale, experiments will be performed to gain access to molecular buildings blocks at liquid-gas interfaces and their effects on other hierarchical elements. These experiments thus provide essential information on foam stability and bubble coalescence, they can be used to verify structure-property relationships and to advance our understanding of foam on a molecular basis.

Project End Date: **2/29/2020**

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** majed.chergui@epfl.ch
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: **9/30/2021**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
679841	**ORDERin1D**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Sofie Cambre** sofie.cambre@uantwerpen.be
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 host system to study restricted diameter-dependent molecular transport and to achieve unique polar molecular order. For the ORDERin1D project, I will capitalize on my recent breakthroughs in the processing, filling, chiral sorting and high-resolution spectroscopic characterization of empty and filled CNTs, aiming for a diameter-dependent characterization of the filling with various molecules, which 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 polar array inside the CNTs, after which their molecular directional properties such as their dipole moment and second-order nonlinear optical responses add up coherently, groundbreaking for the development of nanophotonics applications.

Project End Date: **4/30/2021**

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** elizabeth.gibson@ncl.ac.uk
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: **12/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
637831	**SURFLINK**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator: **Dr. Sabine Maier**
sabine.maier@fau.de

Host Institution: Friedrich-Alexander-Universitat Erlangen Nurnberg, DE

MOLECULAR CARPETS ON INSULATING SURFACES: RATIONAL DESIGN OF COVALENT NETWORKS

Inspired by the possibility to create artificial, three-dimensional covalent organic frameworks, the overall aim of this project is to construct novel two-dimensional (2D), covalently-linked, organic networks in a bottom-up approach on insulating surfaces. 2D materials have unique properties suitable for many scientific and technological applications including nano-electronic devices and sensors. On-surface synthesis of covalent structures is mainly limited to metal surfaces, as controlled growth procedures of molecules on insulators are often hindered by the weak, unspecific interaction with the substrate. We will establish suitable concepts for the covalent linking of molecules on insulators by balancing the molecule-molecule and molecule-surface interactions. That will greatly advance the atomic-scale understanding of molecular structures on insulators. Specially designed molecular building blocks doped with heteroatoms will be used to create functional 2D networks with tunable electronic properties and nanometer-sized pores. Novel concepts will be developed to achieve high quality structures with long-range order; one of the great challenges in all covalently-linked structures. The SURFLINK project uses a surface science approach in ultra-high vacuum to understand the fundamental mechanisms and properties of covalently-linked networks at the atomic level. The covalent networks will be studied by high-resolution scanning probe microscopy and spectroscopy at the atomic-scale. We will determine the electronic properties of the novel nano-porous networks that can be tailored by their geometry. The functionalized pores included in the network will be studied with respect to their size and their prospects to adsorb guest molecules. The rational design of the networks proposed in the SURFLINK project has great potential for materials research and will ultimately result in the development of new materials with adjustable electronic properties.

Project End Date: **4/30/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
648295	**GraM3**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Alexey Popov** a.popov@ifw-dresden.de
Host Institution:	Leibniz-Institut Fuer Festkoerper- Und Werkstoffforschung Dresden E.V., DE

Surface-grafted metallofullerene molecular magnets with controllable alignment of magnetic moments

The molecules retaining their magnetization in the absence of magnetic field are known as single molecule magnets (SMMs). Important problems to be solved on the way to the applications of SMMs in molecular spintronics is their deposition on surfaces and addressing their spins on the single molecular level. In this project we will address these problems by designing SMMs based on endohedral metallofullerenes (EMFs) derivatized with anchoring groups. SMM behaviour recently discovered for DySc2N@C80 and Dy2ScN@C80 in PI's group is governed by a strong magnetic anisotropy (magnetic moments of Dy ions are aligned along the Dy–N bonds) and ferromagnetic exchange interactions between Dy ions within the clusters. Protected by the carbon cages, these SMMs exhibit uniquely long zero-field relaxation times of several hours at 2 K and provide an ideal system for addressing the individual spin states. Spatial orientation of magnetic moments in EMF-SMMs is determined by the endohedral cluster and is therefore influenced by the orientation of the EMFs molecules and their internal dynamics. We will apply three strategies to control the spatial arrangement of the magnetic moments in EMF-SMMs: (i) deposition of EMF molecules via sublimation; (ii) exohedral modification of EMFs with anchoring groups for grafting of EMFs on surfaces; (iii) introducing photoswitchable units into the anchoring groups which can reversibly change their geometry upon impact of light and will allow switching direction of the magnetic moment in a fully controllable way. Magnetic behaviour of the surface-grafted SMMs will be studied by bulk- and surface-sensitive techniques including X-ray magnetic circular dichroism and especially spin-polarized scanning tunneling microscopy. Successful fulfillment of the objectives of this interdisciplinary high-risk/high-gain project will revolutionize the field of the surface molecular magnetism by allowing the study and control of the SMMs on a single spin level.

Project End Date: **5/31/2020**

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** giovanni.volpe@physics.gu.se
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: **8/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677663	**CSI.interface**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Markus Valtiner** Markus.Valtiner@chemie.tu-freiberg.de
Host Institution:	Technische Universitaet Bergakademie Freiberg, DE

A molecular interface science approach: Decoding single molecular reactions and interactions at dynamic solid/liquid interfaces

After decades of truly transformative advancements in single molecule (bio)physics and surface science, it is still no more than a vision to predict and control macroscopic phenomena such as adhesion or electrochemical reaction rates at solid/liquid interfaces based on well-characterized single molecular interactions. How exactly do inherently dynamic and simultaneous interactions of a countless number of interacting “crowded” molecules lead to a concerted outcome/property on a macroscopic scale?

Here, I propose a unique approach that will allow us to unravel the scaling of single molecule interactions towards macroscopic properties at adhesive and redox-active solid/liquid interfaces. Combining Atomic Force Microscopy (AFM) based single molecule force spectroscopy and macroscopic Surface Forces Apparatus (SFA) experiments CSI.interface will (1) derive rules for describing nonlinearities observed in complex, crowded (water and ions) and chemically diverse adhesive solid/liquid interfaces; (2) uniquely characterize all relevant kinetic parameters (interaction free energy and transition states) of electrochemical and adhesive reactions/interactions of single molecules at chemically defined surfaces as well as electrified single crystal facets and step edges. Complementary, (3) my team and I will build a novel molecular force apparatus in order to measure single-molecule steady-state dynamics of both redox cycles as well as binding unbinding cycles of specific interactions, and how these react to environmental triggers.

CSI.interface goes well beyond present applications of AFM and SFA and has the long-term potential to revolutionize our understanding of interfacial interaction under steady state, responsive and dynamic conditions. This work will pave the road for knowledge based designing of next-generation technologies in gluing, coating, bio-adhesion, materials design and much beyond.

Project End Date: **6/30/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
669179	**CRYVISIL**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator: **Dr. Hans-Joachim Freund**
freund@fhi-berlin.mpg.de

Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Crystalline and vitreous silica films and their interconversion

Silicon is the most abundant element in the earth's crust. Its oxide, silica (SiO2) is the basis for most minerals of the earth's crust, and also for a number of technological applications ranging from window glass, via electronics to catalysis. The structure of crystalline materials such as quartz or silica-based minerals is well understood due to the application of scattering techniques such as x-ray or neutron diffraction, for example, which allow accurate structure determinations. Silica, however, also forms glasses, which are amorphous or vitreous. Its structure is not well understood. In fact, diffraction techniques have only been able to deliver pair correlation functions, which reveal the density of a material around a given atom, but do not allow a detailed reconstruction of the atomic structure as in the case of crystalline materials. Until recently, a real space image of a silica glass with atomic resolution had not been recorded. Using scanning probe techniques applied to a thin silica film grown atomically flat on a metal substrate, it has been possible to reveal, for the first time, an atomically resolved image of vitreous silica. Both, a crystalline as well as a vitreous phase have been imaged. With this system, it is now possible to address the transition from a vitreous state to a crystal-line in real space by developing a scanning probe microscope that allows the study of its structure over a wide range of temperatures ranging from cryogenic temperatures to 1500 K. It is the purpose of this grant application to build such a device and apply it to the crystal-glass transition and the study of vibrational properties. This instrument may also be used to address a number of scientific problems related to other glass-formers, such as borates and the influence of silica modifications by atom doping, for example.

Project End Date: **12/31/2020**

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** roithova@natur.cuni.cz
Host Institution:	Univerzita Karlova, CZ

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: **6/30/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
340890	**MAMBA**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Sara Linse** sara.linse@biochemistry.lu.se
Host Institution:	Lunds Universitet, SE

Molecular mechanism of amyloid β aggregation

Generation of toxic oligomers during aggregation of amyloid beta peptide (Abeta42) into amyloid fibrils is a central event in Alzheimer disease. Understanding the aggregation process is therefore one important step towards therapy and diagnosis of the disease. We propose a physical chemistry approach with the goal of finding the molecular mechanisms behind the process in terms of the underlying microscopic steps and the molecular driving forces governing each step. We will use methodology developed recently in our laboratory yielding unprecedented reproducibility in the kinetic data. The methodology relies on optimization of every step from production and purification to isolation of highly pure monomeric peptide, and inertness and minimized area of all surfaces. We will use cell viability studies to detect toxic oligomeric species, and selective radio-labeling experiments to pinpoint the origin of those species. In order to obtain insight into the molecular determinants and the relative role of different kinds of intermolecular interactions for each microscopic step, we will study the concentration dependent aggregation kinetics as a function of extrinsic and intrinsic parameters. Extrinsic parameters include temperature, salt, pH, biological membranes, other proteins, and low and high Mw inhibitors. Intrinsic parameters include point mutations and sequence extension/truncation. We will perform detailed kinetic studies for each inhibitor to learn which step in the process is inhibited coupled to cell toxicity assays to learn whether the generation of toxic oligomers is limited. We will use spectroscopic techniques, dynamic light scattering, cryogenic transmission electron microscopy and mass spectrometry coupled to HD exchange to learn about structural transitions as a function of process progression under different conditions to favor different microscopic steps. The results may lead to improved diagnostics and therapeutics of Alzheimer disease.

Project End Date: **1/31/2019**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
716265	**TSuNAMI**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Jana Kalbacova Vejpravova** jana@mag.mff.cuni.cz
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: **1/31/2022**

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** stefano.corni@unipd.it
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: **3/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694097	**QSpec-NewMat**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Angel Rubio** angel.rubio@mpsd.mpg.de
Host Institution:	Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Quantum Spectroscopy: exploring new states of matter out of equilibrium

This project addresses the development of novel theoretical and computational tools that utilize the quantum nature of light to understand and control quantum phenomena in complex systems in and out of equilibrium. Some examples of these processes include exciton-exciton interaction, quantum coherence, assisted energy and charge transport, photochemistry, and new states of matter. The present project aims to build up the basic theoretical and computational machinery to allow quantum computations of the electronic and ionic dynamics of atomic, molecular or extended systems coupled to quantised electromagnetic fields and thereby set the stage for a new era in the first-principle computational modelling of light-matter interactions. To achieve this goal, we will combine the principles of time-dependent density functional theory (TDDFT) and quantum electrodynamics (QED) into a new quantum electrodynamical-DFT approach named as "QEDFT".Insight, design and control define the scientific rationale of the project, which will focus on the discovery of the general principles that describe and control systems far from equilibrium and orchestrate the behavior of many electrons and atoms to create new phenomena/states of matter. Besides developing and implementing the new theory of QEDFT, we will investigate atoms and molecules with quantum optical fields; whether and how selected laser pulses drive molecules and solids into new states of matter that have no equilibrium counterpart. What happens when it enters these coherent states? The objective is to identify the spectroscopic fingerprint of those new states. Which states arise in the strong light-matter coupling regime? e.g. hybridized states such as photon bound states, exciton/plasmon-polariton states, so far still undiscovered states. The long-term goal is to deliver an all-out theoretical and computational toolbox for QED-TDDFT applicable to complex molecular systems (like presently approachable by DFT and by TDDFT).

Project End Date: **9/30/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
646659	**NANOREACTOR**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Joachim Dzubiella** joachim.dzubiella@helmholtz-berlin.de
Host Institution:	Helmholtz-Zentrum Berlin Fur Materialien Und Energie Gmbh, DE

Multiscale modelling of stimuli-responsive nanoreactors

The catalysis by metal nanoparticles is one of the fastest growing areas in nanoscience due to our society's exploding need for fuels, drugs, and environmental remediation. However, the optimal control of catalytic activity and selectivity remains one of the grand challenges in the 21st century. Here, I propose to theoretically derive design rules for the optimization of nanoparticle catalysis by means of thermosensitive yolk-shell carrier systems. In the latter, the nanoparticle is stabilized in solution by an encapsulating, thermosensitive hydrogel shell. The physicochemical properties of this polymeric 'nanogate' react to stimuli in the environment and thus permit the reactant transport and the diffusion-controlled part of the catalytic reaction to be switched and tuned, e.g., by the temperature or the pH. The novel hybrid character of these emerging 'nanoreactors' opens up unprecedented ways for the control of nanocatalysis due to new designable degrees of freedom. The complex mechanisms behind stimuli-responsive nanocatalysis call for a concerted, interdisciplinary modelling approach that has converged in my group in the recent years. In particular, it can only be achieved by combining my expertise in multiscale computer simulations of solvated polymers with the statistical and continuum mechanics of soft matter structures and dynamics. The key challenge is to integrate the molecular solvation effects and our growing knowledge of hydrogel mechanics and thermodynamics into advanced reaction-diffusion equations for a quantitative rate prediction. In addition, I envision exciting novel phenomena such as a chemo-mechanical 'self-regulated catalysis' or an amplifying 'resonant catalysis', if hydrogel response and fluctuations couple to the chemical output signal. The expected results and design principles will help our collaborators to synthesize tailor-made, superior nanocatalysts and will advance our understanding of their structure-reactivity relationship.

Project End Date: **7/31/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715502	**EvoluTEM**	**PE4 - Physical and Analytical Chemical Sciences**

Principal Investigator:	**Dr. Sarah Haigh** sarah.haigh@manchester.ac.uk
Host Institution:	The University Of Manchester, UK

Illuminating Atomic Scale Processes in Liquids and Gases

EvoluTEM: Illuminating Atomic Scale Processes in Liquids and Gases Objective 1: To build new capability in atomic resolution environmental imaging and analysis.
Objective 2: To apply this platform to synthesise new photonic nanomaterials with enhanced performance. The vision is to design, construct, and make available the next generation of multifunctional in situ specimen holders for the scanning /transmission electron microscope (S/TEM). This new experimental resource will enable ground-breaking characterisation of complex nanoscale reactions under realistic and relevant environmental conditions using a lab-on-a-chip configuration. By providing a platform with unparalleled atomic scale imaging and simultaneous elemental analysis capabilities, as well as flexible in situ (temperature, pressure, and illumination) environments, this effort will provide an experimental module for a wide range of breakthrough in situ nanomaterials experiments. Motivating this work is the goal of being able to fully characterize the synthesis of novel photonic 2D materials, optoelectronic nanoparticles, and photoactive organic-inorganic perovskites. This research could lead to a new level of mechanistic understanding, providing knowledge to realize routes for the production of new nanostructures, with properties that can be optimally tailored for photonic applications (photovoltaics, light emission or optoelectronics). This ambitious research program is only possible because of the principal investigators outstanding electron microscopy expertise, coupled with the world leading nanofabrication capabilities and in situ imaging facilities at the University of Manchester. The project has been structured into five work packages (WPs) with each having well-defined milestones and deliverables.

Project End Date: **3/31/2022**

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 D. Scanlon** micheal.scanlon@ul.ie
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: **3/31/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
306250	**iPes**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. David Mecerreyes** david.mecerreyes@ehu.es
Host Institution:	Universidad Del Pais Vasco/ Euskal Herriko Unibertsitatea, ES

Innovative Polymers for Energy Storage

iPes project aims to provide adequate support to Dr. David Mecerreyes (DM) who is at the stage of consolidating an independent research team. During his scientific career, DM has demonstrated creative thinking and excellent capacity to carry out research and going beyond the state of the art. His meritorious record of research, scientific publications (128 ISI articles, h index = 33), project conception, private sector experience, networking ability (participated in 10 European collaborative projects) and capacity for supervising and coordinating a research team are presented in detail in the initial part of the proposal. He recently moved from the private sector to create a new research group at the University of the Basque Country. He is now in an excellent academic position and research environment to commit and be devoted to an ERC frontier research project. DM's proposal passed to the second stage in the ERC starting grant call of last year. This year the research project has been re-built taking into account his group directions and the detected weak points of last year's proposal. This is his last opportunity for participating to the ERC starting-grant call. iPes proposes an innovative research programme at the forefront of polymer chemistry. The proposal goes in depth into the topic of energetic polymers. iPes activities will fully develop the field of polymers for energy storage by using an innovative macromolecular engineering approach generating the ground for future innovations. The main S&T goal is to obtain new polymeric materials, to get an insight into their unique electronic properties, to model the new energetic polymers and to investigate their application in innovative battery prototypes. These technologies are currently dominated by inorganic electrode materials. iPes aims at bringing polymer chemistry to a next level and developing basic knowledge about innovative polymeric materials which may open up new opportunities for Energy Storage.

Project End Date: **11/30/2018**

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**
michael.cowley@ed.ac.uk

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: **2/28/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
646742	**INCANA**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. Martin Steinhart** martin.steinhart@uos.de
Host Institution:	Universitaet Osnabrueck, DE

Insect-inspired capillary nanostamping

Aim of the proposed project is a) development and establishment of insect-inspired capillary nanostamping (IICN) as next-generation contact nanolithography, b) replacing state-of-the-art lithographic and synthesis protocols requiring use of sacrificial templates or time-consuming self-assembly steps by IICN and c) significant IICN-driven acceleration and upscaling of the production of extended nanostructured systems. To meet these aims, IICN stamp design will be inspired by insect feet depositing small secretion droplets through arrays of hairy contact elements on counterpart surfaces. Monolithic IICN stamps extending cm2 will consist of spongy ink-filled substrates connected to extended arrays of spongy nanoscale dispensing elements with diameters in the 100 nm range (density up to ~130 dispensing elements per square micron). Ink supplied through the spongy pore systems forms capillary bridges between each dispensing element and counterpart surfaces, thus enabling massively parallel capillary bridge-guided nanorod synthesis. Capillary bridge rupture during stamp retraction leads to massively parallel lithographic deposition of ink nanodroplet arrays (target nanodroplet volume: a few 10 zeptolitres). IICN model applications include production of a) ultrathin nanoporous membranes for separation; b) ordered silicon nanostructures by IICN-supported metal-assisted etching; c) nearly-ergodic arrays of encapsulated liquid nanocontainers for massively parallel ensemble nanochemistry or ensemble tracing of single molecules; d) nearly-ergodic biochips for massively parallel analyte detection with single-molecule resolution. As example for substitution of time-consuming self-assembly in nanomaterial synthesis by IICN, IICN-accelerated production of ordered nanoporous alumina will be studied. To pave the way for upscaling and potential commercialization of IICN, high-throughput IICN devices for automated operation in batch and continuous roller modes will be constructed.

Project End Date: **8/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
646740	**RadMag**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. Richard Layfield** Richard.Layfield@manchester.ac.uk
Host Institution:	The University Of Manchester, UK

Radical Solutions for Hysteresis in Single-Molecule Magnets

Single-molecule magnets (SMMs) display magnetic hysteresis that is molecular in origin, and these materials have huge potential to be developed as nano-scale devices. The big challenge is to create SMMs that function without the need for liquid-helium cooling.This project will develop new SMMs that combine the strong magnetic anisotropy of lanthanide ions with a series of novel radical ligands. Our innovative SMMs will have controllable molecular and electronic structures, which will ultimately enable hysteresis at unprecedented temperatures.Highly unusual di- and tri-metallic Ln-SMMs are proposed in which the metals are bridged by radicals with heavy Group 15 (phosphorus-bismuth) and Group 16 (sulphur-tellurium) donor atoms. Trimetallic SMMs will also be based on hexaazatriphenylene (HAT) radicals, and dimetallic SMMs will also be based on nindigo radicals, both of which are nitrogen-donor ligands.The SMM field is dominated by systems with diamagnetic ligands. Our radical ligands have never been used in SMM studies: their diffuse unpaired spin provides a way of switching off the quantum tunnelling mechanisms that otherwise prevent hysteresis. We will exploit the rich electrochemistry of the target ligands: heavy p-block radicals have huge spin densities on the donor atoms; HAT radicals can have up to three unpaired electrons; reduced or oxidized nindigo radicals allow access to redox-switchable SMMs. In the HAT-bridged SMMs, the use of ligands with more than one unpaired electron is unprecedented. The heavy p-block ligands are themselves are novel.The PI's approach to SMMs has already established new directions in lanthanide chemistry and in molecular magnetism. He now proposes a new, radical approach to SMMs with potential to re-define the state of the art, and to extend the frontiers of a vibrant multi-disciplinary field. Achieving the aims will provide a major step towards using SMMs for applications at practical temperatures.

Project End Date: **8/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695009	**FunCapSys**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. Jonathan Nitschke** jrn34@cam.ac.uk
Host Institution:	The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

Functional Systems of Capsules

The simplest living organism is composed of myriad chemical subsystems, each consisting of structurally complex biomolecules that interact in many ways; the properties of life emerge from these dense connections. Understanding how these interactions take place will help elucidate the foundations of biology, as well as enabling the design and creation of new chemical networks with targeted functions. Deciphering and designing chemical systems requires new tools to be developed, however. In this research programme, we will develop new means for engineering functional chemical systems based upon the use of guest-binding capsules. These hosts will respond to many different signals in predictable ways. Their responses will enable their guests to be transformed in new ways or pumped between phases using light. Chemical signals will enable hosts to be transformed reversibly or irreversibly, changing their guest binding properties so as to favour some guests and disfavour others, and catalysts will be released or taken up, accelerating or impeding catalysed transformations. Ultimately we will design systems where signal transduction occurs in complex cycles and feedback loops, allowing complex behaviour to emerge from abiological systems.

Project End Date: **12/31/2021**

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** carlos.marti@uv.es
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: **12/31/2021**

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** javier.montenegro@usc.es
Host Institution:	Universidad De Santiago De Compostela, ES

Dynamic Penetrating Peptide Adaptamers

The aim of this proposal is to identify, at the molecular level, the minimal topological and structural motifs that govern the membrane translocation of short peptides. A covalent reversible bond strategy will be developed for the synthesis of self-adaptive penetrating peptides (adaptamers) for targeted delivery. It is known that the recently developed therapeutic technologies (i.e. gene therapy, chemotherapy, hyperthermia, etc.) cannot reach their expected potential due to limitations in the current delivery strategies, which hinder the efficient targeting of the appropriate tissues, cells and organelles. Despite the enormous therapeutic potential of short penetrating peptides, these molecules suffer from drawbacks such as toxicity, instability to protease digestion and lack of specificity. Dynamic covalent chemistry has significant synthetic advantages. In the proposed research, peptide scaffolds with clickable reversible groups (e.g. hydrazide) will be conjugated with collections of aldehydes to afford self-adaptive biomimetic transporters, whose secondary structure and penetrating properties will be systematically characterized by biophysical, cell-biology and pattern recognition techniques. The versatility of dynamic supramolecular “peptide adaptamers” with precisely positioned protein ligands will be explored for multivalent specific recognition, protein transport, cell targeting of drugs and probes and membrane epitoping. Additionally, we propose to synthesise dynamic and environmentally sensitive fluorescent probes for biocompatible membrane labelling and uptake signalling. The resulting discoveries of this research will allow the formulation of novel transfecting reagents for gene therapy, selective platforms for drug-delivery and the development of dynamic fluorescent membrane probes. The potential results of this proposal will shake the fields of drug-delivery and non-viral gene transfection and will resolve the limitations of the current approaches.

Project End Date: **1/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
678109	**ICARO**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. Teresa Pellegrino** TERESA.PELLEGRINO@iit.it
Host Institution:	Fondazione Istituto Italiano Di Tecnologia, IT

Colloidal Inorganic Nanostructures for Radiotherapy and Chemotherapy

Radio and chemotherapy are the major clinical treatments for cancer. However these treatments lack cell specificity and can have severe side effects against healthy cells, especially when used in combination. My goal is to develop a nanocrystal (NC) platform to merge radio and chemotherapy into a single entity that is more specific towards tumor cells. To achieve ICARO's goal, three main objectives will be pursued. The first objective is to introduce post-synthesis reactions, namely cation exchange (CE) and intercalation (INT) reactions, as new protocols to replace or intercalate cations that are useful as radionuclides within the crystal lattice of water-soluble NCs. Our goal is to establish protocols for the preparation of radiolabelled-NCs that will be easily translated to the medical practice for radiotherapy. This requires CE/INT reactions that occur in aqueous media, possibly with NCs prefunctionalized with specific recognition molecules to achieve targeted radiotherapy. To minimize the radio exposure of the operator, CE/INT protocols will be carried out as the last step of NC preparation. The second objective of ICARO will be to explore in situ CE/INT reactions with NCs entrapped in a matrix that simulates the tumor mass. By first located NCs at the tumor and then let the CE/INT to occur, enhance therapeutic effect is expected. The third objective of ICARO will be to develop heterostructures to combine radio and chemotherapy. They will include at least one semiconductor NC on which to perform radiolabelling protocols and one portion made of a superparamagnetic (SP) NC for magnetically triggered drug release. With respect to magnetic hyperthermia, which exploits SP-NCs to produce bulk heat (>46°C) at the tumor, the local heat effect generated at the surface of SP-NCs will enable drug release using a lower dose of magnetic material. Finally, new types of heterostructures combining radio and chemotherapy will be tested, for the first time, in preclinical trials.

Project End Date: **2/29/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647301	**DECRESIM**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator: **Dr. Alejandro Gaita-Ariño**
gaita@uv.es

Host Institution: Universitat De Valencia, ES

A Chemical Approach to Molecular Spin Qubits: Decoherence and Organisation of Rare Earth Single Ion Magnets

Coordination Chemistry and Molecular Magnetism are in an ideal position for the rational design of Single-Molecule Magnets which can be used as molecular spin qubits, the irreducible components of any quantum technology. Indeed, a major advantage of molecular spin qubits over other candidates stems from the power of Chemistry for a tailored and inexpensive synthesis of systems for their experimental study. In particular, the so-called Lanthanoid-based Single-Ion Magnets, which are currently the hottest topic in Molecular Magnetism, have the potential to be chemically designed, tuning both their single-molecule properties and their crystalline environment. This will allow the independent study of the different quantum processes that cause the loss of quantum information, collectively known as decoherence. The study of quantum decoherence processes in the solid state is necessary both to lay the foundations for next-generation quantum technologies and to answer some fundamental questions.The goals of this project are:#1 To unravel the mechanistic details of decoherence in molecular spin qubits based on mononuclear lanthanoid complexes. This study will stablish criteria for the rational design of single spin qubits.#2 To extend this study to the coupling between two or more spin qubits. This will allow us to explore the use of polynuclear lanthanoid complexes to achieve quantum gates or simple algorithms.#3 To extrapolate to infinite systems formed by the complex organization of spin qubits. This exploratory goal will permit us to move beyond zero-dimensional systems, thus facilitating the advance towards complex quantum functions.

Project End Date: **7/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714429	**MAEROSTRUC**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator: **Dr. Nadja Bigall**
nadja.bigall@pci.uni-hannover.de

Host Institution: Gottfried Wilhelm Leibniz Universitaet Hannover, DE

Multicomponent Aerogels with Tailored Nano-, Micro- Macrostructure

Aerogels and hydrogels from nanocrystal building blocks are a fascinating novel class of materials with extremely low densities and large specific surfaces, which partially exhibit the advantageous properties of their nanoscopic building blocks (e.g. size quantized fluorescence or catalytic activity). In the present project, multicomponent gels with controlled mechanical properties, plasmon enhanced fluorescence, photocatalytic properties, and with controlled conductivity properties will be synthesized. These new materials will not only exhibit the nanoscopic properties of their building blocks, but they will also exhibit new properties which are neither accessible from nanoparticle nor from bulk material. This will e.g. be achieved due to nanoscopic interactions between the materials or due to synergistic combination effects caused by appropriate material combination. Synthetic routes for nanostructuring, microstructuring and macrostructuring nanocrystal hydrogels and aerogels will be developed. Nanostructuring involves advancement of colloidal nanocrystal synthesis as well as postsynthetic gel modifications. Microstructuring involves synthesizing multicomponent gels with defined contact points of the materials and intercalating multicomponent gels. Macrostructuring involves implementation of the gelation techniques into 3D printing, and gel deformation by external triggers and will enhance the applicability of gels. The materials developed will be tailored for several physicochemical effects and hence applications. While the project focuses on the synthesis of these new materials with defined physicochemical properties, the outcome of this project will influence many different research and application fields, such as electrodes and batteries, sensors, photocatalysis and catalysis, solar cells, air and solar batteries, and even membranes and touch screen devices.

Project End Date: **2/28/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
692981	**LEAPS**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. Alberto Credi** alberto.credi@unibo.it
Host Institution:	Alma Mater Studiorum - Universita Di Bologna, IT

Light effected autonomous molecular pumps: Towards active transporters and actuating materials

The crucial role played by molecular motors in major biological processes gives a clue on the potential of these nanoscale devices for technology. Their exploitation depends on our ability to build working and robust artificial systems, and to interface them with their environment or other molecular constructs for using the motion to carry out tasks.The goal of this project is to develop the first synthetic photochemical supramolecular pumps and to apply them for performing nanoscale transport functions and macroscopic actuation. The motor modules, which rely on a functioning and affordable minimalist design based on first principles and threaded topologies, operate autonomously away from equilibrium by using light as a clean energy source, can be switched on/off chemically, and are easy to make and functionalize. Appropriately designed motors will be embedded in the bilayer of vesicles to pump molecules across physically separated places, thereby photogenerating concentration gradients. In parallel we plan to arrange the pump modules in oligomeric tracks and investigate the autonomous, directional and processive displacement of a molecule over a few nm. These linear motors will be equipped with a cargo that can be loaded/unloaded with control, yielding the first man-made molecular transporters. Finally, we will integrate the pump components in polymeric scaffolds such that the photoinduced operation of the motors produces a non-equilibrium entanglement of the polymer chains, that can be eventually unravelled by chemical stimulation. Such materials may be used to convert, store, and reuse the energy of (sun)light upon demand.All the above functionalities are unprecedented for wholly synthetic chemical structures. Their demonstration would be a landmark result in supramolecular chemistry and nanoscience, and open up radically new directions for nanotechnology, nanomedicine, and energy conversion.

Project End Date: **9/30/2021**

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** rob.ameloot@kuleuven.be
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: **11/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
614897	**TRANS-NANO**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator: **Dr. Liberato Manna**
liberato.manna@iit.it

Host Institution: Fondazione Istituto Italiano Di Tecnologia, IT

Advancing the Study of Chemical, Structural and Surface Transformations in Colloidal Nanocrystals

Colloidal inorganic nanocrystals (NCs) are among the most investigated nanomaterials in Nanoscience due to their high versatility. Research on NCs went through much advancement lately, especially on synthesis, assembly and on the study of their transformations, most notably via cation exchange (all fields in which the PI has contributed already). However, the integration of NCs with fabrication tools that employ conditions such as irradiation, etching and annealing is at a very early stage since we do not have a systematic knowledge of what transformations are triggered in the NCs under those conditions. Also, an issue related to the incorporation of NCs in materials/devices is whether, over time, the NCs will remain as they are, or they will transform into other structures. Plus, these transformations in NCs are poorly studied as they require fast recording techniques. This proposal will embark on an ambitious investigation of post-synthetic transformations in solution-grown NCs: by advancing the understanding of various aspects of chemical, structural and surface transformation of NCs, we will uncover new fabrication techniques that will employ such nanostructures as the key ingredients. This in turn will have a strong impact in opto-electronics, as several electronic components entirely made of NCs will be delivered. Four objectives are targeted: i) developing radically new sets of experimental tools for the investigation of chemical transformations in NCs, above all the ability to monitor in real time these transformations; ii) developing solution-grown nanostructures able to undergo programmed transformations under a defined stimulus; iii) understanding the role of irradiation on the fate of surface ligands and on cation exchange reactions in NCs; iv) combining chemical, structural and surface transformations towards NC-based opto-electronics. The success of the proposal hinges on the proven capabilities of the PI, with ample support from the host Institution.

Project End Date: **2/28/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
615653	**synMICs**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator: **Dr. Martin Albrecht**
Martin.albrecht@dcb.unibe.ch

Host Institution: Universitaet Bern, CH

Exploiting Synergistic Properties of Mesoionic Carbene Complexes: Teaching Rusty Metals Challenging Catalysis

The non-innocence of specific ligands in transition metal complexes is well-documented. For example, mesoionic carbenes engage in bond activation processes via reversible hydrogen capture. Such cooperativity between the metal center and the ligand flattens the potential energy surface of a catalytic reaction and hence rises the competence of the catalyst, thus entailing higher turnover numbers as well as the conversion of more challenging substrates. Likewise, such cooperativity is expected to enhance the catalytic activity of metal centers that are typically not considered to be catalytically very active, such as the 'rusty' first row transition metals (Mn, Fe, Ni). Surprisingly, however, this concept has largely been overlooked when designing catalytic transformations based on these earth-abundant and low-cost transition metals. This project will exploit the synergistic potential of mesoionic carbenes as synthetically highly versatile and actively supporting ligands to access a new generation of sustainable high-performance catalysts based on Me, Fe, and Ni for challenging redox transformations such as dehydrogenative oxidations. Specificlly, 1,2,3-triazolylidenes, which support ligand-metal cooperativity through their mesoionic character, will be utilized for (transient) storage/release of protons and electrons. Apart from enabling challenging transformations — with obvious impact on synthetic methodology, energy conversion, and molecular electronics — this project will break into new grounds in catalyst design that will be widely applicable as a new paradigm. Furthermore, this project will capitalize on the unique synthetic versatility of triazolylidene precursors and the opportunity to combine different functional entities such as carbohydrates, surfactants, or dyes with an organometallic entity, thus providing a straightforward approach to new classes of multifunctional materials for application in therapeutics and diagnostics, or as smart surfaces.

Project End Date: **1/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
637624	**ThermoTex**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. Christian Müller** christian.muller@chalmers.se
Host Institution:	Chalmers Tekniska Hoegskola Ab, SE

Woven and 3D-Printed Thermoelectric Textiles

Imagine a world, in which countless embedded microelectronic components continuously monitor our health and allow us to seamlessly interact with our digital environment. One particularly promising platform for the realisation of this concept is based on wearable electronic textiles. In order for this technology to become truly pervasive, a myriad of devices will have to operate autonomously over an extended period of time without the need for additional maintenance, repair or battery replacement. The goal of this research programme is to realise textile-based thermoelectric generators that without additional cost can power built-in electronics by harvesting one of the most ubiquitous energy sources available to us: our body heat.Current thermoelectric technologies rely on toxic inorganic materials that are both expensive to produce and fragile by design, which renders them unsuitable especially for wearable applications. Instead, in this programme we will use polymer semiconductors and nanocomposites. Initially, we will focus on the preparation of materials with a thermoelectric performance significantly beyond the state-of-the-art. Then, we will exploit the ease of shaping polymers into light-weight and flexible articles such as fibres, yarns and fabrics. We will explore both, traditional weaving methods as well as emerging 3D-printing techniques, in order to realise low-cost thermoelectric textiles.Finally, within the scope of this programme we will demonstrate the ability of prototype thermoelectric textiles to harvest a small fraction of the wearer's body heat under realistic conditions. We will achieve this through integration into clothing to power off-the-shelf sensors for health care and security applications. Eventually, it can be anticipated that the here interrogated thermoelectric design paradigms will be of significant benefit to the European textile and health care sector as well as society in general.

Project End Date: **5/31/2020**

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** fenga@ifm.liu.se
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: **2/28/2022**

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 J Vilatela**
juanjose.vilatela@imdea.org

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: **5/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
648831	**MyNano**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. Maria J. Vicent** mjvicent@cipf.es
Host Institution:	Fundacion De La Comunidad Valenciana Centro De Investigacion Principefelipe, ES

Towards the design of Personalised Polymer-based Combination Nanomedicines for Advanced Stage Breast Cancer Patients

Research on anticancer therapies has provided little progress towards improved survival rates for patients with metastatic disease. The intrinsic advantages of polymer conjugates can be optimised to rationally design targeted combination therapies, concept I pioneered that allows enhanced therapeutic efficiency. Early clinical trials involving conjugates showed activity in chemotherapy refractory patients and reduced drug-related toxicity. However, there is a growing concern on patient variability regarding tumor patho-physiology that underlie successful therapeutic outcome. Specific biomarkers are required to select those patients most likely to show good clinical response to these therapies. The objective of MyNano is to engineer polymer-based combination therapies designed to treat metastatic breast cancer in a patient personalised manner. Therefore, novel multicomponent polymer conjugates with precise control over size, shape, solution conformation, multifunctionality and bioresponsiveness will be obtained while in parallel their structure activity relationships to underlying proposed mechanisms of action in clinically relevant models will be studied. Polyglutamates obtained by controlled polymerisation and self-assembly strategies will be the carriers. Primary breast cancer patient tissue will be used to generate cell and in vivo models representing different clinical molecular subtypes. MyNano will also investigate new combination strategies using current treatments together with inhibitors of tumor-derived exosome release pathways, phenomenon related to metastasis and resistance mechanisms. The aim is to provide a novel methodological approach that would allow by reiterative design to optimise the design of the next generation nanoconjugates for the treatment of specific metastatic cancer clinical subtypes. MyNano will be a breakthrough as it introduces a paradigm shift in the strategy to design nanomedicines in areas of unmet clinical need.

Project End Date: **6/30/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647550	**UNBICAT**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. Jose Aleman** jose.aleman@uam.es
Host Institution:	Universidad Autonoma De Madrid, ES

Unconventional Bifunctional Catalysts

The development of sustainable chemical processes is one of the most important features in modern chemistry. It has become a key research area worldwide providing solutions to important societal demands by optimizing the use of natural resources and minimizing waste and environmental impact. Among the relevant methods for achieving this goal, catalysis represents a key and central approach. Both Organocatalysis and Metal Catalysis have emerged as solutions to the problems in this context. In this field, the progress of a novel bifunctional organocatalyst that could increase the number of different activations, and therefore the synthesis of valuable enantio-enriched molecules, would be highly desirable. Especially important, but still unknown, are the bifunctional-catalysts based on a Neutral Coordinate Organocatalyst and Photo-Organocatalysts. This proposal aims to develop two new unconventional approaches for the synthesis of bifunctional organocatalysts.

The first one is based on the development of new Bifunctional Neutral Coordinate Organocatalyst and their application to the synthesis of biologically relevant compounds. I propose to use these bifunctional catalysts to promote the dual activation of silyl reagents and suitable electrophiles. This approach constitutes an unconventional way to synthesize asymmetric molecules and has no precedent in the literature.

The second section of this proposal explores the photo-activation-bifunctional organocatalyst. I propose the design and application of new metal-free Bifunctional Photo-Organocatalysts which are able to chemically and photo-activate the substrate simultaneously in an asymmetric manner.

This project has the potential to change the general view of asymmetric Neutral Coordinate Organocatalyst and Photo-catalysis as we know it today. These unconventional bifunctional would be incorporated into the privileged catalyst library for its applications in new asymmetric transformations.

Project End Date: **8/31/2020**

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** maria.gimenez-lopez@nottingham.ac.uk
Host Institution:	The University Of Nottingham, UK

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 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.

Project End Date: **3/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725172	**SIRFUNCT**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. Christian Adam Olsen** cao@sund.ku.dk
Host Institution:	Københavns Universitet, DK

Chemical Tools for Unravelling Sirtuin Function

It was recently realized that lysine acetylation affects a wide variety of cellular processes in addition to the initially recognized histone related gene regulation. Together with recent groundbreaking results, revealing the presence of additional acyllysine modifications, the basis for a paradigm shift in this area was formed. Examples of enzymes formerly thought to be lysine deacetylases, have been shown to cleave these new types of lysine modification and members of the sirtuin class of enzymes play a central role.

Development of new tools to investigate the importance of these new modifications as well as the sirtuins that cleave them is required. We therefore propose to adopt an interdisciplinary approach by developing selective inhibitors and so-called activity-based probes (ABPs) and applying these to the investigation of proteins recognizing novel post-translational acylations of lysine residues in cells. Such ABPs will be powerful tools for providing insight regarding this rapidly evolving area of biochemistry; however, the current state-of-the-art in ABP design is endowed with severe limitations because the modifications are inherently cleaved by various hydrolases in human cells. Thus, in the present project, I propose that novel designs accommodating non-cleavable modifications are warranted to maintain structural integrity during experiments.

Furthermore, I propose to apply similar mechanism-based designs to develop potent and isoform-selective sirtuin inhibitors, which will serve as chemical probes to investigate links between cancer and metabolism, and may ultimately serve as lead compounds for pre-clinical pharmaceutical development. AIM-I. (a) Development and (b) application of collections of chemical probes for activity-based investigation of enzymes that interact with post-translationally acylated proteins. AIM-II. Utilization of structural and mechanistic insight to design potent and selective inhibitors of sirtuin enzymes.

Project End Date: **3/31/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
616907	**ProtCage**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. Jeroen Cornelissen** j.j.l.m.cornelissen@utwente.nl
Host Institution:	Universiteit Twente, NL

Chemistry in the Confinement of Protein Cages

Protein cages appear to be common structures in biology, found in viruses but also in organelle-like containers discovered in bacteria. In this proposed program I aim to study chemical processes in nano-sized protein cages as mimics of bacterial organelles and to increase the general understanding of chemistry in confinement.

Towards this goal we will investigate the controlled in vivo loading of bacterial protein cages, i.e. encapsulins, with proteins and enzymes. This will allow us to study in detail the chemical conversions that take place inside such capsules and it will increase understanding about the reasons why certain processes inside these simple organisms are encased in the protein organelles.

Completely artificial protein organelles will be constructed by in vitro processes using the well-studied Cowpea Chlorotic Mottle virus cage. By employing DNA technology, cages will be loaded with a single enzyme, a sequence of enzymes or molecular probes. By obtaining this high level of control, we can not only study chemical conversions on the inside, but it will also allow us to monitor the physiochemical properties, such as internal pH, polarity and porosity of the protein mantle by encasing the relevant probes or host/guest systems.

In the ultimate stage of the proposed project the formed artificial organelles will be brought into cells in order to interact with the cell metabolism. CCMV has to be introduced by surface modification, while encapsulins can be formed inside these cells; albeit with different cargo. Such experiments have, to my knowledge, not been carried out and introducing new reactions inside these organisms can lead to new potentially interesting products or interfere with cell vitality. The latter can be of importance for the controlled disruption of bacterial cells.

Project End Date: **4/30/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
648283	**GROWMOF**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator: **Dr. Tina Düren**
t.duren@bath.ac.uk

Host Institution: University Of Bath, UK

Modelling of MOF self-assembly, crystal growth and thin film formation

Metal-organic frameworks (MOFs) constitute one of the most exciting developments in recent nanoporous material science. Synthesised in a self-assembly process from metal corners and organic linkers, a near infinite number of materials can be created by combining different building blocks allowing to fine tune host guest interactions. MOFs are therefore considered promising materials for many applications such as gas separation, drug delivery or sensors for which MOFs in form of nanoparticles, composite materials or thin films are required. For MOFs to realise their potential and to become more than just promising materials, a degree of predictability in the synthesis and the properties of the resulting material is paramount and the full multiscale pathway from molecular assembly to crystal growth and thin film formation needs to be better understood.Molecular simulation has greatly contributed to developing adsorption applications of MOFs and now works hand-in-hand with experimental methods to characterise MOFs, predict their performance and study molecular level phenomena. In contrast, hardly any simulation studies exist about the formation of MOFs, their crystal growth or the formation of thin films. Yet such studies are essential for understanding the fundamentals which will ultimately lead to a better control of the material properties. Building on my expertise in molecular modelling including the development of methods to model the synthesis of porous solids, we will develop new methods to study: 1. the self-assembly process of MOFs under synthesis conditions 2. the formation of nanoparticles 3. the integration of MOF nanoparticles into composite materials and the self-assembly into extended structures 4. the layer-by-layer growth of thin films At the end of the project we will have transformed our understanding of how MOFs form at a variety of length scales and opened up new research directions for the targeted synthesis of MOFs fit for applications.

Project End Date: **7/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
336567	**PP1tools**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator: **Dr. Maja Köhn**
maja.koehn@bioss.uni-freiburg.de

Host Institution: Albert-Ludwigs-Universitaet Freiburg, DE

Development of chemical biology tools for the elucidation of protein phosphatase-1 substrates and druggability

Protein serine/threonine phosphatases (PSTPs) are considered undruggable although they are involved in the most prominent post-translational modifications. This is mainly due to an apparent lack of substrate specificity. One important PSTP is protein phosphatase-1 (PP1), a ubiquitous PSTP that is predicted to catalyze about 1/3rd of Ser and Thr dephosphorylations in eukaryotic cells, counteracting hundreds of kinases. PP1 has broad substrate specificity but is restrained in vivo by numerous PP1-interacting proteins functioning for example as substrate-targeting proteins and forming specific holoenzymes with PP1. PP1 holoenzymes play a role in many different diseases such as cancer (counteracting oncogenic kinases), diabetes (insulin release), Alzheimer's (dephosphorylation of Tau protein) and HIV (viral translation). Currently, there are no chemical modulators available that target PP1 selectively, except that we recently developed the first compound that selectively activates PP1 in intact cells, leading to rapid dephosphorylation of PP1 substrates. The activator does not act on the most closely related protein phosphatase-2A. This proposal aims to generate and apply tools for the investigation of PP1, in part based on our previously developed activator. The tools include selective, photo- and enzymatically releasable chemical inhibitors and activators and semisynthetic proteins, and they will be applied to study PP1–substrate interactions and help identify the correlating interacting proteins. The proposed research will provide long-sought selective chemical tools to study PP1 by applying new concepts of activator and inhibitor design using peptide and small molecule chemistry to an enzyme class that is difficult to be targeted chemically. This research program will contribute to a much more detailed understanding of PP1 biology, and will open doors to investigate PP1 and its holoenzymes as drug targets.

Project End Date: **12/31/2018**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
648711	**GAINBYSTRAIN**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. Daniel B. Werz** d.werz@tu-braunschweig.de
Host Institution:	Technische Universitaet Braunschweig, DE

Gain by Strain: Precise Cuts of Cyclopropanes as Key to Molecular Complexity

A central discipline of chemistry is the design und creation of molecules with defined structural and chemical properties. Stretching synthetic horizons is a never-ending endeavor to inspirit the chemist' s creativity in preparing compounds and materials yet to be discovered. Relying on their high strain energy cyclopropanes, as carriers of the most fundamental ring geometry, offer a unique reactivity which allows for a multitude of transformations being grouped in ring-opening reactions, cycloadditions and rearrangements. Major advantage of all these processes is the cyclopropane-derived intrinsic atom-economy.

In this research project, we propose a number of uncommon and challenging reactions making use of donor-acceptor cyclopropanes. Introducing a distinctively controlled bond cleavage we seek to develop novel modes of 1,3-bifunctionalization by σ-bond metathesis, by using hypervalent iodine reagents and by merging organocatalysis with photoredox catalysis. Unprecedented ring-enlargements to four-membered rings by [3+1]-cycloadditions employing isonitriles, carbenes and nitrenes are envisioned, aryne insertions into the three-membered ring leading to indane systems are planned and a general concept for [3+3]-cycloadditions with 1,3-dipoles is presented paving the way to unusual syntheses of heterocycles.

A distinct class of compounds obtainable by our methodology will set the stage to access completely unexplored heterocyclic π-systems being of interest for material science and molecular electronics.

Besides our central goals of advancing organic methodology and to demonstrating the synthetic utility of these novel reactions, we anticipate that mechanistic insights gained by experimental and computational means will be of high impact for the chemistry of this fundamental structural unit in general.

Project End Date: **6/30/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679211	**FLOWTONICS**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. Fabien Sorin** fabien.sorin@epfl.ch
Host Institution:	Ecole Polytechnique Federale De Lausanne, CH

Solid-state flow as a novel approach for the fabrication of photonic devices

The development of advanced photon-based technologies offers exciting promises in fields of crucial importance for the development of sustainable societies such as energy and food management, security and health care. Innovative photonic devices will however reveal their true potential if we can deploy their functionalities not only on rigid wafers, but also over large-area, flexible and stretchable substrates. Indeed, providing energy harvesting, sensing, or stimulating abilities over windows, screens, food packages, wearable textiles, or even biological tissues will be invaluable technological breakthroughs. Today, however, conventional fabrication approaches remain difficult to scale to large area, and are not well adapted to the mechanical and topological requirements of non-rigid and curved substrates. In FLOWTONICS, we propose innovative materials processing approaches and device architectures to enable the simple and scalable fabrication of nano-structured photonic systems compatible with flexible and stretchable substrates. Our strategy is to direct the flow of optical materials through an innovative and thus far unexplored exploitation of the solid-state dewetting and thermal drawing processes. Our objectives are three-fold: (1) Study and demonstrate, for the first time, the strong potential of the dewetting of chalcogenide glasses layers for the fabrication of large area photonic devices; (2) Show that dewetting can also be exploited to realize photonic architectures onto engineered, nano-imprinted flexible and stretchable polymer substrates; (3) Demonstrate, for the first time, the use of the thermal drawing process as a novel tool to realize advanced flexible and stretchable photonic ribbons and fibers. These novel approaches can contribute to game-changing scientific and technological advances for the sustainable management of our resources and to meet our growing health care needs, putting Europe at the forefront of innovation in these crucial areas.

Project End Date: **1/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
337221	**SIMONE**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. Kasper Moth-Poulsen** mkasper@chalmers.se
Host Institution:	Chalmers Tekniska Hoegskola Ab, SE

Single Molecule Nano Electronics (SIMONE)

The development of micro fabrication and field effect transistors are key enabling technologies for todays information society. It is hard to imagine superfast and omnipresent electronic devices, information technology, the Internet and mobile communication technologies without access to continuously cheaper and miniaturized microprocessors. The giant leaps in performance of microprocessors from the first personal computing machines to todays mobile devices are to a large extent realized via miniaturization of the active components. The ultimate limit of miniaturization of electronic components is the realization of single molecule electronics. Due to fundamental physical limitations, single molecule resolution cannot be achieved using classical top-down lithographic techniques. At the same time, existing surface functionalization schemes do not provide any means of placing a single molecule with high precision at a specific location on a nanostructure. This project has the ambitious goal of establishing the first method ever allowing for self-assembly of multiple single molecule devices in a parallel way and thereby provide the first method ever allowing for multiple individual single molecule components to operate together in the same device.
The impact of the technology platforms described herein goes vastly beyond the field of single molecule electronics and utilization in ultra-sensitive plasmonic biosensors with a digital single molecule response will be explored in parallel with the main roadmaps of the project.

Project End Date: **1/31/2019**

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** chaudretinsa-toulouse.fr
Host Institution:	Centre National De La Recherche Scientifique, 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: **5/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
678883	**CatASus**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. KAtalin Barta** k.barta@rug.nl
Host Institution:	Rijksuniversiteit Groningen, NL

Cleave and couple: Fully sustainable catalytic conversion of renewable resources to amines

Amines are crucially important classes of chemicals, widely present in pharmaceuticals, agrochemicals and surfactants. Yet, surprisingly, a systematic approach to obtaining this essential class of compounds from renewables has not been realized to date.
The aim of this proposal is to enable chemical pathways for the production of amines through alcohols from renewable resources, preferably lignocellulose waste. Two key scientific challenges will be addressed: The development of efficient cleavage reactions of complex renewable resources by novel heterogeneous catalysts; and finding new homogeneous catalyst based on earth-abundant metals for the atom-economic coupling of the derived alcohol building blocks directly with ammonia as well as possible further functionalization reactions. The program is divided into 3 interrelated but not mutually dependent work packages, each research addressing a key challenge in their respective fields, these are:
WP1: Lignin conversion to aromatics; WP2: Cellulose-derived platform chemicals to aromatic and aliphatic diols and solvents. WP3: New iron-based homogeneous catalysts for the direct, atom-economic C-O to C-N transformations.

The approach taken will embrace the inherent complexity present in the renewable feedstock. A unique balance between cleavage and coupling pathways will allow to access chemical diversity in products that is necessary to achieve economic competitiveness with current fossil fuel-based pathways and will permit rapid conversion to higher value products such as functionalized amines that can enter the chemical supply chain at a much later stage than bulk chemicals derived from petroleum. The proposed high risk-high gain research will push the frontiers of sustainable and green chemistry and reach well beyond state of the art in this area. This universal, flexible and iterative approach is anticipated to give rise to a variety of similar systems targeting diverse product outcomes starting from renewables.

Project End Date: **4/30/2021**

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**
gb453@cam.ac.uk

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 that involve disease-associated proteins is limited, to a large extent, by the lack of development of a strategy that can use small coupling partners to react in chemoselective fashion with rapid kinetics that does not interfere with biological function(s) and localisation. In this application, I describe a conceptually new bioorthogonal-labelling approach that combines the introduction of a minimal non-canonical amino acid with chemoselective reactions, which display rapid kinetics, to label proteins in live cells. The small size of the new alkene-tagged amino acids, which will be genetically encoded, should not interfere with the protein's innate structure, function(s) or localisation. Site-selective bioorthogonal labelling will be achieved through the use of a new photo-triggered [2+2] cycloaddition reaction with an alkene-bearing fluorophore and the known inverse-electron-demand Diels-Alder reaction with a fluorogenic tetrazine. Although the former offers potentially improved spatial and temporal resolution, the latter allows for turn-on fluorescence. The proposed new methodology will be applied in the context of a key cytokine involved in cancer progression. The ability to label this cytokine with minimal perturbation of its structure, function(s) and localisation will enable monitoring of its internalisation and intracellular trafficking pathways in cells that overexpress its receptor. In doing so, new insight into cancer biology will be generated that will inform the construction of safer, selective and more efficient protein-drug conjugates for targeted cancer treatment. The concept proposed here is designed to be generally applicable to label and study disease-associated proteins that are difficult to access by means of conventional protein-labelling methods and constitute the first integrated, interdisciplinary approach for the development of protein drug-conjugates.

Project End Date: **9/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
339478	**LAYERENG-HYBMAT**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator: **Dr. Maarit Karppinen**
maarit.karppinen@aalto.fi

Host Institution: Aalto-Korkeakoulusaatio, FI

Molecular-Layer-Engineered Inorganic-Organic Hybrid Materials

On-demand-designed and precision-synthesized multicomponent or hybrid materials with unorthodox combinations of properties are potential keys to fascinating next-generation devices. At the same time there is a strong scientific desire to create a comprehensive repertory of basic understanding, design strategies and experimental tools to construct such outstanding smart materials from different building blocks and to shape them into sophisticated hierarchical architectures.

In LAYERENG-HYBMAT I propose a fundamentally new category of nanocomposite materials, that is, layer-by-layer grown coherent inorganic-organic hybrid materials where the cohesion between the layers is based on covalent bonding. Such materials are – once carefully designed and fabricated – able to display in a single material a tailored combination of properties of conventional inorganics and organics, and even beyond. The core hypothesis is that such intimately fused outstanding hybrids are materialized in a simple but extremely elegant manner by mimicking the state-of-the-art thin-film technology, i.e. ALD (atomic layer deposition), originally developed for purely inorganic thin films. The proposed method combines ALD and MLD (molecular layer deposition) cycles and enables the layer-by-layer deposition of coherent inorganic-organic thin films and coatings through sequential self-limiting gas-surface reactions with high precision for the composition and polymer-chain dispersity. With additional nanostructuring capacity these materials have the potential to open up new horizons in electronics, photonics, thermoelectrics, diagnostics, packaging, etc.

The project builds on my long experience in frontier new-material research on other types of multilayered materials and successful proof-of-the-concept ALD/MLD experiments, and addresses all the fundamental aspects of new-material design, modelling, precision synthesis, property tailoring and function characterization.

Project End Date: **1/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
338849	**GuidedNW**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. Ernesto Joselevich** ernesto.joselevich@weizmann.ac.il
Host Institution:	Weizmann Institute Of Science, IL

Guided Nanowires: From Growth Mechanism to Self-Integrating Nanosystems

The large-scale assembly of nanowires (NWs) with controlled orientation on surfaces remains one challenge toward their integration into practical devices. A recent paper in Science from the PI's group reported the guided growth of millimeter-long horizontal NWs with controlled orientations on crystal surfaces. The growth directions and crystallographic orientation of GaN NWs are controlled by their epitaxial relationship with different planes of sapphire, as well as by a graphoepitaxial effect that guides their growth along surface steps and grooves. Despite their interaction with the surface, these horizontally grown NWs have surprisingly few defects, exhibiting optical and electronic properties superior to those of vertically grown NWs. We observed that whereas in a 2D film stress accumulates in two directions, in a NW stress accumulates along its axis, but can relax in the transversal direction, making the 1D system much more tolerant to mismatch than a 2D film. This new 1D nanoscale effect, along with the graphoepitaxial effect, subverts the paradigm not only in the young field of NWs, but also in the established field of epitaxy. This paves the way to highly controlled semiconductor structures with potential applications not available by other means. The aim of this project is to investigate the guided growth of NWs and unleash its vast possibilities toward the realization of self-integrating nanosystems. First, we will generalize the guided growth of NWs to a variety of semiconductors and substrates, and produce ordered arrays of NWs with coherently modulated composition and doping. Second, we will conduct fundamental studies to investigate the correlated structure, growth mechanism, optical and electronic properties of guided NWs. Third, we will exploit the guided growth of NWs for the production of various functional self-integrating systems, including nanocircuits, LEDs, lasers, photovoltaic cells, photodetectors, photonic and nonlinear optical devices.

Project End Date: **1/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716311	**SWEETBULLETS**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. Alexander Titz** alexander.titz@helmholtz-hzi.de
Host Institution:	Helmholtz-Zentrum Fuer Infektionsforschung Gmbh, DE

Sweet Theranostics in Bitter Infections - Seek and Destroy

Bacterial infections are now a global threat demanding novel treatments due to the appearance of resistances against antibiotics at a high pace. The ESKAPE pathogens are those with highest importance in the EU and chronic infections due to biofilm formation are a particular task. Noninvasive pathogen-specific imaging of the infected tissue is not clinically available. Its successful implementation will enable the choice of appropriate therapy and boost efficacy. Furthermore,
Gram-negative bacteria have a highly protective cellular envelope as an important resistance mechanism for drugs acting intracellularly, resulting in an alarmingly empty drug-pipeline.
To overcome this gap, I will establish Lectin-directed Theranostics targeting pathogens via their extracellular carbohydrate-binding proteins at the site of infection for specific imaging and treatment. This will be implemented for the highly resistant ESKAPE pathogen Pseudomonas aeruginosa through 3 different work packages.
WP1 Sweet Imaging: Design & conjugation of lectin-directed ligands to imaging probes, Optimization of ligand/linker, in vivo proof-of-concept imaging study.
WP2 Sweet Targeting: Delivery of antibiotics to the infection through covalent linking of lectindirecting groups. Employing different antibiotics, assessment of bactericidal potency and targeting efficiency. Manufacturing of nano-carriers with surface exposed lectin-directed ligands, noncovalent charging with antibiotics. In vitro and in vivo targeting.
WP3 Sweet SMART Targeting: Conjugates as SMART drugs: specific release of anti-biofilm lectin inhibitor and drug cargo upon contact with pathogen, development of linkers cleavable by pathogenic enzymes.
SWEETBULLETS will establish fundamentally novel lectin-directed theranostics to fight these deleterious infections and provide relief to nosocomially infected and cystic fibrosis patients. It is rapidly extendable towards other ESKAPE pathogens, e.g. Klebsiella spp..

Project End Date: **1/31/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647281	**SOLACYLIN**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. Julien Bachmann** julien.bachmann@fau.de
Host Institution:	Friedrich-Alexander-Universitat Erlangen Nurnberg, DE

A preparative approach to geometric effects in innovative solar cell types based on a nanocylindrical structure

The ERC Consolidator Grant project SOLACYLIN aims at providing experimental insight into the function of 'third-generation' photovoltaic systems by generating materials stacks structured in a well-defined, accurately tunable, nanocylindrical geometry.

To this goal, we will develop and exploit advanced preparative methods based on two fundamental ingredients: (a) ordered 'anodic' porous oxides and (b) atomic layer deposition (ALD). The former solids will be generated as templates providing ordered arrays of straight, cyclindrical pores, the diameter and length of which can be varied between 20 nm and 300 nm and between 0.5 microns and 50 microns, respectively. The latter method will be used to coat the inner pore walls with one or several layers of the photovoltaic stack, each with a thickness set to values chosen between 1 nm and 30 nm.

We will invent and characterize novel surface reaction schemes for the deposition in ALD mode (from the gas phase and from solutions) of functional materials (doped semiconductors and intrinsic light absorbers) with tailored chemical and physical properties. We will investigate the experimental conditions in which they can be combined in a way that optimizes the quality of their interfaces.

Finally, we will quantify the electrical and photovoltaic performance of p-i-n junctions prepared with our methods. We will have the unique capability of describing in a systematic, accurate manner how the experimental photovoltaic parameters depend on the individual thicknesses of the individual layers and on the length of the cylinders. This direct experimental handle on the amount of light absorbed, on the one hand, and the charge carrier transport distances to the electrical contacts, on the other hand, will be correlated with the relevant material parameters (absorption coefficients, carrier mobilities). This information will unveil the phenomena limiting the efficiency of each type of solar cell, and suggest avenues to remedy them.

Project End Date: **8/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
340698	**Disorder Control**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. Matthias Wuttig** wuttig@physik.rwth-aachen.de
Host Institution:	Rheinisch-Westfaelische Technische Hochschule Aachen, DE

Tuning Disorder in Chalcogenides to realize Advanced Functional Devices

Better performance of future computers and communication equipment requires substantially higher speeds of switching devices at lower energy consumption. Those requirements can only be achieved by substantial improvement of the transport properties of the materials employed. The transport of charge and heat is strongly influenced by disorder. In recent years we have found a unique class of crystalline materials which combines an exceptionally high, yet tuneable degree of disorder with remarkable transport properties. This class includes the best phase change materials, superconductors with an unconventional coupling mechanism, good thermoelectrics, as well as known topological insulators. For these different phenomena disorder is either very beneficial or – if unconditioned - rather detrimental. Hence we need to be able to control disorder in these materials to tailor their properties.

Exploring this concept requires the ability to understand, eliminate or harness the effects of disorder. Recently we have demonstrated an Anderson-type transition from insulating to metallic behaviour upon annealing. However, to fully utilize these ideas it is mandatory to realize devices with a more directly controllable degree of disorder. Within the framework of this project, we will develop a tuneable Anderson insulator to delocalize charge carriers. This allows us to address a) the transition from an insulator to a metal, the impact of disorder on superconductors (b) and topological insulators (c) and finally d) the ability to control thermoelectric properties by tuneable electronic disorder. From the results to be obtained we expect consequences for a wide range of materials listed in our “treasure map”, with promising new technological applications in various devices.

Project End Date: **2/28/2019**

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** m.j.bojdys.02@cantab.net
Host Institution:	Univerzita Karlova, CZ

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: **7/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
726470	**CAM-RIG**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. Professor Oren Alexander Scherman** oas23@cam.ac.uk
Host Institution:	The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

ConfocAl Microscopy and real-time Rheology of dynamIc hyroGels

Hydrogels cross-linked through supramolecular interactions are highly dependant on the dynamic charac- teristics of the physical cross-links. Few fundamental studies have been undertaken to quantitatively de- scribe structure-property relationships for these types of systems. Hydrogels formed from CB[8]-mediated supramolecular physical cross-linking mechanisms have gained significant interest on account of their excel- lent physical and mechanical properties such as self-healing and shear-thinning. This supramolecular motif has been further exploited to introduce and compatibilise a wide variety of different materials into hydrogel networks without phase separation, forming hybrid composite hydrogels attributed with unique and emergent properties. This proposal aims to pioneer the combination of several state-of-the-art characterisation tech- niques into an unique experimental setup (CAM-RIG), which will combine super-resolution and confocal microscopy imaging modalities with simultaneous strain-controlled rheological measurements to investigate fundamental structure-property relationships of these systems. For the first time it will be possible to decon- volute the molecular-level dynamics of the supramolecular physical cross-links from chain entanglement of the polymeric networks and understand their relative contributions on the resultant properties of the hydrogels. Using the fundamental insight gained, a set of key parameters will be determined to maximise the potential of supramolecular biocompatible hydrogels, driving paradigm shifts in sustainable science and biomaterial applications through the precise tuning of physical properties.

Project End Date: **4/30/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677715	**GeneREFORM**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. Amnon Bar-Shir** amnon.barshir@weizmann.ac.il
Host Institution:	Weizmann Institute Of Science, IL

Genetically Encoded Multicolor Reporter Systems For Multiplexed MRI

In order to fully understand the complexity of biological processes that are reflected by simultaneous occurrences of intra and inter-cellular events, multiplexed imaging platforms are needed. Fluorescent reporter genes, with their “multicolor” imaging capabilities, have revolutionized science and their founders have been awarded the Nobel Prize. Nevertheless, the light signal source of these reporters, which restricts their use in deep tissues and in large animals (and potentially in humans), calls for alternatives.

Reporter genes for MRI, although in their infancy, showed several exceptionalities, including the ability to longitudinal study the same subject with unlimited tissue penetration and to coregister information from reporter gene expression with high-resolution anatomical images. Inspired by the multicolor capabilities of optical reporter genes, this proposal aims to develop, optimize, and implement genetically engineered reporter systems for MRI with artificial “multicolor” characteristics. Capitalizing on (i) the Chemical Exchange Saturation Transfer (CEST)-MRI contrast mechanism that allows the use of small bioorganic molecules as MRI sensors, (ii) the frequency encoding, color-like features of CEST, and on (iii) enzyme engineering procedures that allow the optimization of enzymatic activity for a desired substrate, a “multicolor” genetically encoded MRI reporter system is proposed.

By (a) synthesizing libraries of non-natural nucleosides (“reporter probes”) to generate artificially “colored” CEST contrast, and (b) performing directed evolution of deoxyribonucleoside kinase (dNK) enzymes (“reporter genes”) to phosphorylate those nucleosides, the “multicolor” genetically encoded MRI “reporter system” will be created. The orthogonally of the obtained pairs of substrate (CEST sensor)/ enzyme (mutant dNK) will allow their simultaneous use as a genetically encoded reporter system for in vivo “multicolor” monitoring of reporter gene expression with MRI.

Project End Date: **4/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
635928	**PRISM**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. Ilja Voets** i.voets@tue.nl
Host Institution:	Technische Universiteit Eindhoven, NL

Ice-binding proteins: from antifreeze mechanism to resistant soft materials

Crystallization of water into ice is lethal to most organisms and detrimental to many soft materials. Freeze-tolerant fish living in polar seas evolved to tackle this problem with an unusual coping strategy. They produce 'antifreeze' proteins that block the growth of nascent ice crystals within a narrow temperature range known as the 'thermal hysteresis gap' enabling survival under extreme conditions. Encoding this functionality into synthetic polymers would open up new avenues in biomedicine, agrifood and materials science for e.g. cryopreservation, crop hardiness, ice-templating, dispersion stability, and advanced coatings. Progress requires a profound understanding of the mechanism of non-colligative freezing point depression at the molecular level and allows for efficient strategies for the design and preparation of powerful macromolecular antifreezes.I propose to unravel how antifreeze proteins work and to build upon these insights to explore effective routes towards ice-binding polymers aiming to make sensitive soft materials freeze-resistant. Within this challenge we first focus on single-molecule experiments to visualize bound proteins and study the strength of the non-covalent interaction with ice. We will study if and when adsorption on 'foreign' interfaces and solution assembly impact activity. These fundamental insights will guide our research towards synthetic antifreeze agents with superior functionality to achieve record supercooling in complex environments. This knowledge-based design of polymers with high affinity for crystalline interfaces holds great promise for many areas of science and technology in which crystallization plays a decisive role.

Project End Date: **4/30/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
614182	**IonPairsAtCatalysis**	**PE5 - Synthetic Chemistry and Materials**

Principal Investigator:	**Dr. Ruth Gschwind** ruth.gschwind@chemie.uni-regensburg.de
Host Institution:	Universitaet Regensburg, DE

Design Principles of Ion Pairs in Organocatalysis – Elucidation of Structures, Intermediates and Stereoselection Modes as well as Assessment of Individual Interaction Contributions

Ions are nearly omnipresent in chemistry and biochemistry. By providing the highest intermolecular interaction energies, ionic interactions have an extreme impact on molecular structures, which are the key to molecular functions. Experimentally determined structures of small contact ion pairs in solution are very rare and sometimes lacking in complete research fields. In addition, despite the amazing progress in theoretical and supramolecular chemistry, the subtle interplay of interactions in small organic ion pairs remains largely unknown. As a result design principles for small organic ion pairs in solution are not available. To solve this general problem there is an urgent and actual need of the synthetic community, because ion-pairing catalysis is the actual hot topic in asymmetric catalysis. There, new catalysts have to be screened with high effort in a black box mode and reviews state that structural and mechanistic studies will be an essential part of the further progress in the field. In previous projects spread over the fields of organometallic, bioorganic, supramolecular and medicinal chemistry as well as transition metal catalysis and organocatalysis, we gained special NMR expertise in the structure elucidation of ion pairs and reaction intermediates as well as the assessment of intermolecular interactions. Now in this project, nearly all of these various techniques and approaches will be combined in a new and so far unprecedented way and complemented by techniques used for protein ligand interactions and extreme low temperature measurements. With this unique combination, NMR approaches will be developed and applied to elucidate the structures of catalytically active ion pairs and their intermediates in solution and to dissect their intermolecular interactions. The resulting detailed design concept for small ion pairs in solution will revolutionize not only ion-pairing catalysis but all scientific fields working with organic ion pairs in solution.

Project End Date: **3/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
726227	**CSP**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Srdjan Capkun** capkuns@inf.ethz.ch
Host Institution:	Eidgenössische Technische Hochschule Zürich, CH

Cross-Layer Design of Securing Positioning

With the development of new location-based services and the expected deployment of cyber-physical systems (e.g., autonomous cars and drones) the reliance on location and time information in critical applications will only increase. Today's positioning systems are vulnerable to location spoofing by which devices can cheat on their own positions or can manipulate the measured positions of other devices. This problem cannot be fixed by a simple upgrade - existing positioning systems rely on legacy distance measurement techniques and protocols that were designed without security considerations or with security as an after-thought. We therefore need a new approach to the design of positioning systems that takes security requirements into account from the very start, and also accounts for the way that positioning systems are built and used. This is a cross-layer endeavor. In this project we will address the following fundamental questions: (1) Physical Layer. How can we design the right distance measurement (i.e., distance bounding) techniques that provide resilience to physical-layer and logical-layer attacks but retain the performance (range, accuracy and speed of execution) of equivalent non-secure systems? We will extend the existing knowledge in terms of the attacker models as well as achievable limits of security and performance of distance measurement techniques under realistic attacker models. (2) Link Layer. What are the right Medium Access Control (MAC) protocols for secure positioning, what are their performance and scalability limits? (3) Systems. How can distance bounding be integrated in mobile platforms, especially with trusted execution environments. How can this integration strengthen the security of distance bounding and support its use in a wide range of applications?

Project End Date: **2/28/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
713999	**Matryoshka**	**PE6 - Computer Science and Informatics**

Principal Investigator: **Dr. Jasmin Christian Blanchette**
jasmin.blanchette@gmail.com

Host Institution: Stichting Vu, NL

Fast Interactive Verification through Strong Higher-Order Automation

Proof assistants are increasingly used to verify hardware and software and to formalize mathematics. However, despite the success stories, they remain very laborious to use. The situation has improved with the integration of first-order automatic theorem provers -- superposition provers and SMT (satisfiability modulo theories) solvers -- through middleware such as Sledgehammer for Isabelle, codeveloped by the PI; but this research has now reached the point of diminishing returns. Only so much can be done when viewing automatic provers as black boxes. To make interactive verification more cost-effective, we propose to deliver very high levels of automation to users of proof assistants by fusing and extending two lines of research: automatic and interactive theorem proving. This is our grand challenge. Our starting point is that first-order automatic provers are the best tools available for performing most of the logical work. Our approach will be to enrich superposition and SMT with higher-order reasoning in a careful manner, to preserve their desirable properties. We will design proof rules and strategies, guided by representative benchmarks from interactive verification. With higher-order superposition and higher-order SMT in place, we will develop highly automatic provers building on modern superposition provers and SMT solvers, following a novel stratified architecture. To reach end users, these new provers will be integrated in proof assistants, including Coq, Isabelle, and the TLA+ Proof System, and will be available as backends to more specialized verification tools. The users of proof assistants and similar tools stand to experience substantial productivity gains: In the past five years, the success rate of automatic provers on interactive proof obligations from a representative benchmark suite has risen from 47% to 77%; with this project, we aim at 90%--95% proof automation.

Project End Date: **2/28/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714532	**PowAlgDO**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Stanislav Zivny** standa.zivny@cs.ox.ac.uk
Host Institution:	The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Power of Algorithms in Discrete Optimisation

Convex relaxations, such as linear and semidefinite programming, constitute one of the most powerful techniques for designing efficient algorithms, and have been studied in theoretical computer science, operational research, and applied
mathematics. We seek to establish the power convex relaxations through the lens of, and with the extensions of methods designed for, Constraint Satisfaction Problems (CSPs). Our goal is twofold. First, to provide precise characterisations of the applicability of convex relaxations such as which problems can be solved by linear programming relaxations. Secondly, to derive computational complexity consequences such as for which classes of problems the considered algorithms are optimal in that they solve optimally everything that can be solved in polynomial time. For optimisation problems, we aim to characterise the limits of linear and semidefinite programming relaxations for exact, approximate, and robust solvability. For decision problems, we aim to characterise the limits of local consistency methods, one of the fundamental techniques in artificial intelligence, which strongly relates to linear programming relaxations. Recent years have seen some remarkable progress on characterising the power of algorithms for a very important type of problems known as non-uniform constraint satisfaction problems and their optimisation variants. The ultimate goal of this
project is to develop new techniques and establish novel results on the limits of convex relaxations and local consistency methods in a general setting going beyond the realm of non-uniform CSPs.

Project End Date: **12/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
340328	**MECCA**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Per Stenstrom** pers@chalmers.se
Host Institution:	Chalmers Tekniska Hoegskola Ab, SE

Meeting Challenges in Computer Architecture

Computer technology has doubled computational performance every 24 months, over the past several decades. This performance growth rate has been an enabler for the dramatic innovation in information technology that now embraces our society. Before 2004, application developers could exploit this performance growth rate with no effort. However, since 2004 power consumption of computer chips exceeded the allowable limits and from that point and onwards, parallel computer architectures became the norm. Currently, parallelism is completely exposed to application developers and managing it is difficult and time-consuming. This has a serious impact on software productivity that may stall progress in information technology. Technology forecasts predict that by 2020 there will be hundreds of processors on a computer chip. Apart from managing parallelism, keeping power consumption within allowable limits will remain a key roadblock for maintaining historical performance growth rates. Power efficiency must increase by an order of magnitude in the next ten years to not limit the growth rate. Finally, computer chips are also key components in embedded controllers, where stringent timing responses are mandatory. Delivering predictable and tight response times using parallel architectures is a challenging and unsolved problem. MECCA takes a novel, interdisciplinary and unconventional approach to address three important challenges facing computer architecture – the three Ps: Parallelism, Power, and Predictability in a unified framework. Unlike earlier, predominantly disciplinary approaches, MECCA bridges layers in computing systems from the programming language/model, to the compiler, to the run-time/OS, down to the architecture layer. This opens up for exchanging information across layers to manage parallelism and architectural resources in a
transparent way to application developers to meet challenging performance, power, and predictability requirements for future computers.

Project End Date: **1/31/2019**

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** manuel.bodirsky@tu-dresden.de
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: **9/30/2021**

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** luc.deraedt@cs.kuleuven.be
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: **8/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
617951	**ACUITY**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Nikhil Bansal** n.bansal@tue.nl
Host Institution:	Technische Universiteit Eindhoven, NL

Algorithms for coping with uncertainty and intractability

The two biggest challenges in solving practical optimization problems are computational intractability, and the presence
of uncertainty: most problems are either NP-hard, or have incomplete input data which
makes an exact computation impossible. Recently, there has been a huge progress in our understanding of intractability, based on spectacular algorithmic and lower bound techniques. For several problems, especially those with only local constraints, we can design optimum
approximation algorithms that are provably the best possible.
However, typical optimization problems usually involve complex global constraints and are much less understood. The situation is even worse for coping with uncertainty. Most of the algorithms are based on ad-hoc techniques and there is no deeper understanding of what makes various problems easy or hard. This proposal describes several new directions, together with concrete intermediate goals, that will break important new ground in the theory of approximation and online algorithms. The particular directions we consider are (i) extend the primal dual method to systematically design online algorithms, (ii) build a structural theory of online problems based on work functions, (iii) develop new tools to use the power of strong convex relaxations and (iv) design new algorithmic approaches based on non-constructive proof techniques. The proposed research is at the
cutting edge of algorithm design, and builds upon the recent success of the PI in resolving several longstanding questions in these areas. Any progress is likely to be a significant contribution to theoretical
computer science and combinatorial optimization.

Project End Date: **4/30/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
678177	**FOVEDIS**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Constantin Enea** cenea@irif.fr
Host Institution:	Universite Paris Diderot - Paris 7, FR

Formal specification and verification of distributed data structures

The future of the computing technology relies on fast access, transformation, and exchange of data across large-scale networks such as the Internet. The design of software systems that support high-frequency parallel accesses to high-quantity data is a fundamental challenge. As more scalable alternatives to traditional relational databases, distributed data structures (DDSs) are at the basis of a wide range of automated services, for now, and for the foreseeable future. This proposal aims to improve our understanding of the theoretical foundations of DDSs. The design and the usage of DDSs are based on new principles, for which we currently lack rigorous engineering methodologies. Specifically, we lack design procedures based on precise specifications, and automated reasoning techniques for enhancing the reliability of the engineering process. The targeted breakthrough of this proposal is developing automated formal methods for rigorous engineering of DDSs. A first objective is to define coherent formal specifications that provide precise requirements at design time and explicit guarantees during their usage. Then, we will investigate practical programming principles, compatible with these specifications, for building applications that use DDSs. Finally, we will develop efficient automated reasoning techniques for debugging or validating DDS implementations against their specifications. The principles underlying automated reasoning are also important for identifying best practices in the design of these complex systems to increase confidence in their correctness. The developed methodologies based on formal specifications will thus benefit both the conception and automated validation of DDS implementations and the applications that use them.

Project End Date: **4/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
646867	**Learn**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Leonardo Mariani** mariani@disco.unimib.it
Host Institution:	Universita' Degli Studi Di Milano-Bicocca, IT

Learning From Failing and Passing Executions At the Speed of Internet

Modern software systems must be extremely flexible and easily adaptable to different user needs and environments. However, this flexibility also introduces relevant quality issues. These problems are so common that is sufficient browsing the Web to find millions of reports about failures observed after updates and incompatibilities caused by the interaction of a newly installed component with the existing components. The impact of problems introduced by end-users can be dramatic because end-users can easily modify applications, like developers do, but end-users have neither the knowledge nor the skill of developers, and they cannot debug and fix the problems that they unintentionally introduce. It is thus necessary to timely develop novel solutions that can increase the reliability of the moderns systems, which can be extended and adapted by end-users, with the capability to automatically address problems that are unknown at development-time. The Learn project aims to produce innovative solutions for the development of systems that can work around the problems introduced by end-users when modifying their applications. The three key elements introduced by Learn to automatically produce a (temporary) fix for the software are: (1) the definition of the InternetLearn infrastructure, which is a network infrastructure that enables communication between every individual instance of a same program running at different end-users' sites, thus augmenting each application with the capability to access a huge amount of information collected in-the-field from other sites; (2) the definition of analysis techniques that can learn the characteristics of successful and failed runs by monitoring executions in the field from a number of instances running at many end-user sites; and (3) the definition of techniques for the automatic generation and actuation of temporary fixes on an Internet (World) scale.

Project End Date: **9/30/2019**

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** tw@cse.unsw.edu.au
Host Institution:	Technische Universitaet Berlin, DE

Allocation Made PracticaL

Allocation Made PracticaLThe 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: **5/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
648785	**BODY-UI**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Kasper Hornbæk** kash@di.ku.dk
Host Institution:	Københavns Universitet, DK

Using Embodied Cognition to Create the Next Generations of Body-based User Interfaces

Recent advances in user interfaces (UIs) allow users to interact with computers using only their body, so-called body-based UIs. Instead of moving a mouse or tapping a touch surface, people can use whole-body movements to navigate in games, gesture in mid-air to interact with large displays, or scratch their forearm to control a mobile phone. Body-based UIs are attractive because they free users from having to hold or touch a device and because they allow always-on, eyes-free interaction. Currently, however, research on body-based UIs proceeds in an ad hoc fashion and when body-based UIs are compared to device-based alternatives, they perform poorly. This is likely because little is known about the body as a user interface and because it is unclear whether theory and design principles from human-computer interaction (HCI) can be applied to body-based UIs. While body-based UIs may well be the next interaction paradigm for HCI, results so far are mixed.This project aims at establishing the scientific foundation for the next generations of body-based UIs. The main novelty in my approach is to use results and methods from research on embodied cognition. Embodied cognition suggest that thinking (including reasoning, memory, and emotion) is shaped by our bodies, and conversely, that our bodies reflect thinking. We use embodied cognition to study how body-based UIs affect users, and to increase our understanding of similarities and differences to device-based input. From those studies we develop new body-based UIs, both for input (e.g., gestures in mid-air) and output (e.g., stimulating users' muscles to move their fingers), and evaluate users' experience of interacting through their bodies. We also show how models, evaluation criteria, and design principles in HCI need to be adapted for embodied cognition and body-based UIs. If successful, the project will show how to create body-based UIs that are usable and orders of magnitude better than current UIs.

Project End Date: **4/30/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
637277	**FLEXILOG**	**PE6 - Computer Science and Informatics**

Principal Investigator: **Dr. Steven Schockaert**
SchockaertS1@cardiff.ac.uk

Host Institution: Cardiff University, UK

Formal lexically informed logics for searching the web

Semantic search engines use structured knowledge to improve traditional web search, e.g. by directly answering questions from users. Current approaches to semantic search rely on the unrealistic assumption that all true facts about a given domain are explicitly stated in their knowledge base or on the web. To reach their full potential, semantic search engines need the ability to reason about known facts. However, existing logics cannot adequately deal with the imperfect nature of knowledge from the web. One problem is that relevant information tends to be distributed over several heterogeneous knowledge bases that are inconsistent with each other. Moreover, domain theories are seldom complete, which means that a form of so-called plausible reasoning is needed. Finally, as relevant logical theories do not exist for many domains, reasoning may need to rely on imperfect probabilistic theories that have been learned from the web. To overcome these challenges, FLEXILOG will introduce a family of logics for robust reasoning with messy real-world knowledge, based on vector-space representations of natural language terms (i.e. of lexical knowledge). In particular, we will use lexical knowledge to estimate the plausibility of logical models, using conceptual simplicity as a proxy for plausibility (i.e. Occam's razor). This will enable us to implement various forms of commonsense reasoning, equipping classical logic with the ability to draw plausible conclusions based on regularities that are observed in a knowledge base. We will then generalise our approach to probabilistic logics, and show how we can use the resulting lexically informed probabilistic logics to learn accurate and comprehensive domain theories from the web. This project will enable a robust data-driven approach to logic-based semantic search, and more generally lead to fundamental progress in a variety of knowledge-intensive applications for which logical inference has traditionally been too brittle.

Project End Date: **4/30/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
669844	**LASSO**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Kim Guldstrand Larsen** kgl@cs.aau.dk
Host Institution:	Aalborg Universitet, DK

Learning, Analysis, SynthesiS and Optimization of Cyber-Physical Systems

Cyber-physical systems (CPS) are emerging throughout society, e.g. traffic systems, smart grids, smart cities, and medical devices, and brings the promise to society of better solutions in terms of performance, efficiency and usability. However, CPS are often highly safety critical, e.g. cars or medical devices, thus the utmost care must be taken that optimization of performance does not hamper crucial safety conditions. Given the constant growth in complexity of CPS, this task is becoming increasingly demanding for companies to handle with existing methods. The principle barrier for mastering the engineering of complex CPS being both trustworthy and efficient is the lack of a theoretical well-founded framework for CPS engineering supported by powerful tools, that will enable companies to timely meet increasing market demands.With his extensive contributions to model-driven methodologies, and as provider of one of the “foremost” tools for embedded systems verification, the PI is well prepared to provide the missing framework. The LASSO framework will support the quantitative modeling of both cyber- and physical components, their efficient analysis, the learning of models for unknown components, as well as automatic synthesis and optimization of missing cyber-components from specifications. LASSO will provide the new generation of scalable tools for CPS, allowing trade-offs between safety constraints and performance measure to be made.LASSO will achieve its objective by ground-breaking and extensive combinations of two different research areas: model checking and machine learning. The framework will develop a complete metric approximation theory for quantitative models, allowing properties to be inferred from reduced or learned models with metric guarantees of their validity in the original system. Further, the applicability of the framework will be validated through a number of CPS case studies, and the tools developed will be made generally available.

Project End Date: **10/31/2020**

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**
amoeller@cs.au.dk

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 in static and dynamic program analysis for JavaScript. The central idea is to combine static and dynamic analysis in new ways. In addition, the project will make program analysis algorithms and infrastructure available in a form that embraces reusability.

Project End Date: **7/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
693174	**GeCo**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Stefano Ceri** stefano.ceri@polimi.it
Host Institution:	Politecnico Di Milano, IT

Data-Driven Genomic Computing

Next-generation sequencing technology has dramatically reduced the cost and time of reading the DNA. Huge investments are targeted to sequencing the DNA of large populations, and repositories of well-curated sequence data are being collected. Answers to fundamental biomedical problems are hidden in these data, e.g. how cancer arises, how driving mutations occur, how much cancer is dependent on environment. But genomic computing has not comparatively evolved. Bioinformatics has been driven by specific needs and distracted from a foundational approach; hundreds of methods solve individual problems, but miss the broad perspective.The objective of GeCo is to rethink genomic computing through the lens of basic data management. We will first design the data model, using few general abstractions that guarantee interoperability between existing data formats. Next, we will design a new-generation query language inspired by classic relational algebra and extended with orthogonal, domain-specific abstractions for genomics. Query processing will trace metadata and computation steps, opening doors to the seamless integration of descriptive statistics and high-level data analysis (e.g., DNA region clustering and extraction of regulatory networks).Genomic computing is a “big data” problem, therefore we will also achieve computational efficiency by using parallel computing on both clusters and public clouds; the choice of a suitable data model and of computational abstractions will boost performance in a principled way. The resulting technology will be applicable to individual and federated repositories, and will be exploited for providing integrated access to curated data, made available by large consortia, through user-friendly search services. Our most far-fetching vision is to move towards an Internet of Genomes exploiting data indexing and crawling. The PI’s background in distributed data, data modelling, query processing and search will drive a radical paradigm shift.

Project End Date: **8/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679515	**COLORAMAP**	**PE6 - Computer Science and Informatics**

Principal Investigator: **Dr. Nicolas Gillis**
nicolas.gillis@umons.ac.be

Host Institution: Universite De Mons, BE

Constrained Low-Rank Matrix Approximations: Theoretical and Algorithmic Developments for Practitioners

Low-rank matrix approximation (LRA) techniques such as principal component analysis (PCA) are powerful tools for the representation and analysis of high dimensional data, and are used in a wide variety of areas such as machine learning, signal and image processing, data mining, and optimization. Without any constraints and using the least squares error, LRA can be solved via the singular value decomposition. However, in practice, this model is often not suitable mainly because (i) the data might be contaminated with outliers, missing data and non-Gaussian noise, and (ii) the low-rank factors of the decomposition might have to satisfy some specific constraints. Hence, in recent years, many variants of LRA have been introduced, using different constraints on the factors and using different objective functions to assess the quality of the approximation; e.g., sparse PCA, PCA with missing data, independent component analysis and nonnegative matrix factorization. Although these new constrained LRA models have become very popular and standard in some fields, there is still a significant gap between theory and practice. In this project, our goal is to reduce this gap by attacking the problem in an integrated way making connections between LRA variants, and by using four very different but complementary perspectives: (1) computational complexity issues, (2) provably correct algorithms, (3) heuristics for difficult instances, and (4) application-oriented aspects. This unified and multi-disciplinary approach will enable us to understand these problems better, to develop and analyze new and existing algorithms and to then use them for applications. Our ultimate goal is to provide practitioners with new tools and to allow them to decide which method to use in which situation and to know what to expect from it.

Project End Date: **8/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
614331	**SSS**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Rasmus Pagh** pagh@itu.dk
Host Institution:	It-Universitetet I Kobenhavn, DK

Scalable Similarity Search

Similarity search is the task of identifying, in a collection of items, the ones that are “similar” to a given
query item. This task has a range of important applications (e.g. in information retrieval, pattern recognition, statistics, and machine learning) where data sets are often big, high dimensional, and possibly noisy. State-of-the-art methods for similarity search offer only weak guarantees when faced with
big data. Either the space overhead is excessive (1000s of times larger than the space for the data itself),
or the work needed to report the similar items may be comparable to the work needed to go through all
items (even if just a tiny fraction of the items are similar). As a result, many applications have to resort to
the use of ad-hoc solutions with only weak theoretical guarantees. This proposal aims at strengthening the theoretical foundation of scalable similarity search, and
developing novel practical similarity search methods backed by theory. In particular we will: - Leverage new types of embeddings that are kernelized, asymmetric, and complex-valued. - Consider statistical models of noise in data, and design similarity search data structures whose
performance guarantees are phrased in statistical terms. - Build a new theory of the communication complexity of distributed, dynamic similarity search,
emphasizing the communication bottleneck present in modern computing infrastructures. The objective is to produce new methods for similarity search that are: 1) Provably robust, 2) scalable
to large and high-dimensional data sets, 3) substantially more resource efficient than current state-ofthe-
art solutions, and 4) able to provide statistical guarantees on query answers. The study of similarity search has been an incubator for techniques (e.g. locality-sensitive hashing and
random projections) that have wide-ranging applications. The new techniques developed in this project
are likely to have significant impacts beyond similarity search.

Project End Date: **4/30/2019**

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** pcm@unifr.ch
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: **7/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
638049	**SYNTECH**	**PE6 - Computer Science and Informatics**

Principal Investigator: **Dr. Shahar Maoz**
maoz@cs.tau.ac.il

Host Institution: Tel Aviv University, IL

Synthesis Technologies for Reactive Systems Software Engineers

The design and development of open reactive systems, which compute by reacting to ongoing stimuli from their environment, and include, for example, mobile applications running on smart phone devices, web-based applications, industrial robotic systems, embedded software running on chips inside cars and aircraft, etc., is a complex and challenging task. Despite advancement from low-level assembly languages to higher-level languages with powerful abstraction mechanisms, and the use of automated testing and formal verification, reactive systems software development is still a mostly manual and error-prone iterative activity of coding and debugging.A fundamentally different alternative approach to reactive systems development is synthesis, the automatic creation of correct-by-construction software from its specification. Synthesis has the potential to transform the way open reactive systems software is developed, making the process more effective and productive, and making its results more reliable and usable. However, while important advancements have been recently made on the algorithmic aspects of synthesis, no work has yet taken advantage of these achievements to change software engineering practices from “program centric” to “specification centric”. No effective end-to-end means to use synthesis are available to engineers, and the potential revolutionary impact of synthesis on the engineering of reactive systems software is far from being fully explored. The proposal targets four objectives: a new, rich specification language, tailored for synthesis and for use by software engineers; a set of new methods for specification centric development; tool implementations in ‘killer app’ application domains; and systematic evaluation with engineers. The research aims to unleash and evaluate the potential of synthesis to revolutionize reactive systems software development and to open the way for new directions in software engineering research and practice.

Project End Date: **9/30/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682810	**TissueMaps**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Carolina Wählby** carolina@cb.uu.se
Host Institution:	Uppsala Universitet, SE

Integrating spatial and genetic information via automated image analysis and interactive visualization of tissue data

Digital imaging of tissue samples and genetic analysis by next generation sequencing are two rapidly emerging fields in pathology. The exponential growth in digital imaging in pathology is catalyzed by more advanced imaging hardware, comparable to the complete shift from analog to digital images that took place in radiology a couple of decades ago: Entire glass slides can be digitized at near the optical resolution limits in only a few minutes' time, and fluorescence as well as bright field stains can be imaged in parallel. Genetic analysis, and particularly transcriptomics, is rapidly evolving thanks to the impressive development of next generation sequencing technologies, enabling genome-wide single-cell analysis of DNA and RNA in thousands of cells at constantly decreasing costs. However, most of today's available technologies result in a genetic analysis that is decoupled from the morphological and spatial information of the original tissue sample, while many important questions in tumor- and developmental biology require single cell spatial resolution to understand tissue heterogeneity. The goal of the proposed project is to develop computational methods that bridge these two emerging fields. We want to combine spatially resolved high-throughput genomics analysis of tissue sections with digital image analysis of tissue morphology. Together with collaborators from the biomedical field, we propose two approaches for spatially resolved genomics; one based on sequencing mRNA transcripts directly in tissue samples, and one based on spatially resolved cellular barcoding followed by single cell sequencing. Both approaches require development of advanced digital image processing methods. Thus, we will couple genetic analysis with digital pathology. Going beyond visual assessment of this rich digital data will be a fundamental component for the future development of histopathology, both as a diagnostic tool and as a research field.

Project End Date: **3/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
338164	**iHEARu**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Björn Schuller** schuller@ieee.org
Host Institution:	Universität Passau, DE

Intelligent systems' Holistic Evolving Analysis of Real-life Universal speaker characteristics

Recently, automatic speech and speaker recognition has matured to the degree that it entered the daily lives of thousands of Europe's citizens, e.g., on their smart phones or in call services. During the next years, speech processing technology will move to a new level of social awareness to make interaction more intuitive, speech retrieval more efficient, and lend additional competence to computer-mediated communication and speech-analysis services in the commercial, health, security, and further sectors. To reach this goal, rich speaker traits and states such as age, height, personality and physical and mental state as carried by the tone of the voice and the spoken words must be reliably identified by machines. In the iHEARu project, ground-breaking methodology including novel techniques for multi-task and semi-supervised learning will deliver for the first time intelligent holistic and evolving analysis in real-life condition of universal speaker characteristics which have been considered only in isolation so far. Today's sparseness of annotated realistic speech data will be overcome by large-scale speech and meta-data mining from public sources such as social media, crowd-sourcing for labelling and quality control, and shared semi-automatic annotation. All stages from pre-processing and feature extraction, to the statistical modelling will evolve in "life-long learning" according to new data, by utilising feedback, deep, and evolutionary learning methods. Human-in-the-loop system validation and novel perception studies will analyse the self-organising systems and the relation of automatic signal processing to human interpretation in a previously unseen variety of speaker classification tasks. The project's work plan gives the unique opportunity to transfer current world-leading expertise in this field into a new de-facto standard of speaker characterisation methods and open-source tools ready for tomorrow's challenge of socially aware speech analysis.

Project End Date: **12/31/2018**

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** jcheney@inf.ed.ac.uk
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: **8/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
640110	**BASTION**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Thorsten Holz** thorsten.holz@rub.de
Host Institution:	Ruhr-Universitaet Bochum, DE

Leveraging Binary Analysis to Secure the Internet of Things

We are in the midst of the shift towards the Internet of Things (IoT), where more and more (legacy) devices are connected to the Internet and communicate with each other. This paradigm shift brings new security challenges and unfortunately many current security solutions are not applicable anymore, e.g., because of a lack of clear network boundaries or resource-constrained devices. However, security plays a central role: In addition to its classical function in protecting against manipulation and fraud, it also enables novel applications and innovative business models. We propose a research program that leverages binary analysis techniques to improve the security within the IoT. We concentrate on the software level since this enables us to both analyze a given device for potential security vulnerabilities and add security features to harden the device against future attacks. More specifically, we concentrate on the firmware (i.e., the combination of persistent memory together with program code and data that powers such devices) and develop novel mechanism for binary analysis of such software. We design an intermediate language to abstract away from the concrete assembly level and this enables an analysis of many different platforms within a unified analysis framework. We transfer and extend program analysis techniques such as control-/data-flow analysis or symbolic execution and apply them to our IL. Given this novel toolset, we can analyze security properties of a given firmware image (e.g., uncovering undocumented functionality and detecting memory corruption or logical vulnerabilities,). We also explore how to harden a firmware by retrofitting security mechanisms (e.g., adding control-flow integrity or automatically eliminating unnecessary functionality). This research will deepen our fundamental understanding of binary analysis methods and apply it to a novel area as it lays the foundations of performing this analysis on the level of intermediate languages.

Project End Date: **2/29/2020**

European Research Council
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Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679681	**Tamed Cancer**	**PE6 - Computer Science and Informatics**

Principal Investigator: **Dr. Levente Kovacs**
kovacs.levente@nik.uni-obuda.hu

Host Institution: Obudai Egyetem, HU

Personalized Cancer Therapy by Model-based Optimal Robust Control Algorithm

Imagine if tumor growth would be reduced and then kept in a minimal and safe volume in an automated manner and in a personalized way, i.e. cancer drug would be injected using a continuous therapy improving the patient's quality of life.

By control engineering approaches it is possible to create model-based strategies for health problems. Artificial pancreas is an adequate example for this, where by continuous glucose measurement device and insulin pump it is possible to improve diabetes treatment. Gaining expertise from this problem, the current proposal focuses on taming the cancer by developing an engineering-based medical therapy.

The interdisciplinary approach focuses on modern robust control algorithm development in order to stop the angiogenesis process (i.e. vascular system development) of the tumor; hence, to stop tumor growth, maintaining it in a minimal, "tamed" form. This breakthrough concept could revitalize cancer treatment. It is the right time to do it as some investigations regarding tumor growth modeling have been already done; now, it should be refined by model identification tools and validated on animal trials. The benefit of robust control was already demonstrated in artificial pancreas; hence, it could be adapted to cancer research. The result could end with a personalized healthcare approach for drug-delivery in cancer, improving quality of life, optimizing drug infusion and minimizing treatment costs. This interdisciplinary approach combines control engineering with mathematics, computer science and medical sciences.

As a result, the model-based robust control approach envisage refining the currently existing tumor growth modeling aspects, design an optimal control algorithm and extend it by robust control theory to guarantee its general applicability. Based on our research background, validation will be done first in a manually controlled way, but then in an automatic mode to propose it for further human investigations.

Project End Date: **6/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
638605	**SenseX**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Marianna Obrist** m.obrist@sussex.ac.uk
Host Institution:	University Of Sussex, UK

Sensory Experiences for Interactive Technologies

The senses we call upon to interact with technology are still very limited relying mostly on visual and auditory senses. The grand challenge and vision of this project is to gain a rich and integrated understanding on touch, taste, and smell experiences for interactive technologies.We aim to achieve this ambitious grand vision by 1) creating a 'sensory interaction framework' on the bases of a systematic empirical investigation of touch, taste, and smell experiences, 2) integrating the generated understanding on the three senses into meaningful and efficient experiential cross-sensory gamuts and interaction principles, and 3) demonstrating the added value of the created experiential understanding on touch, taste, and smell – aka the experiential gamuts – through their integration into the development of multi-sensory systems verifying the short-, mid- and long-term societal and scientific impact (short-term: multi-sensory media experiences; mid-term: interaction concepts for partially sensory impaired people; long-term: multi-sensory interaction approach for life beyond Earth).This research will pioneer novel interaction concepts for interactive technologies in relation to essential components of multi-sensory experiences. This project will transform existing interaction paradigm in Human-Computer Interaction (HCI) and likewise impact other disciplines such as sensory and cognitive sciences by delivering ground-breaking new insights on the experiential dimensions underlying neurological processes and human perception.The PI's research excellence and her track record (three recent seminal papers on touch, taste, and smell at the premier HCI – CHI conference) provide a rock solid foundation for the feasibility of the proposed scientific venture. This ERC project would enable her to establish an independent and interdisciplinary team to revolutionize multi-sensory research within the HCI community with impact across disciplines.

Project End Date: **3/31/2020**

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** danupon@gmail.com
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: **1/31/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
615517	**FORSIED**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Tijl De Bie** tijl.debie@ugent.be
Host Institution:	Universiteit Gent, BE

Formalizing Subjective Interestingness in Exploratory Data Mining

The rate at which research labs, enterprises and governments accumulate data is high and fast increasing. Often, these data are collected for no specific purpose, or they turn out to be useful for unanticipated purposes: Companies constantly look for new ways to monetize their customer databases; Governments mine various databases to detect tax fraud; Security agencies mine and cross-associate numerous heterogeneous information streams from publicly accessible and classified databases to understand and detect security threats. The objective in such Exploratory Data Mining (EDM) tasks is typically ill-defined, i.e. it is unclear how to formalize how interesting a pattern extracted from the data is. As a result, EDM is often a slow process of trial and error. During this fellowship we aim to develop the mathematical principles of what makes a pattern interesting in a very subjective sense. Crucial in this endeavour will be research into automatic mechanisms to model and duly consider the prior beliefs and expectations of the user for whom the EDM patterns are intended, thus relieving the users of the complex task to attempt to formalize themselves what makes a pattern interesting to them. This project will represent a radical change in how EDM research is done. Currently, researchers typically imagine a specific purpose for the patterns, try to formalize interestingness of such patterns given that purpose, and design an algorithm to mine them. However, given the variety of users, this strategy has led to a multitude of algorithms. As a result, users need to be data mining experts to understand which algorithm applies to their situation. To resolve this, we will develop a theoretically solid framework for the design of EDM systems that model the user's beliefs and expectations as much as the data itself, so as to maximize the amount of useful information transmitted to the user. This will ultimately bring the power of EDM within reach of the non-expert.

Project End Date: **4/30/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647423	**SEDAL**	**PE6 - Computer Science and Informatics**

Principal Investigator: **Dr. Gustau Camps-Valls**
gustau.camps@uv.es

Host Institution: Universitat De Valencia, ES

Statistical Learning for Earth Observation Data Analysis.

SEDAL is an interdisciplinary project that aims to develop novel statistical learning methods to analyze Earth Observation (EO) satellite data. In the last decade, machine learning models have helped to monitor land, oceans, and atmosphere through the analysis and estimation of climate and biophysical parameters. Current approaches, however, cannot deal efficiently with the particular characteristics of remote sensing data. In the coming few years, this problem will largely increase: several satellite missions, such as the operational EU Copernicus Sentinels, will be launched, and we will face the urgent need to process and understand huge amounts of complex, heterogeneous, multisource, and structured data to monitor the rapid changes already occurring in our Planet. SEDAL aims to develop the next generation of statistical inference methods for EO data analysis. We will develop advanced regression methods to improve efficiency, prediction accuracy and uncertainties, encode physical knowledge about the problem, and attain self-explanatory models learned from empirical data. Even more importantly, we will learn graphical causal models to explain the potentially complex interactions between key observed variables, and discover hidden essential drivers and confounding factors. This project will thus aboard the fundamental problem of moving from correlation to dependence and then to causation through EO data analysis. The theoretical developments will be guided by the challenging problems of estimating biophysical parameters and learning causal relations at both local and global planetary scales. The long-term vision of SEDAL is tied to open new frontiers and foster research towards algorithms capable of discovering knowledge from EO data, a stepping stone before the more ambitious far-end goal of machine reasoning of anthropogenic climate change.

Project End Date: **8/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
339691	**FEALORA**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Pavel Pudlak** pudlak@math.cas.cz
Host Institution:	Matematicky Ustav Av Cr V.V.I., CZ

Feasibility, logic and randomness in computational complexity

We will study fundamental problems in complexity theory using means developed in logic, specifically, in the filed of proof complexity. Since these problems seem extremely difficult and little progress has been achieved in solving them, we will prove results that will explain why they are so difficult and in which direction theory should be developed. Our aim is to develop a system of conjectures based on the concepts of feasible incompleteness and pseudorandomness. Feasible incompleteness refers to conjectures about unprovability of statements concerning low complexity computations and about lengths of proofs of finite consistency statements. Essentially, they say that incompleteness in the finite domain behaves in a similar way as in the infinite. Several conjectures of this kind have been already stated. They have strong consequences concerning separation of complexity classes, but only a few special cases have been proved. We want to develop a unified system which will also include conjectures connecting feasible incompleteness with pseudorandomness. A major part of our work will concern proving special cases and relativized versions of these conjectures in order to provide evidence for their truth. We believe that the essence of the fundamental problems in complexity theory is logical, and thus developing theory in the way described above will eventually lead to their solution.

Project End Date: **12/31/2018**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
666981	**TAMING**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Jean Bernard Lasserre** lasserre@laas.fr
Host Institution:	Centre National De La Recherche Scientifique, FR

Taming non convexity?

In many important areas and applications of science one has to solve non convex optimization problems and ideally and ultimately one would like to find the global optimum. However in most cases one is faced with NP-hard problems and therefore in practice one has been often satisfied with only a local optimum obtained with some ad-hoc (local) optimization algorithm. TAMING intends to provide a systematic methodology for solving hard non convex polynomial optimization problems in all areas of science. Indeed the last decade has witnessed the emergence of Polynomial Optimization as a new field in which powerful positivity certificates from real algebraic geometry have permitted to develop an original and systematic approach to solve (at global optimality) optimization problems with polynomial (and even semi-algebraic) data. The backbone of this powerful methodology is the « moment-SOS » approach also known as « Lasserre hierarchy » which has attracted a lot of attention in many areas (e.g., optimization, applied mathematics, quantum computing, engineering, theoretical computer science) with important potential applications. It is now a basic tool for analyzing hardness of approximation in combinatorial optimization and the best candidate algorithm to prove/disprove the famous Unique Games Conjecture. Recently it has also become a promising new method for solving the important Optimal Power Flow Problem in the strategic domain of Energy Networks (as the only method that could solve to optimality certain types of such problems). However in its present form this promising methodology inherits a high computational cost and a (too) severe problem size limitation which precludes from its application many important real life problems of significant size. Proving that indeed this methodology can fulfill its promises and solve important practical problems in various areas poses major theoretical & practical challenges.

Project End Date: **8/31/2019**

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** aleks.nanevski@imdea.org
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: **3/31/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
339233	**ALEXANDRIA**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Wolfgang Nejdl** nejdl@kbs.uni-hannover.de
Host Institution:	Gottfried Wilhelm Leibniz Universitaet Hannover, DE

Foundations for Temporal Retrieval, Exploration and Analytics in Web Archives

Significant parts of our cultural heritage are produced on the Web, yet only insufficient opportunities exist for accessing and exploring the past of the Web. The ALEXANDRIA project aims to develop models, tools and techniques necessary to archive and index relevant parts of the Web, and to retrieve and explore this information in a meaningful way. While the easy accessibility to the current Web is a good baseline, optimal access to Web archives requires new models and algorithms for retrieval, exploration, and analytics which go far beyond what is needed to access the current state of the Web. This includes taking into account the unique temporal dimension of Web archives, structured semantic information already available on the Web, as well as social media and network information. Within ALEXANDRIA, we will significantly advance semantic and time-based indexing for Web archives using human-compiled knowledge available on the Web, to efficiently index, retrieve and explore information about entities and events from the past. In doing so, we will focus on the concurrent evolution of this knowledge and the Web content to be indexed, and take into account diversity and incompleteness of this knowledge. We will further investigate mixed crowd- and machine-based Web analytics to support long- running and collaborative retrieval and analysis processes on Web archives. Usage of implicit human feedback will be essential to provide better indexing through insights during the analysis process and to better focus harvesting of content. The ALEXANDRIA Testbed will provide an important context for research, exploration and evaluation of the concepts, methods and algorithms developed in this project, and will provide both relevant collections and algorithms that enable further research on and practical application of our research results to existing archives like the Internet Archive, the Internet Memory Foundation and Web archives maintained by European national libraries.

Project End Date: **2/28/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
340113	**VHIA**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Patrice Radu HORAUD** radu.horaud@inria.fr
Host Institution:	Institut National De Recherche En Informatique Et En Automatique, FR

Vision and Hearing in Action

The objective of VHIA is to elaborate a holistic computational paradigm of perception and of perception-action loops. We plan to develop a completely novel twofold approach: (i) learn from mappings between auditory/visual inputs and structured outputs, and from sensorimotor contingencies, and (ii) execute perception-action interaction cycles in the real world with a humanoid robot. VHIA will achieve a unique fine coupling between methodological findings and proof-of-concept implementations using the consumer humanoid NAO manufactured in Europe. The proposed multimodal approach is in strong contrast with current computational paradigms influenced by unimodal biological theories. These theories have hypothesized a modular view, postulating quasi-independent and parallel perceptual pathways in the brain. VHIA will also take a radically different view than today's audiovisual fusion models that rely on clean-speech signals and on accurate frontal-images of faces; These models assume that videos and sounds are recorded with hand-held or head-mounted sensors, and hence there is a human in the loop who intentionally supervises perception and interaction. Our approach deeply contradicts the belief that complex and expensive humanoids (often manufactured in Japan) are required to implement research ideas. VHIA's methodological program addresses extremely difficult issues: how to build a joint audiovisual space from heterogeneous, noisy, ambiguous and physically different visual and auditory stimuli, how to model seamless interaction, how to deal with high-dimensional input data, and how to achieve robust and efficient human-humanoid communication tasks through a well-thought tradeoff between offline training and online execution. VHIA bets on the high-risk idea that in the next decades, social robots will have a considerable economical impact, and there will be millions of humanoids, in our homes, schools and offices, which will be able to naturally communicate with us.

Project End Date: **1/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
683300	**OSARES**	**PE6 - Computer Science and Informatics**

Principal Investigator: **Dr. Bernd Finkbeiner**
finkbeiner@cs.uni-saarland.de

Host Institution: Universitat Des Saarlandes, DE

Output-Sensitive Algorithms for Reactive Synthesis

Reactive synthesis has the potential to revolutionize the development of distributed embedded systems. From a given logical specification, the synthesis algorithm automatically constructs an implementation that is correct-by-design. The vision is that a designer analyzes the design objectives with a synthesis tool, automatically identifies competing or contradictory requirements and obtains an error-free prototype implementation. Coding and testing, the most expensive stages of development, are eliminated from the development process. Recent case studies from robotic control and from hardware design, such as the automatic synthesis of the AMBA AHB bus controller, demonstrate that this vision is in principle feasible. So far, however, synthesis does not scale to large systems. Even if successful, it produces code that is much larger and much more complicated than the code produced by human programmers for the same specification. Our goal is to address both of these fundamental shortcomings at the same time. We will develop output-sensitive synthesis algorithms, i.e. algorithms that, in addition to optimal performance in the size of the specification, also perform optimally in the size and structural complexity of the implementation. Target applications for our algorithms come from both the classic areas of reactive synthesis, such as hardware circuits, and from new and much more challenging application areas such as the distributed control and coordination of autonomous vehicles and manufacturing robots, which are far beyond the reach of the currently available synthesis algorithms.

Project End Date: **6/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
615074	**ERCC**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Eike Kiltz** eike.kiltz@rub.de
Host Institution:	Ruhr-Universitaet Bochum, DE

Efficient Resource Constrained Cryptography

Traditionally, cryptographic protocols were run on servers or personal computers which have large and easily scalable computational resources. For these applications there exist a large variety of well-established cryptographic systems. Right now, we are in the midst of the shift toward ubiquitous computing on resource constrained devices (RCDs): small devices with severe constraints in terms of computing power, code size, and network capacities. RCDs are used virtually everywhere: smart phones, bank cards, electronic ID-cards, medical implants, cars, RFIDs as bar code replacement, etc. Due to their computational constraints, many current cryptographic security solutions are no longer applicable to RCDs. Existing solutions are often “ad-hoc” and do not come with a formal security treatment. The central objective of the ERCC project is to initiate an overarching formal treatment of cryptographic solutions for RCDs, particularly focusing on efficiency. The main conceptual novelty is to follow the concept of provable security. We intend to design new cryptographic protocols that have a mathematical proof of security (assuming the hardness of some mathematical problem) and are still competitive with constructions currently used on RCDs. While we certainly cannot hope that all our new provably secure constructions will be superior to existing ad-hoc constructions, recent preliminary research
results give rise to optimism. Concretely, we will base our new protocols on hard problems in ideal and structures lattices and we will study weaker (yet still realistic) security models for RCDs allowing for efficient instantiations.

Project End Date: **10/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
637076	**RoboExNovo**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Barbara Caputo** caputo@dis.uniroma1.it
Host Institution:	Universita Degli Studi Di Roma La Sapienza, IT

Robots learning about objects from externalized knowledge sources

While today's robots are able to perform sophisticated tasks, they can only act on objects they have been trained to recognize. This is a severe limitation: any robot will inevitably face novel situations in unconstrained settings, and thus will always have knowledge gaps. This calls for robots able to learn continuously about objects by themselves. The learning paradigm of state-of-the-art robots is the sensorimotor toil, i.e. the process of acquiring knowledge by generalization over observed stimuli. This is in line with cognitive theories that claim that cognition is embodied and situated, so that all knowledge acquired by a robot is specific to its sensorimotor capabilities and to the situation in which it has been acquired. Still, humans are also capable of learning from externalized sources – like books, illustrations, etc – containing knowledge that is necessarily unembodied and unsituated. To overcome this gap, RoboExNovo proposes a paradigm shift. I will develop a new generation of robots able to acquire perceptual and semantic knowledge about object from externalized, unembodied resources, to be used in situated settings. As the largest existing body of externalized knowledge, I will consider the Web as the source from which to learn from. To achieve this, I propose to build a translation framework between the representations used by robots in their situated experience and those used on the Web, based on relational structures establishing links between related percepts and between percepts and the semantics they support. My leading expertise in machine learning applied to multi modal data and robot vision puts me in a strong position to realize this project. By enabling robots to use knowledge resources on the Web that were not explicitly designed to be accessed for this purpose, RoboExNovo will pave the way for ground-breaking technological advances in home and service robotics, driver assistant systems, and in general any Web-connected situated device.

Project End Date: **5/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714381	**SOLARIS**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Julien Mairal** julien.mairal@inria.fr
Host Institution:	Institut National De Recherche En Informatique Et En Automatique, FR

Large-Scale Learning with Deep Kernel Machines

Machine learning has become a key part of scientific fields that produce a massive amount of data and that are in dire need of scalable tools to automatically make sense of it. Unfortunately, classical statistical modeling has often become impractical due to recent shifts in the amount of data to process, and in the high complexity and large size of models that are able to take advantage of massive data. The promise of SOLARIS is to invent a new generation of machine learning models that fulfill the current needs of large-scale data analysis: high scalability, ability to deal with huge-dimensional models, fast learning, easiness of use, and adaptivity to various data structures. To achieve the expected breakthroughs, our angle of attack consists of novel optimization techniques for solving large-scale problems and a new learning paradigm called deep kernel machine. This paradigm marries two schools of thought that have been considered so far to have little overlap: kernel methods and deep learning. The former is associated with a well-understood theory and methodology but lacks scalability, whereas the latter has obtained significant success on large-scale prediction problems, notably in computer vision. Deep kernel machines will lead to theoretical and practical breakthroughs in machine learning and related fields. For instance, convolutional neural networks were invented more than two decades ago and are today's state of the art for image classification. Yet, theoretical foundations and principled methodology for these deep networks are nowhere to be found. The project will address such fundamental issues, and its results are expected to make deep networks simpler to design, easier to use, and faster to train. It will also leverage the ability of kernels to model invariance and work with a large class of structured data such as graphs and sequences, leading to a broad scope of applications with potentially groundbreaking advances in diverse scientific fields.

Project End Date: **2/28/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
637422	**EVERYSOUND**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Tuomas Virtanen** tuomas.virtanen@tut.fi
Host Institution:	Tty-Saatio, FI

Computational Analysis of Everyday Soundscapes

Sounds carry a large amount of information about our everyday environment and physical events that take place in it. For example, when a car is passing by, one can perceive the approximate size and speed of the car. Sound can easily and unobtrusively be captured e.g. by mobile phones and transmitted further – for example, tens of hours of audio is uploaded to the internet every minute e.g. in the form of YouTube videos. However, today's technology is not able to recognize individual sound sources in realistic soundscapes, where multiple sounds are present, often simultaneously, and distorted by the environment.The ground-breaking objective of EVERYSOUND is to develop computational methods which will automatically provide high-level descriptions of environmental sounds in realistic everyday soundscapes such as street, park, home, etc. This requires developing several novel methods, including joint source separation and robust pattern classification algorithms to reliably recognize multiple overlapping sounds, and a hierarchical multilayer taxonomy to accurately categorize everyday sounds. The methods are based on the applicant's internationally recognized and awarded expertise on source separation and robust pattern recognition in speech and music processing, which will allow now tackling the new and challenging research area of everyday sound recognition.The results of EVERYSOUND will enable searching for multimedia based on its audio content, which is not possible with today's technology. It will allow mobile devices, robots, and intelligent monitoring systems to recognize activities in their environments using acoustic information. Producing automatically descriptions of vast quantities of audio will give new tools for geographical, social, cultural, and biological studies to analyze sounds related to human, animal, and natural activity in urban and rural areas, as well as multimedia in social networks.

Project End Date: **4/30/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
637339	**CoqHoTT**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. nicolas tabareau** nicolas.tabareau@inria.fr
Host Institution:	Institut National De Recherche En Informatique Et En Automatique, FR

Coq for Homotopy Type Theory

Every year, software bugs cost hundreds of millions of euros to companies and administrations. Hence, software quality is a prevalent notion and interactive theorem provers based on type theory have shown their efficiency to prove correctness of important pieces of software like the C compiler of the CompCert project. One main interest of such theorem provers is the ability to extract directly the code from the proof. Unfortunately, their democratization suffers from a major drawback, the mismatch between equality in mathematics and in type theory. Thus, significant Coq developments have only been done by virtuosos playing with advanced concepts of computer science and mathematics. Recently, an extension of type theory with homotopical concepts such as univalence is gaining traction because it allows for the first time to marry together expected principles of equality. But the univalence principle has been treated so far as a new axiom which breaks one fundamental property of mechanized proofs: the ability to compute with programs that make use of this axiom. The main goal of the CoqHoTT project is to provide a new generation of proof assistants with a computational version of univalence and use them as a base to implement effective logical model transformation so that the power of the internal logic of the proof assistant needed to prove the correctness of a program can be decided and changed at compile time—according to a trade-off between efficiency and logical expressivity. Our approach is based on a radically new compilation phase technique into a core type theory to modularize the difficulty of finding a decidable type checking algorithm for homotopy type theory.

The impact of the CoqHoTT project will be very strong. Even if Coq is already a success, this project will promote it as a major proof assistant, for both computer scientists and mathematicians. CoqHoTT will become an essential tool for program certification and formalization of mathematics.

Project End Date: **5/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
615075	**ALUnif**	**PE6 - Computer Science and Informatics**

Principal Investigator:	**Dr. Rahul Santhanam** rahul.santhanam@cs.ox.ac.uk
Host Institution:	The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Algorithms and Lower Bounds: A Unified Approach

One of the fundamental goals of theoretical computer science is to understand the possibilities and limits of efficient computation. This quest has two dimensions. The theory of algorithms focuses on finding efficient solutions to problems, while computational complexity theory aims to understand when and why problems are hard to solve. These two areas have different philosophies and use different sets of techniques. However, in recent years there have been indications of deep and mysterious connections between them. In this project, we propose to explore and develop the connections between algorithmic analysis and complexity lower bounds in a systematic way.

On the one hand, we plan to use complexity lower bound techniques as inspiration to design new and improved algorithms for Satisfiability and other NP-complete problems, as well as to analyze existing algorithms better.

On the other hand, we plan to strengthen implications yielding circuit lower bounds from non-trivial algorithms for Satisfiability, and to derive new circuit lower bounds using these stronger implications. This project has potential for massive impact in both the areas of algorithms and computational complexity. Improved algorithms for Satisfiability could lead to improved SAT solvers, and the new analytical tools would lead to a better understanding of existing heuristics. Complexity lower bound questions are fundamental but notoriously difficult, and new lower bounds would open the way to unconditionally secure cryptographic protocols and derandomization of probabilistic algorithms. More broadly, this project aims to initiate greater dialogue between the two areas, with an exchange of ideas and techniques which leads to accelerated progress in both, as well as a deeper understanding of the nature of efficient computation.

Project End Date: **2/28/2019**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
714562	**PIONEER**	**PE7 - Systems and Communication Engineering**

Principal Investigator: **Dr. Christos Bergeles**
c.bergeles@ucl.ac.uk

Host Institution: University College London, UK

Peri-Ocularly Navigated Exteroceptive Snake Robot for Novel Retinal Interventions

Intraocular treatments require manipulation of structures with dimensions comparable to hand tremor. The demanded dexterity, coupled with reduced haptic and depth perception, calls for robotic assistance. Despite notable benefits, existing robots are not clinically disruptive but follow well-trodden intervention protocols with significant limitations, e.g. lack of flexibility at the scleral incision and limited manipulation bandwidth, as to avoid scleral, lens, and retinal damage. Robotics also does not obviate the prerequisite of the risky, cataract-inducing vitrectomy, which may cause retinal detachment (RD) or sight loss. Novel interventions like stem-cell delivery pose yet further challenges. Apart from removing healthy vitreous, they require millimetre-long retinal tears, lifting the retinal membrane, and injecting a stem-cell suspension or sheet. Current robots facilitate manipulations but conceivably neither enable alternative approaches nor reduce retinal-tear-induced risks. PIONEER, the proposed snake robot, can disrupt clinical protocol by navigating peri-ocularly and around the orbital muscles to suprachoroidally reach the retina. Revolutionizing existing robot paradigms, PIONEER innovates both scientifically and technically. Optimal robot compliance will ensure force-adaptive peri-ocular steering conforming to the eye's exterior. A tactile sleeve with micro-sensors will provide exteroceptive force sensing and shape estimation. Enhanced navigation, fusing optical coherence tomography with on-line vessel detection from novel tip-mounted probes, will ensure safe guidance to avoid vessels through imposed virtual fixtures and path planning. No vitrectomy will be required and the posterior scleral incision will leave the retinal membrane intact, minimising RD risk. PIONEER can be an enabler of emerging stem-cell interventions and futuristic procedures like drug-implant insertion and nerve interfacing, currently at human-dexterity limits or impossible.

Project End Date: **3/31/2022**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715770	**QD-NOMS**	**PE7 - Systems and Communication Engineering**

Principal Investigator:	**Dr. Fei Ding** f.ding@ifw-dresden.de
Host Institution:	Gottfried Wilhelm Leibniz Universitaet Hannover, DE

Elementary quantum dot networks enabled by on-chip nano-optomechanical systems

Is there any limit to the size of a quantum system? How large and how small can it be? Both questions are related to scalability, a most critical issue in quantum technologies. A scalable quantum network, which can be extended almost infinitely, is built by entangling individual quantum systems, e.g. atoms. It will provide thrilling opportunities across a range of intellectual and technical frontiers in quantum information science. Building such a network is however a great challenge, in both physics and engineering. Often referred to as artificial atoms, semiconductor quantum dots (QDs) are among the most promising single and entangled photon sources to build a photonic quantum network. However there is a longstanding and yet unsolved challenge on scalability, since, unlike real atoms, every QD is different. By engineering individual QDs with an innovative nano-optomechanical system (NOMS), elementary QD networks will be built via scalable interactions of single or entangled photons, in a fashion similar to that of real atoms.

The scientific goals are to upscale QD networks with the first demonstrations of (1) indistinguishable entangled photons from different QDs, (2) deterministic entanglement swapping, purification and graph states with multiple QDs (3) deterministic Boson sampling with more than 4 QDs on chip.

The technological goals are (1) to downscale the footprint (<50 μm) of individual QD sources with full tunabilities, and to realize (2) arrays (>4×4) of tunable single and entangled photon sources, (3) waveguide integration on III-V/silicon chips, and (4) compact quantum LED demonstrators.

QD-NOMS will address the physical and technological challenges in building a solid-state QD-based quantum network. Its success does not only provide a novel toolkit to realize scalable QD systems for cutting-edge fundamental researches but also brings the semiconductor QD based platforms, after a decade of development, to the attention of practical applications.

Project End Date: **12/31/2021**

European Research Council
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Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
638059	**HEROIC**	**PE7 - Systems and Communication Engineering**

Principal Investigator:	**Dr. Mario Caironi** mario.caironi@iit.it
Host Institution:	Fondazione Istituto Italiano Di Tecnologia, IT

High-frequency printed and direct-written Organic-hybrid Integrated Circuits

The HEROIC project aims at filling the gap between the currently low operation frequencies of printed, organic flexible electronics and the high-frequency regime, by demonstrating polymer-based field-effect transistors with maximum operation frequencies of 1 GHz and complementary integrated logic circuits switching in the 10-100 MHz range, fabricated by means of printing and direct-writing scalable processes in order to retain low temperature manufacturability of cost-effective large area electronics on plastic. The recent development of semiconducting polymers with mobilities in the range of 1 to 10 cm^2/Vs, and even higher in the case of aligned films, suggests that suitably downscaled printed polymer transistors with operation frequencies in the GHz regime, at least three orders of magnitude higher than current printed polymer devices, are achievable, by addressing in a holistic approach the specific challenges set in the HEROIC trans-disciplinary research programme: (i)development of scalable high resolution processes for the patterning of functional inks, where printing will be combined with direct-writing techniques such as fs-laser machining, both in an additive and subtractive approach; (ii)development of printable nanoscale hybrid dielectrics with high specific capacitance, where low-k polymer buffer materials will be combined with solution processable high-k dielectrics, such as insulating metal oxides; (iii)improvement of the control of charge injection and transport in printed polymer and hybrid semiconductors, where high-mobility 1-D and 2-D structures are included in polymer films; (iv)development of advanced printed and direct-written transistors architectures with low parasitic capacitances for high-speed operation. HEROIC will radically advance and expand the applicability of polymer-based printed electronics, thus making it suitable for next generation portable and wearable short-range wireless communicating devices with low power consumption.

Project End Date: **3/31/2020**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
337596	**SPEAR**	**PE7 - Systems and Communication Engineering**

Principal Investigator:	**Dr. Bram Vanderborght** bram.vanderborght@vub.ac.be
Host Institution:	Vrije Universiteit Brussel, BE

Series-Parallel Elastic Actuators for Robotics

Actuators are key components for moving and controlling a mechanism or system. However, the torque and efficiency of the current state-of-the-art actuators are insufficient and much lower than in humans. There are several applications (including prostheses, exoskeletons and running robots) where the unavailability of suitable actuators hinders the development of well-performing machines with capabilities comparable to a human. Remarkable, the power density and efficiency of electric motors are higher than a human muscle, so the problems of insufficient torque and efficiency resides in the transmission of the power and that the motors are not used at their highest efficiency. The first innovation of SPEAR is to solve the torque and efficiency problems, by investigating in depth a novel actuation paradigm, which I call Series-Parallel Elastic Actuation (SPEA) and that goes beyond variable impedance actuators. This new actuation paradigm is inspired by the series-parallel organisation of the muscle fibres. Modularity in actuation is currently introduced by placing in all joints the same motor, leading to over- or underactuated joints. In our body however, all the skeletal muscles are built of the same basic actuation unit: a muscle fibre. Modularity in actuation in a biological system is not at muscle level, but on a sublevel: the muscle fibre. SPEAR will introduce a second major innovation: the SPEA will introduce a basic actuation unit, a “transistor for actuation”. Such a SPEA-element is a missing link in robotics and will innovate the way robots are designed and built. The project will study the theoretical framework, the design principles, the control algorithms and the validation of demonstrators. SPEAR will fully answer all the research challenges and explore the frontiers of this novel actuation paradigm, leading to a tremendous impact on all engineered, actuated systems, especially in robotics.

Project End Date: **1/31/2019**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
336917	**BetterSense**	**PE7 - Systems and Communication Engineering**

Principal Investigator:	**Dr. Juan Daniel Prades Garcia** dprades@el.ub.edu
Host Institution:	Universitat De Barcelona, ES

Nanodevice Engineering for a Better Chemical Gas Sensing Technology

BetterSense aims to solve the two main problems in current gas sensor technologies: the high power consumption and the poor selectivity. For the former, we propose a radically new approach: to integrate the sensing components and the energy sources intimately, at the nanoscale, in order to achieve a new kind of sensor concept featuring zero power consumption. For the latter, we will mimic the biological receptors designing a kit of gas-specific molecular organic functionalizations to reach ultra-high gas selectivity figures, comparable to those of biological processes. Both cutting-edge concepts will be developed in parallel an integrated together to render a totally new gas sensing technology that surpasses the state-of-the-art.

As a matter of fact, the project will enable, for the first time, the integration of gas detectors in energetically autonomous sensors networks. Additionally, BetterSense will provide an integral solution to the gas sensing challenge by producing a full set of gas-specific sensors over the same platform to ease their integration in multi-analyte systems. Moreover, the project approach will certainly open opportunities in adjacent fields in which power consumption, specificity and nano/micro integration are a concern, such as liquid chemical and biological sensing.

In spite of the promising evidences that demonstrate the feasibility of this proposal, there are still many scientific and technological issues to solve, most of them in the edge of what is known and what is possible today in nano-fabrication and nano/micro integration. For this reason, BetterSense also aims to contribute to the global challenge of making nanodevices compatible with scalable, cost-effective, microelectronic technologies.

For all this, addressing this challenging proposal in full requires a funding scheme compatible with a high-risk/high-gain vision to finance the full dedication of a highly motivated research team with multidisciplinary skill

Project End Date: **1/31/2019**

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** n.neophytou@warwick.ac.uk
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: **6/30/2021**

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** Avinoam.Zadok@biu.ac.il
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: **3/31/2021**

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** i.m.vellekoop@utwente.nl
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: **2/28/2021**

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** piet.demeester@ugent.be
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: **12/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
648635	**RESCUE**	**PE7 - Systems and Communication Engineering**

Principal Investigator: **Dr. Daniele Ielmini**
daniele.ielmini@polimi.it

Host Institution: Politecnico Di Milano, IT

REsistive-Switch CompUting bEyond CMOS

Digital computers rely today on CMOS (complementary metal-oxide-semiconductor) technology, which improves its performance every generation thanks to the Moore's law of downscaling. As CMOS transistor size approaches few nm, alternative logic switches with better scaling capability must be identified to prolong Moore's law beyond CMOS. Among the emerging switching concepts, resistive switching (RS) devices can change their resistance by electrically-induced redox reactions. RS provides the basis for the resistive memory (ReRAM) technology which is currently investigated as future computer memory and storage technology. The objective of this project is to design, develop and demonstrate a novel computing paradigm based on RS devices. The project will pursue this objective at 3 levels of increasing complexity, namely the device fabrication, the design of new logic gates and the demonstration of computing circuits. RS logic will be finally compared to CMOS and other approaches to identify the strength and the potential applications of RS logic in the computing scenario.

Project End Date: **7/31/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682723	**SmartGraphene**	**PE7 - Systems and Communication Engineering**

Principal Investigator:	**Dr. Coskun Kocabas** ckocabas@fen.bilkent.edu.tr
Host Institution:	Bilkent Üniversitesi, TR

Graphene based smart surfaces: from visible to microwave

The aim of this proposal is to develop adaptive camouflage systems using graphene-enabled smart surfaces. We propose a new class of active surfaces capable of real-time electrical-control of its appearance in a very broad spectrum ranging from visible to microwave covering 6 orders of magnitude in wavelength. The proposed method relies on controlling electromagnetic waves by tuning density of high-mobility charges on single or multilayers of atomically thin graphene electrodes. We will realize this goal by efficient gating of large-area graphene using ionic liquids which yields unprecedented ability to control intensity and phase of the reflected and transmitted electromagnetic waves from the surface. Based on underlying physical mechanisms and applications, the proposed research plan is structured in 3 main directions; (1) Active surfaces in microwave and THz, (2) Active thermal surfaces, and (3) Active surfaces in the visible. The core idea of the proposal is based on a mutually-gated capacitor structure consisting of ionic liquid electrolyte sandwiched between two large area graphene. The voltage applied between the electrodes polarizes the ionic liquid and accumulates high-density of charges. Combining large scale chemical synthesis of graphene, novel device architectures and ionic liquid electrolyte we will develop new tools to understand and control light-matter interaction in a very broad spectrum. Then we will use these tools to fabricate new camouflage and display technologies on flexible polymers and paper substrates which cannot be realized by conventional semiconducting materials. We will challenge specific applications, such as THz compressive imaging, reconfigurable thermal shields, and electronic paper display. At the basic science level, this project revisits and challenges our basic understanding of light-matter interaction, in parallel, the proposed graphene-based smart surfaces will serve as a tool for developing new enabling technologies.

Project End Date: **4/30/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
678567	**PLASMIC**	**PE7 - Systems and Communication Engineering**

Principal Investigator:	**Dr. Kirsten Moselund** kmo@zurich.ibm.com
Host Institution:	Ibm Research Gmbh, CH

Plasmonically-enhanced III-V nanowire lasers on silicon for integrated communications

The ambition of PLASMIC is to address the bottleneck caused by electrical interconnects and develop on-chip optical interconnect solutions based on plasmonically-enhanced nanoscale emitters.
Nanoscale photonic components are desirable for on-chip communications because of density, speed and because reducing the size of the cavity might reduce the lasing threshold. Conventional photonics are limited in scale by the diffraction-limit to dimensions of half of the wavelength of light in the material. This limit does not apply to plasmonics, an optical mode that exists at the interface between a metal and a dielectric. Thus, they have a great potential for applications where down-scaling and confinement are primordial.
One of the barriers for applying plasmonics is the large losses associated with the metals. Thus in PLASMIC alternative plasmonic metals will be investigated based on their potential for tuning, VLSI compatibility, deposition methods and achieving lower optical losses in the near-IR. I will focus on highly doped semiconductors, metal nitrides, as well as multi-layers and compounds to form new plasmonic materials. Specifically, I will evaluate the use of the field-effect to achieve the semiconductor-metal transition to tune the plasma frequency.
New pioneering device concepts for plasmonic-photonic emitters on a silicon platform integrated with passive silicon photonic waveguides will be developed. To implement the gain medium for the lasers, I will exploit a novel nanowire (NW) integration approach: Template-Assisted Epitaxy. The unique advantages make it possible to grow III-V NWs on any orientation of silicon and aligned to lithographic features.
The devices will be based on a hybrid cavity formed between the NW and a Si waveguide with gratings to provide feedback. My team and I will explore dimensional scaling potential as well as the energy efficiency of plasmonic and photonic devices operating both in a lasing as well as in a subthreshold operation mode.

Project End Date: **3/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
648580	**OptnanoATcryo**	**PE7 - Systems and Communication Engineering**

Principal Investigator:	**Dr. Bernd Rieger** b.rieger@tudelft.nl
Host Institution:	Technische Universiteit Delft, NL

Optical nanoscopy at 1 nm resolution: far-field fluorescence control at cryogenic temperatures

Optical nanoscopy is a powerful technique used in biology to study subcellular structures and function via specifically targeted fluorescent labels. Localization microscopy in particular offers a much better resolution (~10-50 nm) than conventional microscopy (~250 nm) while being relatively undemanding on the experimental setup and the subsequent image analysis. The next revolution in imaging to 1 nm isotropic resolution in 3D must realize a big increase in the number of collected photons from single fluorescent emitters as well as in the labelling density. Only then can subcellular structures be imaged at the molecular level to study the molecular machinery of the cell. Notably observations of DNA conformation in 3D at such resolutions would be spectacular and enable investigation of biophysical models ranging from chromosomal DNA packaging to gene regulation.I propose a new imaging technique based on fluorescence control at cryogenic temperatures in combination with novel data driven super-resolution reconstruction schemes employing prior knowledge that promises this unprecedented optical far-field resolution. I introduce a twofold technical leap by i) much higher photon counts due to negligible photobleaching at cryogenic temperatures while maintaining the sparsity required for single emitter localization and ii) relaxing the required labelling density using a priori information and the averaging of many identical entities. Orientational blinking ensures single emitter localization via a combination of polarization sensitive excitation, detection and stimulated depletion and triplet state shelving.Biophysical models of cell structures and data driven priors mean that fewer samples are needed to fully describe a structure.In a larger perspective, the outcome of this research will enable the combination of structural cryo-electron microscopy imaging at subnanometer resolutions with functional fluorescent imaging at the nanometer scale.

Project End Date: **6/30/2020**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
637935	**CONT-ACT**	**PE7 - Systems and Communication Engineering**

Principal Investigator:	**Dr. Ludovic Righetti** ludovic.righetti@tuebingen.mpg.de
Host Institution:	Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Control of contact interactions for robots acting in the world

What are the algorithmic principles that would allow a robot to run through a rocky terrain, lift a couch while reaching for an object that rolled under it or manipulate a screwdriver while balancing on top of a ladder? Answering this seemingly naïve question resorts to understanding the fundamental principles for robot locomotion and manipulation, which is very challenging. However, it is a necessary step towards ubiquitous robots capable of helping humans in an uncountable number of tasks. The fundamental aspect of both locomotion and manipulation is that the dynamic interaction of the robot with its environment through the creation of physical contacts is at the heart of the tasks. The planning of such interactions in a general manner is an unsolved problem. Moreover, it is not clear how sensory information (e.g. tactile and force sensors) can be included to improve the robustness of robot behaviors. Most of the time, it is simply discarded. CONT-ACT has the ambition to develop a consistent theoretical framework for motion generation and control where contact interaction is at the core of the approach and an efficient use of sensory information drives the development of high performance, adaptive and robust planning and control methods. CONT-ACT develops an architecture based on real-time predictive controllers that fully exploit contact interactions. In addition, the structure of sensory information during contact interactions is experimentally analyzed to create sensor representations adapted for control. It is then possible to learn predictive models in sensor space that are used to create very reactive controllers. The robot constantly improves its performance as it learns better sensory models. It is a step towards a general theory for robot movement that can be used to control any robot with legs and arms for both manipulation and locomotion tasks and that allows robots to constantly improve their performances as they experience the world.

Project End Date: **5/31/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
337508	**DANCeR**	**PE7 - Systems and Communication Engineering**

Principal Investigator:	**Dr. Liam O'Faolain** liam.ofaolain@tyndall.ie
Host Institution:	Cork Institute Of Technology, IE

DAtacommunications based on NanophotoniC Resonators

A key challenge for the 21st century is, therefore to provide billions of people with the means to access, move and manipulate, what has become, huge volumes of information. The environmental and economic implications becoming serious, making energy efficient data communications key to the operation of today's society. In this project, the Principal Investigator will develop a new framework for optical interconnects and provide a common platform that spans Fibre-to-the-home to chip-to-chip links, even as far as global on-chip interconnects. The project is based on the efficient coupling of the Photonic Crystal resonators with the outside world. These provide the ultimate confinement of light in both space and time allowing orders of magnitude improvements in performance relative to the state of the art, yet in a simpler simple system- the innovator's dream. New versions of the key components of optical links- light sources, modulators and photo-detectors- will be realised in this new framework providing a new paradigm for energy efficient communication.

Project End Date: **5/31/2019**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
615170	**DIDYMUS**	**PE7 - Systems and Communication Engineering**

Principal Investigator:	**Dr. Davide Iannuzzi** d.iannuzzi@vu.nl
Host Institution:	Stichting Vu, NL

MICROMACHINED OPTOMECHANICAL DEVICES: looking at cells, tissues, and organs ... with a gentle touch.

Every time we grab an object to look at its geometrical details or to feel if it is hard or soft, we are ineluctably confronted with the limits of our senses. Behind its appearances, the object may still hide information that, encrypted in its microscopic features, remains undetected to our macroscopic assessment. In life sciences, those limits are more than just frustrating: they are an obstacle to study and detect life threatening conditions. Many different instruments may overcome those limits, but the vast majority of them rely either on “sight” (optics) or “touch” (mechanics) separately. On the contrary, I believe that it is from the combination of those two “senses” that we have more chances to tackle the future challenges of cell biology, tissue engineering, and medical diagnosis. Inspired by this tantalizing perspective, and supported by a technology that I have brought from blackboard to market, I have now designed a scientific program to breach into the microscopic scale via an unbeaten path. The program develops along three projects addressing the three most relevant scales in life sciences: cells, tissues, and organs. In the first project, I will design and test a new optomechanical probe to investigate how a prolonged mechanical load on a brain cell of a living animal may trigger alterations in its Central Nervous System. With the second project, I will develop an optomechanical tactile instrument that can assess how subsurface tissues deform in response to a mechanical stroke – a study that may change the way physicians look at tissue classification. For the third project, I will deliver an acousto-optical gas trace sensors so compact that can penetrate inside the lungs of an adult patient, where it could be used for early detection of pulmonary life threatening diseases. Each project represents an opportunity to open an entire new field, where optics and micromechanics are combined to extend our senses well beyond their natural limits.

Project End Date: **5/31/2019**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682756	**FLAMENCO**	**PE7 - Systems and Communication Engineering**

Principal Investigator:	**Dr. Haluk Külah** kulah@metu.edu.tr
Host Institution:	Middle East Technical University, TR

A Fully-Implantable MEMS-Based Autonomous Cochlear Implant

Sensorineural impairment, representing the majority of the profound deafness, can be restored using cochlear implants (CIs), which electrically stimulates the auditory nerve to repair hearing in people with severe-to-profound hearing loss. A conventional CI consists of an external microphone, a sound processor, a battery, an RF transceiver pair, and a cochlear electrode. The major drawback of conventional CIs is that, they replace the entire natural hearing mechanism with electronic hearing, even though most parts of the middle ear are operational. Also, the power hungry units such as microphone and RF transceiver cause limitations in continuous access to sound due to battery problems. Besides, damage risk of external components especially if exposed to water and aesthetic concerns are other critical problems. Limited volume of the middle ear is the main obstacle for developing fully implantable CIs.

FLAMENCO proposes a fully implantable, autonomous, and low-power CI, exploiting the functional parts of the middle ear and mimicking the hair cells via a set of piezoelectric cantilevers to cover the daily acoustic band. FLAMENCO has a groundbreaking nature as it revolutionizes the operation principle of CIs. The implant has five main units: i) piezoelectric transducers for sound detection and energy harvesting, ii) electronics for signal processing and battery charging, iii) an RF coil for tuning the electronics to allow customization, iv) rechargeable battery, and v) cochlear electrode for neural stimulation. The utilization of internal energy harvesting together with the elimination of continuous RF transmission, microphone, and front-end filters makes this system a perfect candidate for next generation autonomous CIs. In this project, a multi-frequency self-powered implant for in vivo operation will be implemented, and the feasibility will be proven through animal tests.

Project End Date: **6/30/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
648328	**QUANTUMMETALINK**	**PE7 - Systems and Communication Engineering**

Principal Investigator:	**Dr. Nicolae Panoiu** n.panoiu@ucl.ac.uk
Host Institution:	University College London, UK

Quantum Metamaterials: A Theoretical and Computational Approach Towards Seamlessly Integrated Hybrid Classical/Quantum Nano-structures

The overarching aim of this proposal is to initiate and advance an integrated theoretical and computational research programme in an emerging area of metamaterials research, namely Quantum Metamaterials. Thus, it is commonly believed that one of the most noteworthy developments witnessed in the last decade in physical sciences and engineering is the emergence of metamaterials. Unlike ordinary materials, which are assembled at the atomic level, metamaterials are composite materials built up from artificially engineered meta-atoms and meta-molecules. The fundamental idea in this area of research is that remarkable physical properties beyond those available in naturally occurring materials can be achieved by designing the meta-constituents of the metamaterial and structuring it at a scale comparable or smaller than the optical wavelength. In this context, a new paradigm in metamaterials research emerges when the building blocks of metamaterials are quantum resonators, e.g., quantum dots (QDs), QD molecules, graphene disks coupled to interacting QDs, and quantum nanowires, case in which the macroscopic properties of quantum metamaterials are determined by the quantum properties of their basic constituents. We have organised this research programme along three broad, synergistically integrated themes. The first will focus on the development of a general theory of the effective, macroscopic properties of quantum metamaterials. The key challenge is to build a theoretical framework in which the macroscopic properties of quantum metamaterials are derived directly from those of their quantum building blocks. The second theme will be geared towards developing a set of numerical methods and software tools for ab initio simulations of fundamental physical properties quantum metamaterials. The foundational work pertaining to the first two themes will enable us to pursue the main objective of the third theme, which is the exploration of new science and novel applications.

Project End Date: **5/31/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
616922	**MINERVA**	**PE7 - Systems and Communication Engineering**

Principal Investigator:	**Dr. Ozgur Akan** oba21@cam.ac.uk
Host Institution:	Koc University, TR

Communication Theoretical Foundations of Nervous System Towards BIO-inspired Nanonetworks and ICT-inspired Neuro-treatment

"There's Plenty of Room at the Bottom", stated by Nobel laureate Richard Feynman, describes the possibility of manipulating individual atoms and molecules to realise nanomachines. Emerging nanoscale applications mandate enabling nanomachines to communicate and form nanonetworks to overcome the limitations of a single one. Thus, our aim is to find the answer to the profound question, i.e., "is the room down there sufficient for a communication network?" Thanks to natural evolution, the affirmative answer is right inside us. Human body is a large- scale communication network of molecular nanonetworks composed of billions of nanomachines, i.e., cells, which use molecules to encode, transmit and receive information. Any communication failure that is beyond the recovery capabilities of this network leads to diseases. In this project, first, (1) we will investigate the communication theoretical foundations of nanoscale neuro-spike communication channels between neurons. Second, (2) we will study multi-terminal, i.e., multiple-access, relay, broadcast, neuro-spike channels and nervous nanonetwork in terms of communication theoretical metrics. Third, (3) we will validate our channel and nanonetwork models with physiological data, and develop a nervous nanonetwork simulator (N4Sim). Finally, (4) we will develop the first nanoscale bio-inspired communication system for ICT-inspired neuro-treatment for spinal cord injury, i.e., nanoscale artificial synapse, which will mimic neuron behaviour by realising both electrical and nanoscale molecular communications.The MINERVA project will pave the way for the realisation of emerging nanonetwork applications with significant societal impact, e.g., intra-body networks for health monitoring, drug delivery, chemical and biological attack prevention systems. The project will help develop the future ICT-inspired treatment techniques for communication related neural disorders.

Project End Date: **2/28/2019**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679425	**In-Need**	**PE7 - Systems and Communication Engineering**

Principal Investigator:	**Dr. Elison Matioli** elison.matioli@epfl.ch
Host Institution:	Ecole Polytechnique Federale De Lausanne, CH

III-Nitrides Nanostructures for Energy-Efficiency Devices

Energy efficiency offers a vast and low-cost resource to address future energy demand while reducing carbon dioxide emissions. The unique properties of III-Nitride semiconductors make them the ideal material for future energy challenges. Their outstanding optical properties are revolutionizing the world with efficient LED light bulbs. Even greater impact is anticipated for power electronics. The much larger Baliga's figure of merit of GaN compared to SiC and Si enables drastically more efficient power switches, which are at the heart of any energy generation/management system. However, current III-Nitride device performance is far from the fundamental materials capabilities, and severe thermal management and reliability limitations hinder their full potential for energy-efficiency.

The In-Need proposes a unique approach to address concurrently all current challenges based on advanced nanostructures designed to optimally exploit the superior properties of the new bulk GaN materials. Nanostructuring distinct regions of the device will allow a precise control over their intrinsic characteristics. To address reliability issues and yield unprecedented device performance, these nanostructures will be combined to the excellent properties of bulk GaN. This will open opportunities for new vertical devices, enabling smaller structures with larger voltages and higher efficiencies. Efficient thermal management will be achieved with ultra-near junction cooling. Nano/micro-channels filled with high thermal conductivity materials or coolants will be embedded inside the device.

We believe our judicious nano-scale design of new high-performing materials will result in state-of-the-art devices, leading to a large-scale impact in energy efficiency. The miniaturization and large power density enabled by our approach will allow future integration of power devices into single power microchips. This will revolutionize energy use much like Silicon microchips did for information processing.

Project End Date: **1/31/2021**

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** andreas.hierlemann@bsse.ethz.ch
Host Institution:	Eidgenössische Technische Hochschule Zürich, 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: **9/30/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
678908	**RESHAPE**	**PE7 - Systems and Communication Engineering**

Principal Investigator:	**Dr. Giovanni Di Pino** GIOVANNIDIPINO@GMAIL.COM
Host Institution:	Universita Campus Bio Medico Di Roma, IT

REstoring the Self with embodiable HAnd ProsthesEs

Amputation distorts the body representation, a fundamental aspect of self-consciousness. Hand prostheses counteract sensorimotor impairment, but poor attention has been posed to target the alteration of body-image.

RESHAPE aims to study prosthesis embodiment, identify what makes a hand prosthesis easily embodiable, and test non-invasive brain stimulation to facilitate the embodiment.

Amputees claim to perceive prostheses as tools; RESHAPE enables amputees to project their self into the prosthesis, improving in parallel their dexterity.

The first of three phases develops the enabling technology and defines the embodiment protocol.

The following phase evaluates thirty myoelectric-prosthesis users and the first of two amputees implanted with peripheral neural electrodes, for functional ability, prosthesis embodiment and acceptability and for phantom limb pain (PLP), before and after neuromodulation.

In the last phase, a neuro-controlled prosthesis is optimized in line with the specifications defined in the previous phase and tested in the second implanted amputee.

An embodiment and a sensory/manipulation platform, integrating a discrimination setup with sensorized wearable systems, induce and weigh the embodiment and its impact on prosthesis performance.

Embodiment neural correlates are investigated with EEG and fMRI-based techniques, thanks to a prosthesis virtual model controllable inside the scanner.

Patients are stimulated with a homeostatic plasticity-based rTMS either on premotor cortex or on intraparietal sulcus. A robot-aided TMS compensates head-coil relative displacement, allowing the subject to operate the prosthesis during the stimulation.

RESHAPE is a paradigm shift in Prosthetics. It offers the guidelines for highly-embodiable prostheses, four technological platforms beyond the state-of-the-art, novel insights on how tools shape the body-image, the proof of a TMS-induced embodiment and a new strategy to readdress amputees' aberrant plasticity and PLP.

Project End Date: **8/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677683	**MODEM**	**PE7 - Systems and Communication Engineering**

Principal Investigator:	**Dr. Ferruccio Pisanello** ferruccio.pisanello@iit.it
Host Institution:	Fondazione Istituto Italiano Di Tecnologia, IT

Multipoint Optical DEvices for Minimally invasive neural circuits interface

A primary goal of experimental neuroscience is to dissect the neural microcircuitry underlying brain function, ultimately to link specific neural circuits to behavior. There is widespread agreement that innovative new research tools are required to better understand the incredible structural and functional complexity of the brain. To this aim, optical techniques based on genetically encoded neural activity indicators and actuators have represented a revolution for experimental neuroscience, allowing genetic targeting of specific classes of neurons and brain circuits. However, for optical approaches to reach their full potential, we need new generations of devices better able to interface with the extreme complexity and diversity of brain topology and connectivity.

This project aspires to develop innovative technologies for multipoint optical neural interfacing with the mammalian brain in vivo. The limitations of the current state-of-the-art will be surmounted by developing a radically new approach for modal multiplexing and de-multiplexing of light into a single, thin, minimally invasive tapered optical fiber serving as a carrier for multipoint signals to and from the brain. This will be achieved through nano- and micro-structuring of the taper edge, capitalizing on the photonic properties of the tapered waveguide to precisely control light delivery and collection in vivo. This general approach will propel the development of innovative new nano- and micro-photonic devices for studying the living brain.

The main objectives of the proposals are: 1) Development of minimally invasive technologies for versatile, user-defined optogenetic control over deep brain regions; 2) Development of fully integrated high signal-to- noise-ratio optrodes; 3) Development of minimally invasive technologies for multi-point in vivo all-optical “electrophysiology” through a single waveguide; 4) Development of new optical methodologies for dissecting brain circuitry at small and large scale

Project End Date: **9/30/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
638992	**OPT4SMART**	**PE7 - Systems and Communication Engineering**

Principal Investigator:	**Dr. Giuseppe Notarstefano** giuseppe.notarstefano@unisalento.it
Host Institution:	Universita Del Salento, IT

Distributed Optimization Methods for Smart Cyber-Physical Networks

The combination of embedded electronics and communication capability in almost any mobile or portable device has turned this century into the age of cyber-physical networks. Smart communicating devices with their sensing, computing and control capabilities promise to make our cities, transportation systems, factories and living environments more intelligent, energy-efficient, safe and secure. This extremely complex system has raised a number of new challenges involving ICT disciplines. In particular, a novel peer-to-peer distributed computational model is appearing as a new opportunity in which a service is built-up cooperatively by peers, rather than by a unique provider that knows and owns all data. The interdisciplinary “Optimization Community” is facing this revolution sharing a common need: to find new theories, methodologies and tools to optimize over this complex network system. With this in mind, OPT4SMART has a twofold objective. First, to provide a comprehensive theoretical framework to solve distributed optimization problems over peer-to-peer networks. Second, to develop effective numerical tools, based on this framework, to solve estimation, learning, decision and control problems in cyber-physical networks. To achieve this twofold objective, we will take a systems-theory perspective. Specific problems from these four areas will be abstracted to a common mathematical set-up, and addressed by means of interdisciplinary methodologies arising from a synergic combination of optimization, controls, and graph theories. In particular, OPT4SMART will face the challenge of solving optimization problems under severe communication limitations, very-large-scale problem and data size, and real-time computational constraints. The expected result will be a combination of strong theoretical methods and effective numerical toolboxes available to people in Engineering, Computer Science, Mathematics and other areas, who are facing optimization in cyber-physical networks.

Project End Date: **9/30/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
648382	**WILLOW**	**PE7 - Systems and Communication Engineering**

Principal Investigator:	**Dr. Petar Popovski** petarp@es.aau.dk
Host Institution:	Aalborg Universitet, DK

WIreLess LOWband communications: massive and ultra-reliable access

The overall objective of WILLOW is to make wireless communication a true commodity by enabling lowband communications: low-rate links for massive number of devices and ultra-reliable connectivity. This research effort is a major endeavour in the area of wireless communications, taking a different path from the mainstream research that aims at "4G, but faster". Lowband communication is the key to enabling new applications, such as massive sensing, ultra-reliable vehicular links and wireless cloud connectivity with guaranteed minimal rate. The research in WILLOW is centred on two fundamental issues. First, it is the efficient communication with short packets, in which the data size is comparable to the size of the metadata, i.e. control information, which is not the case in broadband communication. Communication of short packets that come from a massive number of devices and/or need to meet a latency constraint requires fundamental rethinking of the packet structure and the associated communication protocols. Second is the system architecture in which graceful rate degradation, low latency and massive access can exist simultaneously with the broadband services. The principles from WILLOW will be applied to: (a) clean-slate wireless systems; (b) reengineer existing wireless systems. Option (b) is unique to lowband communication that does not require high physical-layer speed, but can reuse the physical layer of an existing system and redefine the metadata/data relationship to achieve massive/ultra-reliable communication. WILLOW carries high risk by conjecturing that it is possible to support an unprecedented number of connected devices and wireless reliability levels. Considering the timeliness and the relevance, the strong track record of the PI and the rich wireless research environment at Aalborg University, WILLOW is poised to make a breakthrough towards lowband communications and create the technology that will enable a plethora of new wireless usage modes.

Project End Date: **3/31/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714161	**LOLITA**	**PE7 - Systems and Communication Engineering**

Principal Investigator:	**Dr. Tobias Koch** koch@tsc.uc3m.es
Host Institution:	Universidad Carlos Iii De Madrid, ES

Information Theory for Low-Latency Wireless Communications

The majority of wireless connections in the fifth generation (5G) of wireless systems will most likely be originated by autonomous machines and devices rather than by the human-operated mobile terminals for which traditional broadband services are intended. It is thus expected that enhanced mobile-broadband services will be complemented by new services centered on machine-type communications (MTC). An important emerging area among MTC systems is that of low-latency communications, which targets systems that require reliable real-time communication with stringent requirements on latency and reliability. The design of low-latency wireless communication systems is a great challenge, since it requires a fundamentally different design approach than the one used in current high-rate systems. Indeed, current systems exchange packets of several thousand bits. For such packet lengths, there are error-correcting codes that can correct transmission errors with high probability at rates close to the capacity. Consequently, the design of current systems is supported by the extensive information-theoretical knowledge we have about wireless communications. In contrast, low-latency systems exchange packets of only several hundred bits, so the rate of the error-correcting code must be significantly below the capacity to achieve the desired reliability. Consequently, for such systems, capacity is not a relevant performance measure, and design guidelines that are based on its behavior will be misleading. Currently, we are lacking the theoretical understanding of low-latency wireless communication systems that would be crucial to design them optimally. The presented project addresses this problem by establishing the theoretical framework required to describe the fundamental tradeoffs in low-latency wireless communications. The project's vision is that finite-blocklength information theory will play the same role for low-latency systems as information theory has for current systems.

Project End Date: **2/28/2022**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
679820	**MYKI**	**PE7 - Systems and Communication Engineering**

Principal Investigator:	**Dr. Christian Cipriani** Ch.cipriani@sssup.it
Host Institution:	Scuola Superiore Di Studi Universitari E Di Perfezionamento Sant'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: **8/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
617721	**SEARCHLIGHT**	**PE7 - Systems and Communication Engineering**

Principal Investigator:	**Dr. Joerg Widmer** joerg.widmer@imdea.org
Host Institution:	Fundacion Imdea Networks, ES

A new communication paradigm for future very high speed wireless networks

Due to the tremendous growth in mobile devices such as smartphones, tablet PCs, and laptops over the past years, a larger and larger fraction of Internet traffic is delivered wirelessly. Dealing with this vast increase in traffic is one of the most important challenges for future wireless networks. State-of-the-art wireless communication already operates close to Shannon capacity. The only viable option to further increase data rates is to use high bandwidth channels in the very high frequency part of the radio spectrum. However, this spectrum suffers from high attenuation and signal absorption, restricting communication primarily to line-of-sight (LOS) scenarios. This in turn requires a radical rethinking of wireless networking. We envision that future wireless networks will consist of many highly directional LOS channels for communication between access points (APs) and end devices. Such an environment is extremely dynamic, in particular for mobile devices. At the same time, such channels experience very little interference and resources that would otherwise be used to handle interference can now be used to further increase achievable data rates. We propose to build a wireless network architecture that maintains directional LOS channels between several APs and (mobile) end devices. Data is transmitted via all of these channels and end device uses multiple antennas to receive and decode several such data streams simultaneously. The main complexity of the design lies in the selection of APs as well as the beamforming directions of their antennas, given the large number of end devices that future wireless networks will have to support. To speed up this decision process, the system maintains a map of the radio environment and learns likely sequences of beamforming patterns and APs. This further allows to intelligently switch off APs to improve energy efficiency. We believe that such a design is the key element for the scalability of future wireless networks.

Project End Date: **3/31/2019**

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** d.gunduz@imperial.ac.uk
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: **9/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714605	**VADEMECOM**	**PE8 - Products and Processes Engineering**

Principal Investigator: **Dr. Alessandro Parente**
Alessandro.Parente@ulb.ac.be

Host Institution: Universite Libre De Bruxelles, BE

VAlidation driven DEvelopment of Modern and Efficient COMbustion technologies

Combustion science will play a major role in the future quest for sustainable, secure and environmentally friendly energy sources. Two thirds of the world energy supply rely on combustion of fossil and alternative fuels, and all scenarios forecast an increasing absolute energy supply through combustion, with an increasing share of renewables. Thus, combustion will remain the major actor in transportation and power generation as well as in manufacturing processes, like steel and glass. Nevertheless, combustion science will need profound innovation to meet future energy challenges, such as energy efficiency and fuel flexibility, and ensure future generations with affordable and sustainable energy and healthy environment. In this context, MILD combustion represents a very attractive solution for its fuel flexibility and capability to deliver very high combustion efficiency with virtually zero pollutant emissions. Such a combustion regime is the result of a very strong interaction between turbulent mixing and chemical kinetics. The fundamental mechanism of this interaction is not fully understood, thus justifying the need for experimental and numerical investigations. The overall objective of the present research proposal is to drive the development of modern and efficient combustion technologies, by means of experimental, theoretical, and numerical simulation approaches. New-generation simulation tools for MILD combustion will be developed, to reduce the dependence on sub-grid models and increase the fidelity of numerical simulations. High-fidelity experimental data will be collected on quasi-industrial systems, to disclose the nature of the interactions between fluid dynamics, chemistry and pollutant formation processes in MILD combustion. Experiment and numerical simulations will be tied together by Validation and Uncertainty Quantification techniques, to allow the ground-breaking application of the developed approaches and promote innovation in the energy sector.

Project End Date: **3/31/2022**

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** nele.moelans@kuleuven.be
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: **2/28/2022**

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**
jramon@ibecbarcelona.eu

Host Institution: Fundacio Institut De Bioenginyeria De Catalunya, 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: **12/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
340025	**INTELHYB**	**PE8 - Products and Processes Engineering**

Principal Investigator:	**Dr. Jürgen Eckert** Juergen.eckert@unileoben.acat; juergen.eckert@oeaw.ac.at
Host Institution:	Oesterreichische Akademie Der Wissenschaften, AT

Next generation of complex metallic materials with intelligent hybrid structures

In a modern society, metallic materials are crucially important (e.g. energy, safety, infrastructure, transportation, health, medicine, life sciences, IT). Contemporary examples with inherent challenges to be overcome are the design of ultrahigh specific strength materials. There is a critical need for successful developments in this area in particular for reduced energy consumption, reduction of pollutant emissions and passenger safety. Alternative approaches include improved thermal stability and creep resistance of high-temperature alloys for energy conversion, which are generally used in power plants and turbine engines, high temperature process technology, and fossil-fuel driven engines. The ageing European society makes biomedical materials for implant and stent design also crucially important. A drawback of nearly all current high strength metallic materials is that they lack ductility (i.e. are brittle and hard to form)- or on the opposite side, they may be highly ductile but lack strength. The key concept behind INTELHYB is to define new routes for creation of tailored metallic materials based on scale-bridging intelligent hybrid structures enabling property as well as function optimization. The novelty of this proposal as compared to conventional ideas is that they apply to monolithic amorphous materials or bulk microcrystalline. The basis will be founded on innovative strategies for the design, synthesis and characterization of intrinsic length-scale modulation and phase transformation under highly non-equilibrium conditions. This will include the incorporation of dispersed phases which are close to or beyond their thermodynamic and mechanical stability limit thus forming a hierarchically structured hybrid and ductile/tough alloys. Alternatively, the material itself will be designed in a manner such that it is at the verge of its thermodynamic/mechanical stability.

Project End Date: **1/31/2019**

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** l.nicola@tudelft.nl
Host Institution:	Technische Universiteit Delft, NL

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: **5/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
615456	**i-CaD**	**PE8 - Products and Processes Engineering**

Principal Investigator:	**Dr. Joris Thybaut** Joris.Thybaut@UGent.be
Host Institution:	Universiteit Gent, BE

Innovative Catalyst Design for Large-Scale, Sustainable Processes

A systematic and novel, multi-scale model based catalyst design methodology will be developed. The fundamental nature of the models used is unprecedented and will represent a breakthrough compared to the more commonly applied statistical, correlative relationships. The methodology will focus on the intrinsic kinetics of (potentially) large-scale processes for the conversion of renewable feeds into fuels and chemicals. Non-ideal behaviour, caused by mass and heat transfer limitations or particular reactor hydrodynamics, will be explicitly accounted for when simulating or optimizing industrial-scale applications. The selected model reactions are situated in the area of biomass upgrading to fuels and chemicals: fast pyrolysis oil stabilization, glycerol hydrogenolysis and selective oxidation of (bio)ethanol to acetaldehyde. For the first time, a systematic microkinetic modelling methodology will be developed for oxygenates conversion. In particular, stereochemistry in catalysis will be assessed. Two types of descriptors will be quantified: kinetic descriptors that are catalyst independent and catalyst descriptors that specifically account for the effect of the catalyst properties on the reaction kinetics. The latter will be optimized in terms of reactant conversion, product yield or selectivity. Fundamental relationships will be established between the catalyst descriptors as determined by microkinetic modelling and independently measured catalyst properties or synthesis parameters. These innovative relationships allow providing the desired, rational feedback in from optimal descriptor values towards synthesis parameters for a new catalyst generation. Their fundamental character will guarantee adequate extrapolative properties that can be exploited for the identification of a groundbreaking next catalyst generation.

Project End Date: **5/31/2019**

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** anna.coclite@tugraz.at
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: **11/30/2021**

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** lothar.wondraczek@uni-jena.de
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: **8/31/2021**

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** serge.bourbigot@ensc-lille.fr
Host Institution:	Universite Des Sciences Et Technologies De Lille - Lille I, 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 flameThe 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: **12/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647067	**BIOLOCHANICS**	**PE8 - Products and Processes Engineering**

Principal Investigator:	**Dr. Stéphane AVril** avril@emse.fr
Host Institution:	Association Pour La Recherche Et Le Developpement Des Methodes Et Processus Industriels, FR

Localization in biomechanics and mechanobiology of aneurysms: Towards personalized medicine

Rupture of Aortic Aneurysms (AA), which kills more than 30 000 persons every year in Europe and the USA, is a complex phenomenon that occurs when the wall stress exceeds the local strength of the aorta due to degraded properties of the tissue. The state of the art in AA biomechanics and mechanobiology reveals that major scientific challenges still have to be addressed to permit patient-specific computational predictions of AA rupture and enable localized repair of the structure with targeted pharmacologic treatment. A first challenge relates to ensuring an objective prediction of localized mechanisms preceding rupture. A second challenge relates to modelling the patient-specific evolutions of material properties leading to the localized mechanisms preceding rupture. Addressing these challenges is the aim of the BIOLOCHANICS proposal. We will take into account internal length-scales controlling localization mechanisms preceding AA rupture by implementing an enriched, also named nonlocal, continuum damage theory in the computational models of AA biomechanics and mechanobiology. We will also develop very advanced experiments, based on full-field optical measurements, aimed at characterizing localization mechanisms occurring in aortic tissues and at identifying local distributions of material properties at different stages of AA progression. A first in vivo application will be performed on genetic and pharmacological models of mice and rat AA. Eventually, a retrospective clinical study involving more than 100 patients at the Saint-Etienne University hospital will permit calibrating estimations of AA rupture risk thanks to our novel approaches and infuse them into future clinical practice. Through the achievements of BIOLOCHANICS, nonlocal mechanics will be possibly extended to other soft tissues for applications in orthopaedics, oncology, sport biomechanics, interventional surgery, human safety, cell biology, etc.

Project End Date: **4/30/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
666983	**MaGic**	**PE8 - Products and Processes Engineering**

Principal Investigator:	**Dr. Berend Smit** berend.smit@eplf.ch
Host Institution:	Ecole Polytechnique Federale De Lausanne, CH

The Materials Genome in Action

It is now possible to make an enormous spectrum of different, novel nanoporous materials simply by changing the building blocks in the synthesis of Metal Organic Frameworks (MOF) or related materials. This unique chemical tunability allows us to tailor-make materials that are optimal for a given application. The promise of finding just the right material seems remote however: because of practical limitations we can only ever synthesize, characterize, and test a tiny fraction of all possible materials. To take full advantage of this development, therefore, we need to develop alternative techniques, collectively referred to as Materials Genomics, to rapidly screen large numbers of materials and obtain fundamental insights into the chemical nature of the ideal material for a given application. The PI will tackle the challenge and promise posed by this unprecedented chemical tunability through the development of a multi-scale computational approach, which aims to reliably predict the performance of novel materials before synthesis. We will develop methodologies to generate libraries of representative sets of synthesizable hypothetical materials and perform large-scale screening of these libraries. These studies should give us fundamental insights into the common molecular features of the top-performing materials. The methods developed will be combined into an open access infrastructure in which our hypothetical materials are publicly accessible for data mining and big-data analysis. The project is organized in three Work Packages, each centered around finding better materials for carbon capture: (1) screen materials for gas separations and develop the tools to predict the best materials for carbon capture; (2) gain insights into and develop a computational methodology for screening the mechanical properties of nanoporous materials; (3) achieve an understanding of the amine-CO2 chemistry in diamine-appended MOFs and use this to predict their performance.

Project End Date: **10/31/2020**

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** i.papakonstantinou@ucl.ac.uk
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: **2/28/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
669141	**VIRMETAL**	**PE8 - Products and Processes Engineering**

Principal Investigator:	**Dr. Javier LLorca** javier.llorca@imdea.org
Host Institution:	Fundacion Imdea Materiales, ES

Virtual Design, Virtual Processing and Virtual Testing of Metallic Materials

The project VIRMETAL is aimed at developing multiscale modeling strategies to carry out virtual design, virtual processing and virtual testing of advanced metallic alloys for engineering applications so new materials can be designed, tested and optimized before they are actually manufactured in the laboratory. The focus of the project is on materials engineering i.e. understanding how the structure of the materials develops during processing (virtual processing), the relationship between this structure and the properties (virtual testing) and how to select materials for a given application (virtual design). Multiscale modeling will be tackled using a bottom-up, hierarchical, modeling approach. Modeling efforts will begin with ab initio simulations and bridging of the length and time scales will be accomplished through different multiscale strategies which will encompass the whole range of length and time scales required by virtual design, virtual processing and virtual testing. Nevertheless, not everything can or should be computed and critical experiments are an integral part of the research program for the calibration and validation of the multiscale strategies. The research will be focused on two cast metallic alloys from the Al-Si-Mg and Mg-Al-Zn systems. The expected breakthrough is precisely to demonstrate that the structure and properties of two standard engineering alloys of considerable industrial interest can be obtained from first principles by bridging a cascade of modeling tools at the different length scales. Once this is proven, further research will lead to the continuous expansion of both the number and the capability of multiscale simulation tools, leading to widespread application of Computational Materials Engineering in academia and industry. This will foster the implementation of this new revolutionary technology in leading European industries from aerospace, automotive, rail transport, energy generation and engineering sectors.

Project End Date: **10/31/2020**

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**
arri.priimagi@tut.fi

Host Institution: Tty-Saatio, 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: **4/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
337739	**HIENA**	**PE8 - Products and Processes Engineering**

Principal Investigator:	**Dr. Michael De Volder** mfld2@cam.ac.uk
Host Institution:	The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

Hierarchical Carbon Nanomaterials

Over the past years, carbon nanomaterial such as graphene and carbon nanotubes (CNTs) have attracted the interest of scientists, because some of their properties are unlike any other engineering material. Individual graphene sheets and CNTs have shown a Youngs Modulus of 1 TPa and a tensile strength of 100 GPa, hereby exceeding steel at only a fraction of its weight. Further, they offer high currents carrying capacities of 10^9 A/cm², and thermal conductivities up to 3500 W/mK, exceeding diamond. Importantly, these off-the-chart properties are only valid for high quality individualized nanotubes or sheets. However, most engineering applications require the assembly of tens to millions of these nanoparticles into one device. Unfortunately, the mechanical and electronic figures of merit of such assembled materials typically drop by at least an order of magnitude in comparison to the constituent nanoparticles. In this ERC project, we aim at the development of new techniques to create structured assemblies of carbon nanoparticles. Herein we emphasize the importance of controlling hierarchical arrangement at different length scales in order to engineer the properties of the final device. The project will follow a methodical approach, bringing together different fields of expertise ranging from macro- and microscale manufacturing, to nanoscale material synthesis and mesoscale chemical surface modification. For instance, we will pursue combined top-down microfabrication and bottom-up self-assembly, accompanied with surface modification through hydrothermal processing. This research will impact scientific understanding of how nanotubes and nanosheets interact, and will create new hierarchical assembly techniques for nanomaterials. Further, this ERC project pursues applications with high societal impact, including energy storage and water filtration. Finally, HIENA will tie relations with EU's rich CNT industry to disseminate its technologic achievements.

Project End Date: **12/31/2018**

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**
guillaume.haiat@univ-paris-est.fr

Host Institution: Centre National De La Recherche Scientifique, 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: **9/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
640151	**BRAIN MICRO SNOOPER**	**PE8 - Products and Processes Engineering**

Principal Investigator:	**Dr. Gaelle OFFRANC PIRET** gaelle.offranc-piret@inserm.fr
Host Institution:	Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

A mimetic implant for low perturbation, stable stimulation and recording of neural units inside the brain.

Developing brain implants is crucial to better decipher the neuronal information and intervene in a very thin way on neural networks using microstimulations. This project aims to address two major challenges: to achieve the realization of a highly mechanically stable implant, allowing long term connection between neurons and microelectrodes and to provide neural implants with a high temporal and spatial resolution. To do so, the present project will develop implants with structural and mechanical properties that resemble those of the natural brain environment. According to the literature, using electrodes and electric leads with a size of a few microns allows for a better neural tissue reconstruction around the implant. Also, the mechanical mismatch between the usually stiff implant material and the soft brain tissue affects the adhesion between tissue cells and electrodes. With the objective to implant a highly flexible free-floating microelectrode array in the brain tissue, we will develop a new method using micro-nanotechnology steps as well as a combination of polymers. Moreover, the literature and preliminary studies indicate that some surface chemistries and nanotopographies can promote neurite outgrowth while limiting glial cell proliferation. Implants will be nanostructured so as to help the neural tissue growth and to be provided with a highly adhesive property, which will ensure its stable contact with the brain neural tissue over time. Implants with different microelectrode configurations and number will be tested in vitro and in vivo for their biocompatibility and their ability to record and stimulate neurons with high stability. This project will produce high-performance generic implants that can be used for various fundamental studies and applications, including neural prostheses and brain machine interfaces.

Project End Date: **7/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
648375	**iNanoEOR**	**PE8 - Products and Processes Engineering**

Principal Investigator: **Dr. Dongsheng Wen**
d.wen@leeds.ac.uk

Host Institution: University Of Leeds, UK

In-situ produced nanoparticles for enhanced oil recovery

The era of finding "easy oil" is coming to an end, and future supply will become more reliant on fossil fuels produced from enhanced oil recovery (EOR) process. Many EoR methods have been used, including mechanical, chemical, thermal and biological approaches, but there are still 50~70% of the original oil trapped in reservoir rocks after the primary and secondary recovery. NanoEOR, i.e, injecting nanoparticles (NPs) together with flooding fluids, is an emerging field. However all proposed applications are based on pre-fabricated NPs, which encountered enormous problems in NP stabilization and transport under reservoir conditions. This project proposes a revolutionary concept, iNanoEOR: in-situ production of NPs inside the reservoir for enhanced oil recovery. Rather than pre-manufacturing, dispersing and stabilizing NPs in advance, NPs will be produced in the reservoir by controlled hydrothermal reactions, acting as sensors to improve reservoir characterisation, or as property modifiers to effectively mobilize the trapped oil. This project will validate the innovative iNanoEOR concept by answering three questions: i) how the concept works? ii) what kind of NPs should be produced that can effectively mobilize trapped oil? iii) what are desired NP properties to allow them flow through a reservoir? Three work programs are designed, and a number of breakthroughs beyond state-of-art research are expected, which include i) proof-of-concept of the innovative iNanoEOR, ii) developing a new methodology for temperature measurement inside a reservoir, iii) revelation of the influence of NPs on EOR under reservoir-like conditions, iv) understanding the controlling factors in NP transport at different scales. The project will not only contribute directly to iNanoEOR, but also transfers the PI's expertise in nanomaterials and multiphase flow into oil and gas sector and underpin many NP-related subsurface applications, which currently is non-existing in the Europe.

Project End Date: **7/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724480	**EXSEED**	**PE8 - Products and Processes Engineering**

Principal Investigator:	**Dr. David Grojo** grojo@lp3.univ-mrs.fr
Host Institution:	Centre National De La Recherche Scientifique, FR

Extreme-Light Seeded Control of Ultrafast Laser Material Modifications

High-peak power compact femtosecond lasers allow strong-field interactions that are the basis for high-precision laser micro-fabrication. They also create extreme conditions within the matter, leading to the generation of rainbow light used to produce even shorter pulses and new frequencies that can extend from the X-ray to the TeraHertz domain. However, due to the low conversion efficiencies, these attractive light pulses remain unexploited in the context of laser nano-/micro-fabrication.

The main objective of this project is to exceed the intrinsic limits of ultrafast laser material processing by developing novel seeded-control technologies with extreme light pulses. In the proposed concept, seed free carriers are injected into materials from extreme light and then avalanched with perfectly synchronized infrared pulses to extract all potential benefits from modest energy new types of radiation.

The project includes the study of interactions seeded with deep-ultraviolet, few-optical-cycle and mid-infrared ultrashort pulses. The expected nonlinear processes with these radiations open new and exciting opportunities to tailor material properties with nanometer-scale spatial resolutions and in the three dimensions (3D) for materials inside which the occurrence of breakdown is, today, inaccessible (e.g. semiconductors). This will lead to the first demonstrations of rapid 3D prototyping by laser of silicon photonics microdevices.

A long term objective is to open the door to the use of the most extreme ultrashort laser-induced radiations, including extreme-ultraviolet attosecond pulses that hold promises to reach the highest degree of control in the time and space of the interactions.

These and other ideas require investigations on ionization physics by ultrashort pulses at extreme wavelengths. They also require tight control of the ultrafast pulses, broadband manipulations and novel interaction diagnostics technologies that will be developed as parts of the project.

Project End Date: **4/30/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715475	**FlexNanoFlow**	**PE8 - Products and Processes Engineering**

Principal Investigator:	**Dr. Lorenzo Botto** l.botto@qmul.ac.uk
Host Institution:	Queen Mary University Of London, UK

Ultra-flexible nanostructures in flow: controlling folding, fracture and orientation in large-scale liquid processing of 2D nanomaterials

2D nanomaterials hold immense technological promise thanks to extraordinary intrinsic properties such as ultra-high conductivity, strength and unusual semiconducting properties. Our understanding of how these extremely thin and flexible objects are processed in flow is however inadequate, and this is hindering progress towards true market applications. When processed in liquid environments to make nanocomposites, conductive coatings and energy storage devices, 2D nanomaterials tend to fold and break owing to strong shear forces produced by the mechanical agitation of the liquid. This can lead to poorly-oriented, crumpled sheets of small lateral size and therefore of low intrinsic value. Orientation is also a major issue, as ultra-flexible materials are difficult to extend and align. In this project, I will develop nanoscale fluid-structure simulation techniques to capture with unprecedented resolution the unsteady deformation and fracture dynamics of single and multiple sheets in response to the complex hydrodynamic load produced by shearing flows. In addition, I will demonstrate via simulations new strategies to exploit capillary forces to structure 2D nanomaterials into 3D constructs of desired morphology. To guide the simulations and explore a wider parameter space than allowed in computations, I will develop conceptually new experiments on “scaled-up 2D nanomaterials”, macroscopic particles having the same dynamics as the nanoscopic ones. The simulations will include continuum treatments and atomistic details, and will be analysed within the theoretical framework of microhydrodynamics and non-linear solid mechanics. By uncovering the physical principles governing flow-induced deformation of 2D nanomaterials, this project will have a profound impact on our ability to produce and process 2D nanomaterials on large scales.

Project End Date: **3/31/2022**

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** gianni.ciofani@iit.it
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: **2/28/2022**

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** marino.arroyo@upc.edu
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: **8/31/2021**

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**
p.j.withers@manchester.ac.uk

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 scaleObjective 2: To apply it to gain new insights into damage accumulationCorrelative 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: **10/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
680032	**BCOOL**	**PE8 - Products and Processes Engineering**

Principal Investigator:	**Dr. Xavier Moya** xm212@cam.ac.uk
Host Institution:	The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

Barocaloric materials for energy-efficient solid-state cooling

Cooling is essential for food and drinks, medicine, electronics and thermal comfort. Thermal changes due to pressure-driven phase transitions in fluids have long been used in vapour compression systems to achieve continuous refrigeration and air conditioning, but their energy efficiency is relatively low, and the working fluids that are employed harm the environment when released to the atmosphere. More recently, the discovery of large thermal changes due to pressure-driven phase transitions in magnetic solids has led to suggestions for environmentally friendly solid-state cooling applications. However, for this new cooling technology to succeed, it is still necessary to find suitable barocaloric (BC) materials that satisfy the demanding requirements set by applications, namely very large thermal changes in inexpensive materials that occur near room temperature in response to small applied pressures. I aim to develop new BC materials by exploiting phase transitions in non-magnetic solids whose structural and thermal properties are strongly coupled, namely ferroelectric salts, molecular crystals and hybrid materials. These materials are normally made from cheap abundant elements, and display very large latent heats and volume changes at structural phase transitions, which make them ideal candidates to exhibit extremely large BC effects that outperform those observed in state-of-the-art BC magnetic materials, and that match applications. My unique approach combines: i) materials science to identify materials with outstanding BC performance, ii) advanced experimental techniques to explore and exploit these novel materials, iii) materials engineering to create new composite materials with enhanced BC properties, and iv) fabrication of BC devices, using insight gained from modelling of materials and device parameters. If successful, my ambitious strategy will culminate in revolutionary solid-state cooling devices that are environmentally friendly and energy efficient.

Project End Date: **3/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
340391	**SuPro**	**PE8 - Products and Processes Engineering**

Principal Investigator:	**Dr. Hans-Jürgen Butt** butt@mpip-mainz.mpg.de
Host Institution:	Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Superamphiphobic surfaces for chemical processing

Superhydrophobic surfaces hold enormous promise as future self-cleaning or anti-fouling coatings. Their widespread use was, however, limited by contamination with oils and dissolved substances and insufficient mechanical stability. Superamphiphobic surfaces prevent contamination. They not only repel water but also non-polar liquids, surfactant and protein solutions. We recently developed a concept to fabricate transparent, robust superamphiphobic coatings, that is potentially upscalable for industrial mass production. The almost contact-free interface will open up new opportunities in membrane technology, solvent-free production of microspheres, in microfluidics, and in preventing biofilm formation. With targeted experiments and simulation we relate the microscopic structure of superamphiphobic layers to their impalement pressure, roll-off angle, mechanical strength and hydrodynamic drag. Based on these insight, improved and adapted designs will be developed. This project will make it possible to determine the potential of superamphiphobic layers in novel approaches to microchemical processing including improved transport, synthesis and characterization.

Project End Date: **2/28/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
637460	**EyeRegen**	**PE8 - Products and Processes Engineering**

Principal Investigator:	**Dr. Mark Ahearne** ahearnm@tcd.ie
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

Engineering a scaffold based therapy for corneal regeneration

Corneal blindness resulting from disease, physical injury or chemical burns affects millions worldwide and has a considerable economic and social impact on the lives of people across Europe. In many cases corneal transplants can restore vision however the shortage of donor corneas suitable for transplantation has necessitated the development of alternative treatments. The aim of this project is to develop a new approach to corneal tissue regeneration. Previous approaches at engineering corneal tissue have required access to donor cells and lengthy culture periods in an attempt to grow tissue in vitro prior to implantation with only limited success and at great expense. Our approach will differ fundamentally from these in that we will design artificial corneal scaffolds that do not require donated cells or in vitro culture but instead will recruit the patient's own cells to regenerate the cornea post-implantation. These biomaterial scaffolds will incorporate specific chemical and physical cues with the deliberate aim of attracting cells and inducing tissue formation. Studies will be undertaken to examine how different chemical, biochemical, physical and mechanical cues can be used to control the behaviour of corneal epithelial, stromal and endothelial cells. Once the optimal combination of these cues has been determined, this information will be incorporated into the design of the scaffold. Recent advances in manufacturing and material processing technology will enable us to develop scaffolds with organized nanometric architectures and that incorporate controlled growth factor release mechanisms. Techniques such as 3D bio-printing and nanofiber electrospinning will be used to fabricate scaffolds. The ability of the scaffold to attract cells and promote matrix remodelling will be examined by developing an in vitro bioreactor system capable of mimicking the ocular environment and by performing in vivo tests using a live animal model.

Project End Date: **6/30/2020**

European Research Council
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Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679086	**COMPASS**	**PE8 - Products and Processes Engineering**

Principal Investigator: **Dr. Camilla Colombo**
camilla.colombo@polimi.it

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: **7/31/2021**

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Project ID:	Project Acronym:	Evaluation Panel:
639495	**INTHERM**	**PE8 - Products and Processes Engineering**

Principal Investigator: **Dr. Alberto Fina**
alberto.fina@polito.it

Host Institution: Politecnico Di Torino, IT

Design, manufacturing and control of INterfaces in THERMally conductive polymer nanocomposites

This proposal addresses the design, manufacturing and control of interfaces in thermally conductive polymer/graphene nanocomposites.
In particular, the strong reduction of thermal resistance associated to the contacts between conductive particles in a percolating network throughout the polymer matrix is targeted, to overcome the present bottleneck for heat transfer in nanocomposites.
The project includes the investigation of novel chemical modifications of nanoparticles to behave as thermal bridges between adjacent particles, advanced characterization methods for particle/particle interfaces and controlled processing methods for the preparations of nanocomposites with superior thermal conductivity.
The results of this project will contribute to the fundamental understanding of heat transfer in complex solids, while success in mastering interfacial properties would open the way to a new generation of advanced materials coupling high thermal conductivity with low density, ease of processing, toughness and corrosion resistance.

Project End Date: **2/29/2020**

European Research Council
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Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681146	**ULTRA-SOFC**	**PE8 - Products and Processes Engineering**

Principal Investigator: **Dr. Albert Tarancón**
atarancon@irec.cat

Host Institution: Fundacio Institut De Recerca De L'Energia De Catalunya, ES

Breaking the temperature limits of Solid Oxide Fuel Cells: Towards a new family of ultra-thin portable power sources

Solid Oxide Fuel Cells (SOFCs) are one of the most efficient and fuel flexible power generators. However, a great limitation on their applicability arises from temperature restrictions. Operation approaching room temperature (RT) is forbidden by the limited performance of known electrolytes and cathodes while typical high temperatures (HT) avoid their implementation in portable applications where quick start ups with low energy consumption are required. The ULTRASOFC project aims breaking these historical limits by taking advantage of the tremendous opportunities arising from novel fields in the domain of the nanoscale (nanoionics or nano photochemistry) and recent advances in the marriage between micro and nanotechnologies. From the required interdisciplinary approach, the ULTRASOFC project addresses materials challenges to (i) reduce the operation to RT and (ii) technological gaps to develop ultra-low-thermal mass structures able to reach high T with extremely low consumption and immediate start up.

A unique µSOFC technology fully integrated in ultrathin silicon will be developed to allow operation with hydrogen at room temperature and based on hydrocarbons at high temperature. Stacking these µSOFCs will bring a new family of ultrathin power sources able to provide 100 mW at RT and 5W at high T in a size of a one-cent coin. A stand-alone device fuelled with methane at HT will be fabricated in the size of a dice. Apart from breaking the state-of-the-art of power portable generation, the ULTRASOFC project will cover the gap of knowledge existing for the migration of high T electrochemical devices to room temperature and MEMS to high T. Therefore, one should expect that ULTRASOFC will open up new horizons and opportunities for research in adjacent fields like electrochemical transducers or chemical sensors. Furthermore, new technological perspectives of integration of unconventional materials will allow exploring unknown devices and practical applications.

Project End Date: **3/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
616186	**TRITOS**	**PE8 - Products and Processes Engineering**

Principal Investigator:	**Dr. Luca Brandt** luca@mech.kth.se
Host Institution:	Kungliga Tekniska Hoegskolan, SE

TRansItions and Turbulence Of complex Suspensions

The aim of this project is to forge a physical understanding of the transitions and of the turbulent flow of semi-dilute/dense non-colloidal suspensions, for different particle features and suspending fluids.

It is estimated that 10% of the world energy consumption is due to the transport and handling of granular materials of which particle suspensions are an important part. A deep understanding of the mechanisms underlying the flow of particle suspensions, the transition to turbulence and the turbulence characteristics is crucial for many important practical applications involving engineered complex fluids, such as pastes and paper pulp. A better prediction and control of the flow of suspensions will therefore have a huge impact.

Complex fluids are multiscale by nature where the physics at the microscale affects the macroscopic behaviour of the flow and vice versa giving rise to surprising and spectacular phenomena as well as making this one of the most important practical problem still to solve. Investigating the mechanisms by which the system microstructure determines the macroscopic flow properties and vice versa will not only give valuable insights into the nature of flowing suspensions but also will also lead to new ways to model and control it. Future generations of engineering CFD tools will have to contain models for complex suspensions. The fundamental approach proposed here, combined with challenging scientific and engineering examples backed up by experimental evidence, will make this possible and demonstrate it to a wider engineering community. The proposed project is based on highly accurate simulations of multiphase flow systems and state-of-the-art experiments. Such a holistic approach will enable us to understand the underlying mechanisms of instabilities and suspension turbulence and to develop accurate criteria for their prediction far in advance of what we could achieve with either approach separately.

Project End Date: **3/31/2019**

European Research Council
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Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
615102	**BrainMicroFlow**	**PE8 - Products and Processes Engineering**

Principal Investigator: **Dr. Sylvie Lorthois**
lorthois@imft.fr

Host Institution: Centre National De La Recherche Scientifique, FR

Brain Microcirculation : Numerical simulation for inter-species translation with applications in human health

The cerebral microvascular system is essential to a large variety of physiological processes in the brain, including blood delivery and blood flow regulation as a function of neuronal activity (neuro-vascular coupling). It plays a major role in the associated mechanisms leading to disease (stroke, neurodegenerative diseases, …). In the last decade, cutting edge technologies, including two-photon scanning laser microscopy (TPSLM) and optical manipulation of blood flow, have produced huge amounts of anatomic and functional experimental data in normal and Alzheimer Disease (AD) mice. These require accurate, highly quantitative, physiologically informed modeling and analysis for any coherent understanding and for translating results between species.

In this context, our first aim is to develop a general methodological framework for physiologically informed microvascular fluid dynamics modeling, understood in a broad meaning, i.e. blood flow, molecule transport and resulting functional imaging signals or signal surrogates.

Our second aim is to validate this methodological framework by direct comparison of in vivo anatomical and functional TPSLM measurements with the simulation results based on the same anatomical data.

The third objective is to exploit these methodologies in order to identify the logic of the structure/function relationships of brain microcirculation and neurovascular coupling, in human health and disease, with a focus on the role of vascular factors in AD.

Specific hypotheses on how vascular changes in AD affect both vascular function and neurovascular coupling can be experimentally tested in animal models of AD. Crucially, similar anatomical (but not functional) data can be acquired in healthy and AD humans. This will enable us to model how AD-induced vascular alterations could affect human patients. Ultimately, it provides us with new avenues for design and/or evaluation of improved diagnosis/preventive/treatment strategies.

Project End Date: **5/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
335929	**PLASMATS**	**PE8 - Products and Processes Engineering**

Principal Investigator:	**Dr. Nathalie De Geyter** nathalie.degeyter@ugent.be
Host Institution:	Universiteit Gent, BE

Plasma-assisted development and functionalization of electrospun mats for tissue engineering purposes

In this project, I will explore the unique combination of two fascinating research themes: electrospinning and plasma technology. Electrospun nanofibrous matrices (so-called mats) are an exciting class of materials with a wide range of possible applications. Nevertheless, the development and functionalization of these electrospun materials remain very challenging tasks. Atmospheric pressure plasma technology will be utilized by my research group to create advanced biodegradable electrospun mats with unprecedented functionality and performance. To realise such a major breakthrough, plasma technology will be implemented in different steps of the manufacturing process: pre-electrospinning and post-electrospinning. My group will focus on four cornerstone research lines, which have been carefully chosen so that all critical issues one could encounter in creating advanced biodegradable electrospun mats are tackled. Research cornerstone A aims to develop biodegradable electrospun mats with appropriate bulk properties, while in research cornerstone B pre-electrospinning polymer solutions will be exposed to non-thermal atmospheric plasmas. This will be realized by probing unexplored concepts such as discharges created inside polymer solutions. In a third cornerstone C, an in-depth study of the interactions between an atmospheric pressure plasma and an electrospun mat will be carried out. Finally, the last cornerstone D will focus on plasma-assisted surface modification of biodegradable electrospun mats for tissue engineering purposes. Realization of these four cornerstones would result in a major breakthrough in their specific field which makes this proposal inherently a relatively high risk/very high gain proposal. I therefore strongly believe that this research program will open a whole new window of opportunities for electrospun materials with a large impact on science and society.

Project End Date: **1/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
617972	**StruBa**	**PE8 - Products and Processes Engineering**

Principal Investigator:	**Dr. Angelo Simone** a.simone@tudelft.nl
Host Institution:	Technische Universiteit Delft, NL

Computational modelling of structural batteries

Competition in consumer electronics has pushed the boundaries of technological development towards miniaturization, with weight/size limitations and increasing power demands being the two most stringent requirements. Although almost all the components of any portable device become smaller, lighter and more powerful by the months, electrochemical technology is far from presenting us with the ideal battery. From a different perspective, the equation mobile device = casing + electronics + battery could be simplified by merging the structural function of the casing with that of the energy source of the battery into a structural battery. This approach would immediately reduce weight and size of our mobile devices. This project aims at investigating the effect of electrochemical-mechanical interactions on the mechanical performance of structural batteries. Understanding and controlling mechanical degradation in structural batteries is of prime importance given the dual structural-electrical function of these devices. In fact, the main concern when dealing with structural batteries is whether the internal stresses caused by external loads will influence the performance of the battery, and, conversely, whether the functioning of the battery will have a detrimental effect on its mechanical properties. The complexity of these processes can only be addressed with dedicated computational techniques. This project offers a unique opportunity for the design and implementation of the first multiphysics and multiscale computational framework for the analysis of structural batteries. Macroscale processes originating at the level of a basic components will be elucidated through physically-based constitutive laws. The overall impact of this project will be felt across many research communities. Apart from the energy storage community, the developed tools and procedures will influence research and development related to many fibre-reinforced composites.

Project End Date: **5/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
337753	**IgYPurTech**	**PE8 - Products and Processes Engineering**

Principal Investigator: **Dr. Mara Freire Martins**
maragfreire@ua.pt

Host Institution: Universidade De Aveiro, PT

IgY Technology: A Purification Platform using Ionic-Liquid-Based Aqueous Biphasic Systems

With the emergence of antibiotic-resistant pathogens the development of antigen-specific antibodies for use in passive immunotherapy is, nowadays, a major concern in human society. Despite the most focused mammal antibodies, antibodies obtained from egg yolk of immunized hens, immunoglobulin Y (IgY), are an alternative option that can be obtained in higher titres by non-stressful and non-invasive methods. This large amount of available antibodies opens the door for a new kind of cheaper biopharmaceuticals. However, the production cost of high-quality IgY for large-scale applications remains higher than other drug therapies due to the lack of an efficient purification method. The search of new purification platforms is thus a vital demand to which liquid-liquid extraction using aqueous biphasic systems (ABS) could be the answer. Besides the conventional polymer-based systems, highly viscous and with a limited polarity/affinity range, a recent type of ABS composed of ionic liquids (ILs) may be employed. ILs are usually classified as “green solvents” due to their negligible vapour pressure. Yet, the major advantage of IL-based ABS relies on the possibility of tailoring their phases’ polarities aiming at extracting a target biomolecule. A proper manipulation of the system constituents and respective composition allows the pre-concentration, complete extraction, or purification of the most diverse biomolecules.

This research project addresses the development of a new technique for the extraction and purification of IgY from egg yolk using IL-based ABS. The proposed plan contemplates the optimization of purification systems at the laboratory scale and their use in countercurrent chromatography to achieve a simple, cost-effective and scalable process. The success of this project and its scalability to an industrial level certainly will allow the production of cheaper antibodies with a long-term impact in human healthcare.

Project End Date: **1/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714793	**APACHE**	**PE8 - Products and Processes Engineering**

Principal Investigator:	**Dr. Cristina Canal** cristina.canal@upc.edu
Host Institution:	Universitat Politecnica De Catalunya, ES

Atmospheric Pressure plAsma meets biomaterials for bone Cancer HEaling

Cold atmospheric pressure plasmas (APP) have been reported to selectively kill cancer cells without damaging the surrounding tissues. Studies have been conducted on a variety of cancer types but to the best of our knowledge not on any kind of bone cancer. Treatment options for bone cancer include surgery, chemotherapy, etc. and may involve the use of bone grafting biomaterials to replace the surgically removed bone.

APACHE brings a totally different and ground-breaking approach in the design of a novel therapy for bone cancer by taking advantage of the active species generated by APP in combination with biomaterials to deliver the active species locally in the diseased site. The feasibility of this approach is rooted in the evidence that the cellular effects of APP appear to strongly involve the suite of reactive species created by plasmas, which can be derived from a) direct treatment of the malignant cells by APP or b) indirect treatment of the liquid media by APP which is then put in contact with the cancer cells.

In APACHE we aim to investigate the fundamentals involved in the lethal effects of cold plasmas on bone cancer cells, and to develop improved bone cancer therapies. To achieve this we will take advantage of the highly reactive species generated by APP in the liquid media, which we will use in an incremental strategy: i) to investigate the effects of APP treated liquid on bone cancer cells, ii) to evaluate the potential of combining APP treated liquid in a hydrogel vehicle with/wo CaP biomaterials and iii) to ascertain the potential three directional interactions between APP reactive species in liquid medium with biomaterials and with chemotherapeutic drugs.

The methodological approach will involve an interdisciplinary team, dealing with plasma diagnostics in gas and liquid media; with cell biology and the effects of APP treated with bone tumor cells and its combination with biomaterials and/or with anticancer drugs.

Project End Date: **3/31/2022**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
667483	**NANOSHOCK**	**PE8 - Products and Processes Engineering**

Principal Investigator:	**Dr. Nikolaus Adams** nikolaus.adams@tum.de
Host Institution:	Technische Universitaet Muenchen, DE

Manufacturing Shock Interactions for Innovative Nanoscale Processes

Fluid dynamics are fundamental to a wide spectrum of natural phenomena and technological applications. Among the most intriguing fluid dynamics events are shockwaves, discontinuities in the macroscopic fluid state that can lead to extreme temperatures, pressures and concentrations of energy.The violence and yet the spatial localization of shockwaves presents us with a unique potential for in situ control of fluid processes with surgical precision. Applications range from kidney-stone lithotripsy and drug delivery to advanced aircraft design. How can this potential be leveraged/harnessed? What mechanisms and inherent properties allow for formation and control of shocks in complex environments such as living organisms? How can shocks be generated in situ and targeted for drug delivery with high precision while minimizing side effects? What is the potential of reactive/fluidic-process steering by shock-interaction manufacturing?Our objective is to answer these questions by state of the art computational methods, supported by benchmark quality experiments. Computations will be based on advanced multi-resolution methods for multi-physics problems with physically consistent treatment of sub-resolution scales. Uncertainty quantification will be employed for deriving robust flow and shock-dynamic field designs. Paradigms and efficient computational tools will be delivered to the scientific and engineering community. Our group has strong foundations in complex-fluid physics and computational methods and a strong record of successfully integrating research and technical applications. Our goal is to provide un-precedented insight into shock generation and dynamics in complex environments and to unravel the path to technical solutions. Leveraging the enormous potential of manufactured shocks in situ gives access to breakthrough innovations and high-impact technologies, ranging from shock-driven nanoparticle reactors to non-invasive shock-mediated low-impact cancer therapies.

Project End Date: **11/30/2020**

European Research Council
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Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695070	**MILEPOST**	**PE8 - Products and Processes Engineering**

Principal Investigator: **Dr. Mercedes Maroto-Valer**
m.maroto-valer@hw.ac.uk

Host Institution: Heriot-Watt University, UK

Microscale Processes Governing Global Sustainability

Reactive transport modelling is a key tool in understanding the extremely complex interplay of flow, transport and reactions occurring over various temporal and spatial scales in the subsurface. The most difficult challenge in reactive transport is the capture of scale dependence, and upscaling reactive transport will ultimately only be successful if there is a detailed understanding of fundamental mechanisms at the pore level and the supporting data are available. State-of-the-art tools (e.g. X-ray microtomography and on-chip porous media) are not sufficient to understand reactive flow, as they do not provide real-time mapping of propagation of fronts (e.g. temperature, pressure, concentration) that are critical to refine and validate simulations. The ambition is to progress beyond the state of the art via additive manufacturing tools to print 3D replicas of porous cores that enable monitoring the properties within the pores. Our unique approach is to develop for the first time three-dimensional instrumented replicas of porous structures, so we can gain much needed dynamic data at the pore scale that can be incorporated into validated simulations coupling flow and reactive transport processes. We combine expertise and integrating ground-breaking work in: (i) additive manufacturing to produce three dimensional replicas of porous structures; (ii) tools to embed sensors to determine in-vivo propagation of fronts (pressure, temperature, pH) within complex structures; and (iii) novel high-fidelity in-silico pore models coupling relative permeability functions and critical saturations with compositional changes and validated using virtual reality tools. The ERC MILEPOST project will transform our ability to analyse and predict the behaviour of a wide range of pore-scale processes governing the macroscopic behaviour of complex subsurface systems and open up new horizons for science in other areas, e.g porosity controlled in polymers and bioprinting.

Project End Date: **8/31/2021**

European Research Council
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Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715027	**Uniting PV**	**PE8 - Products and Processes Engineering**

Principal Investigator:	**Dr. Bart Vermang** bart.vermang@imec.be
Host Institution:	Interuniversitair Micro-Electronica Centrum, BE

Applying silicon solar cell technology to revolutionize the design of thin-film solar cells and enhance their efficiency, cost and stability

Thin film (TF) photovoltaics (PV) hold high potential for Building Integrated PV, an important market as European buildings require to be nearly zero-energy by 2020. Currently, Cu(In,Ga)(S,Se)2 (= CIGS(e)) TF solar cells have high efficiency, but also a simple one-dimensional cell design with stability and reliability concerns. Furthermore, its present research has been mainly focused on improving the absorber and buffer layers.

Scientifically, Uniting PV aims to study the practical boundaries of CIGS(e) TF solar cell efficiency. For that reason, its goal is to revolutionize the design of CIGS(e) solar cells through implementation of advanced three-dimensional silicon (Si) solar cell concepts. This novel design consists of (i) surface passivation layers and (ii) light management methods integrated into ultra-thin (UT) CIGS(e) solar cells: (i) Passivation layers will be studied to reduce charge carrier recombination at CIGS(e) surfaces. The aim is to create new understanding and thus scientific models. (ii) Light management methods will be studied to optimize optical confinement in UT CIGS(e) layers. The aim is to examine the interaction between light management and charge carrier recombination in UT CIGS(e), and to create scientific models. The main reasons to introduce these developments is to reduce charge carrier recombination at the CIGS(e) surfaces and in the CIGS(e) bulk, while maintaining optical confinement.

Technologically, the project targets to establish a solar cell with: (1) Increased cell efficiency, at least 23.0 % and up to 26.0 %; (2) improved stability and reliability, due to reduced CIGS(e) thickness and passivation layers hindering alkali metal movement; and (3) reduced cost, due to the use of less Ga and In, and industrially viable materials, methods and equipment. Hence, its outcome will be upscalable, valuable for other TF PV materials, and start a new wave of innovation in and collaboration between TF and Si PV research fields.

Project End Date: **2/28/2022**

European Research Council
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Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
717001	**DELPHI**	**PE9 - Universe Sciences**

Principal Investigator: **Dr. Pratika Dayyal**
p.dayal@rug.nl

Host Institution: Rijksuniversiteit Groningen, NL

DELPHI: a framework to study Dark Matter and the emergence of galaxies in the epoch of reionization

Our Universe started as a dark featureless sea of hydrogen, helium, and dark matter of unknown composition about 13 and a half billion years ago. The earliest galaxies lit up the Universe with pinpricks of light, ushering in the era of 'cosmic dawn'. These galaxies represent the primary building blocks of all subsequent galaxies and the sources of the first (hydrogen ionizing) photons that could break apart the hydrogen atoms suffusing all of space starting the process of 'cosmic reionization'. By virtue of being the smallest bound structures in the early Universe, these galaxies also provide an excellent testbed for models wherein Dark Matter is composed of warm, fast moving particles as opposed to the sluggish heavy particles used in the standard Cold Dark Matter paradigm. Exploiting the power of the latest cosmological simulations as well as semi-analytic modelling rooted in first principles, DELPHI will build a coherent and predictive model to answer three of the key outstanding questions in physical cosmology:

- how did the interlinked processes of galaxy formation and reionization drive each other?
- what were the physical properties of early galaxies and how have they evolved through time to give rise to the galaxy properties we see today?
- what is the nature (mass) of the mysterious Dark Matter that makes up 80% of the matter content in the Universe? The timescale of the ERC represents an excellent opportunity for progress on these fundamental questions: observations with cutting-edge instruments (e.g. the Hubble and Subaru telescopes) are providing the first tantalising glimpses of early galaxies assembling in an infant Universe, required to pin down theoretical models. The realistic results obtained by DELPHI will also be vital in determining survey strategies and exploiting synergies between forthcoming key state-of-the-art instruments such as the European-Extremely Large Telescope, the James Webb Space Telescope and the Square Kilometre Array.

Project End Date: **2/28/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
614922	**GALACTICNUCLEUS**	**PE9 - Universe Sciences**

Principal Investigator: **Dr. Rainer Schoedel**
rainer@iaa.es

Host Institution: Agencia Estatal Consejo Superior Deinvestigaciones Cientificas, ES

The Fingerprint of a Galactic Nucleus: A Multi-Wavelength, High-Angular Resolution, Near-Infrared Study of the Centre of the Milky Way

Galactic stellar nuclei are very common in all types of galaxies and are marked by the presence of nuclear star clusters, the densest and most massive star clusters in the present-day Universe. Their formation is still an unresolved puzzle. The centre of the Milky Way contains a massive black hole and a stellar nucleus and is orders of magnitude closer than any comparable target. It is the only galactic nucleus and the most extreme astrophysical environment that we can examine on scales of milli-parsecs. It is therefore a crucial laboratory for studying galactic nuclei and their role in the context of galaxy evolution. Yet, suitable data that would allow us to examine the stellar component of the Galactic Centre exist for less than 1% of its projected area. Moreover, the well-explored regions are extraordinary, like the central parsec around the massive black hole, and therefore probably not representative for the overall environment. Fundamental questions on the stellar population, structure and assembly history of the Galactic Centre remain therefore unanswered. This project aims at addressing the open questions by obtaining accurate, high-angular resolution, multi-wavelength near-infrared photometry for an area of several 100 pc^2, a more than ten-fold increase compared to the current state of affairs. The Galactic Centre presents unique observational challenges because of a combination of high extinction and extreme stellar crowding. It is therefore not adequately covered by existing or upcoming imaging surveys. I present a project that is specifically tailored to overcome these observational challenges. In particular, I have developed a key technique to obtain the necessary sensitive, high-angular resolution images with a stable point spread function over large, crowded fields. It works with a range of existing ground-based instruments and will serve to complement existing data to provide a global and detailed picture of the stellar nucleus of the Milky Way.

Project End Date: **1/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
321271	**NewClusters**	**PE9 - Universe Sciences**

Principal Investigator: **Dr. Huub Rottgering**
rottgering@strw.leidenuniv.nl

Host Institution: Universiteit Leiden, NL

A new window on the Universe: The formation and evolution of galaxy clusters and proto-clusters

The formation and evolution of clusters and proto-clusters of galaxies will be studied using unique diagnostic tools provided by the new pan-European radio telescope LOFAR and the APERTIF phased arrays on WSRT radio telescope. Combined with new ultra low frequency antennas (an extension to LOFAR here proposed), these new facilities will for the first time enable sensitive observations from the lowest possible frequencies accessible from the ground (~15 MHz) up to 1400 MHz. The guaranteed time projects (PI HR) to carry out ultra deep pointed observations and to survey the entire northern sky will be unique in terms of angular resolution, depth, and extremely large frequency range. This enables a coherent study of clusters of galaxies over the entire history of the universe up to the formation of the first proto-clusters. Studies of the associated shock waves produced by cluster mergers and the magnetic field properties of the cluster gas will constrain models of the formation of galaxy clusters.The large field of views of both LOFAR will enable the detection of radio emission from millions of star-forming galaxies up to z=2-3, at the epoch at which the bulk of galaxy formation is believed to have occurred. In combination with infrared surveys, the first significant sample of proto-clusters of galaxies will be obtained. This will enable the first complete study of the overall properties of proto-clusters and their galaxy contents.With LOFAR's ability to pinpoint radio sources with extremely steep radio spectra, we will detect radio galaxies at unprecedented distances. As our previous radio and optical investigations have established that distant radio galaxies are often located in proto-clusters, the most distant LOFAR radio galaxies would be excellent targets to locate and study the first proto-clusters close to or even at the epoch of reionisation.

Project End Date: **12/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695671	**QUENCH**	**PE9 - Universe Sciences**

Principal Investigator: **Dr. Roberto Maiolino**
r.maiolino@mrao.cam.ac.uk

Host Institution: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

Star formation quenching and feedback in galaxies throughout the cosmic epochs

Throughout the whole life of the universe only 4% of the baryons have beenconverted into stars, implying that some physical processes must be responsiblefor suppressing star formation in galaxies. Within this context, one of themost hotly debated open questions is the identification of the processresponsible for quenching star formation in galaxies and transforming them into passive and quiescent (gas poor) systems. Theories of galaxyformation have proposed various possible mechanisms, such as: gasremoval by powerful outflows or ram pressure stripping, heatingand photoionization of the interstellar medium, turbulent orgravitational quenching, halting of the gas supply inflow (often referred to as "strangulation"). The relevance andrelative role of these mechanisms (as a function of cosmic epoch, galaxy properties and environment), especially at high redshift, are not yet understood because the constraints providedby current observational data have not yet been able to discriminatebetween different scenarios.In the proposed project I will make use of some of the most advanced observational facilities that will be available in the coming yearsto tackle this major outstanding open issue. More specifically, I willexploit the James Webb Space Telescope, MOONS (the next generationmulti-object spectrograph at the ESO-VLT) and the Atacama Large MillimeterArray (ALMA).Observing programs making use of these unique facilitieswill provide an unprecedented amount of information, with unprecedented quality, that will enable us to discriminate between various quenching and feedback processes proposedby theories. More specifically, the aim of this project is toidentify and quantify the dominant quenching and feedback mechanisms in galaxies as a function of redshift, as a function of galaxy propertiesand as a function of environment. The groundbreaking results of this project will bea benchmark for any model of galaxy evolution.

Project End Date: **9/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
320360	**Gaia-ESO-MW**	**PE9 - Universe Sciences**

Principal Investigator: **Dr. Gerard Gilmore**
gil@ast.cam.ac.uk

Host Institution: The Chancellor, Masters And Scholars Of The University Of Cambridge, UK

The Gaia-ESO Milky Way Survey

Understanding how galaxies actually form and evolve within our dark matter and dark energy dominated [ΛCDM] universe continues to be an enormous challenge. State of the art simulations of the aggregation of cold dark matter under its own gravitational influence suggest that galaxies grow from very smooth initial conditions through a sequence of merger and accretion events. However, theoretical models of galaxy formation, which necessarily involve modelling star formation and stellar evolution, the creation and dispersal of the chemical elements, the formation and energy output of massive black holes, and the response of gas to radiation and supernova shock waves, among much more, rely more heavily on phenomenological models than on a detailed understanding of physical theory. Thus, these models require calibration with well-studied (nearby) test cases of galaxies which we can study in detail, specifically our own Milky Way Galaxy.

The Gaia-ESO Survey is Europe's major ground-based project to meet this scientific challenge.

The Gaia-ESO Survey, which began data-taking in January 2012, has been allocated 300nights of telescope time over five years using the European Southern Observatory's Very Large Telescope (VLT-UT2) with its premier multi-object spectrograph, FLAMES. The project will obtain high-quality spectroscopy of some 100,000 faint stars, systematically covering all the major components of the Milky Way. This will provide the first homogeneous overview of the distributions of kinematics and chemical elemental abundances in the Galaxy. With well-defined samples the Survey will quantify the kinematic+ multi-chemical element abundance distribution functions of the bulge, the thick disk, the thin disc, and the halo stellar components.

This proposal is to provide the core support team for the Co-Principal Investigator of the Gaia-ESO Survey with responsibility for the Milky Way Survey.

Project End Date: **3/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677117	**DUST-IN-THE-WIND**	**PE9 - Universe Sciences**

Principal Investigator: **Dr. Sebastian Hoenig**
S.Hoenig@soton.ac.uk

Host Institution: University Of Southampton, UK

Dust in the wind — a new paradigm for inflow and outflow structures around supermassive black holes

Active galactic nuclei (AGN) represent the active growing phases of supermassive black holes. For the first time, we are able to resolve the dusty gas on parsec scales and directly test our standard picture of these objects. While this "unification scheme" relates the parsec-scale IR emission with a geometrically-thick disk, I have recently found that the bulk of the dust emission comes from the polar region of the alleged disk where gas is blown out from the vicinity of the black hole. Along with these polar features, the compactness of the dust distribution seems to depend on the accretion state of the black hole. Neither of these findings have been predicted by current models and lack a physical explanation.

To explain the new observations, I proposed a revision to the AGN unification scheme that involves a dusty wind driven by radiation pressure. Depending on their masses, velocities, and frequency, such dusty winds might play a major role in self regulating AGN activity and, thus, impact the interplay between host and black hole evolution. However, as of now we do not know if these winds are ubiquitous in AGN and how they would work physically. Upon completion of the research program, I want to

• characterise the pc-scale mass distribution, its kinematics, and the connection to the accretion state of the AGN,

• have a physical explanation of the dusty wind features and constrain its impacts on the AGN environment, and

• have established dust parallax distances to several nearby AGN, as a multi-disciplinary application of the constraints on the dust distribution.

For that, I will combine the highest angular resolution observations in the IR and sub-mm to create the first pc-scale intensity, velocity, and density maps of a sample of 11 AGN. I will develop a new model that combines hydrodynamic simulations with an efficient treatment of radiative transfer to simulate dusty winds. Finally, direct distances to 12 AGN with a combined 3% precision will be measured.

Project End Date: **4/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
617119	**ExoLights**	**PE9 - Universe Sciences**

Principal Investigator: **Dr. Giovanna Tinetti**
g.tinetti@ucl.ac.uk

Host Institution: University College London, UK

Decoding Lights from Exotic Worlds

It is now accepted that exoplanets are ubiquitous. However little is known about those planets we have detected beyond the fact they exist and their location. For a minority, we know their weight, size and orbital parameters. For less than twenty, we have some clues about their atmospheric temperature and composition. How do we progress from here?

We are still far from a hypothetical Hertzsprung–Russell diagram for planets and we do not even know whether there ever will be such classification for planets. The planetary parameters mass, radius and temperature alone do not explain the diversity revealed by current observations. The chemical composition of these planets is needed to trace back their formation history and evolution, as was the case for the Solar System.

Pioneering results were obtained through transit spectroscopy with Hubble, Spitzer and ground-based facilities, enabling the detection of ionic, atomic and molecular species and of the planet's thermal structure. With the arrival of improved or dedicated instruments in the coming decade, planetary science will expand beyond the narrow boundaries of our Solar System to encompass our whole Galaxy.

In the next five years, ExoLights will address the following fundamental questions:

– Why are exoplanets as they are?

– What are the causes for the observed diversity?

– Can their formation history be traced back from their current composition and evolution?

New spectroscopic observations of a select sample of exoplanets' atmospheres (~ 20 out of the 150 observable today) will be analysed with state-of-the art statistical techniques and interpreted through a comprehensive set of spectral retrieval models, developed by the PI and her team. This programme, together with the homogeneous re-analysis of archive observations of a larger sample of exoplanets, will allow us to use the chemical composition as a powerful diagnostic of the history, formation mechanisms and evolution of gaseous and rocky exoplanets.

Project End Date: **4/30/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
646928	**Multi-Pop**	**PE9 - Universe Sciences**

Principal Investigator: **Dr. Nathan Bastian**
N.J.Bastian@ljmu.ac.uk

Host Institution: Liverpool John Moores University, UK

Fulfilling the Potential of Globular Clusters as Tracers of Cosmological Mass Assembly

Globular clusters (GCs) are among the oldest luminous sources in the universe, bearing witness to theearliest stages of galaxy formation as well as their evolution to the present day. While GCs have played apivotal role in our understanding of the assembly of galaxies, their full potential remains unfulfilled due toour lack of understanding of how they form. One of the largest stumbling blocks has been the anomalouschemistry (both metallicity distributions and abundance patterns) of GCs relative to field stars within galaxy.Here, we will turn the problem around and exploit these differences to understand the co-evolution of GCsand their host galaxies.Our understanding of GCs and their formation has undergone a radical change in the past two decades. First,it is now clear that while traditionally thought of as the quintessential simple stellar populations (i.e., all starswithin a cluster have the same chemical abundances and age), globular clusters host multiple stellarpopulations with spreads in He, many light elements (e.g., Na, O, Al) and even Fe in a few cases. Secondly,GCs, once thought to only be able to form in the special conditions present in the early Universe, are nowknown to be still forming today (known as Young Massive Clusters - YMCS). These two facts have openedup a new window into the interconnectedness of GC and galaxy formation and co-evolution.In this project we will quantitatively test current GC formation models with observations of YMCs, as wellas organise what is known of the stellar populations within GCs (e.g., abundance spreads, CMDmorphologies), providing, for the first time, a global view (i.e., which characteristics are specific toindividual GCs and which are common to all GCs). These results, when combined with what is known aboutmassive cluster formation in the local universe, will provide an unprecedented opportunity to use GCs toconstrain the hierarchical assembly of galaxies.

Project End Date: **8/31/2020**

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**
walch@ph1.uni-koeln.de

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: **8/31/2021**

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**
desert@uva.nl

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: **2/28/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
615929	**SPCND**	**PE9 - Universe Sciences**

Principal Investigator: **Dr. Mark Sullivan**
m.sullivan@soton.ac.uk

Host Institution: University Of Southampton, UK

Supernovae: Physics and Cosmology in the Next Decade

Exploding stars, or supernovae, impact upon many diverse areas of astrophysics, from galaxy formation, to stellar evolution, to cosmology and studies of dark energy. I am playing a leading role in new, wide-field, high-cadence optical surveys that are revolutionising the study of supernovae, searching vast volumes of space, locating hundreds of events to study their demographics in detail, and uncovering new and bizarre types of explosions. In concert with a major European Southern Observatory public spectroscopic survey, PESSTO, these imaging surveys will provide an extraordinary dataset for understanding all facets of the supernova and explosive transient population. My work will perform several tests of the progenitors and physics of the classical type Ia supernovae in an attempt to understand how these crucial standard candles depend on their progenitor stellar populations. I will use these results to inform a new generation of models of type Ia supernovae. I will this distill these results to make a detailed measurement of the dark energy that powers the accelerating universe in which we live, greatly improving upon existing measurements of the variation of dark energy over the last ten billion years. A final aspect of my research is an innovative search for superluminous supernovae: a new class of supernova explosion a hundred times brighter than traditional supernovae, capable of being studied in the very distant universe. These objects may become cosmology's new standard candle, visible far beyond the reach of type Ia supernovae. My new search will significantly increase both the quantity and quality of superluminous supernova observations, allowing us to further our understanding of these enigmatic objects and use them in a cosmological setting for the first time.

Project End Date: **5/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647208	**imbh**	**PE9 - Universe Sciences**

Principal Investigator: **Dr. Peter Jonker**
p.jonker@sron.nl

Host Institution: Stichting Sron Netherlands Institute For Space Research, NL

Do intermediate-mass black holes exist?

With this proposed project I will determine whether intermediate-mass black holes (IMBHs) exist. I propose to use ESA's new Gaia mission, the rich Hubble Space Telescope data archive, and state-of-the-art techniques to investigate systems predicted to exist but not yet found hitherto, such as recoiled hyper-compact stellar systems, red-supergiant mass donors to ultra-luminous X-ray sources, and white dwarf tidal disruption events. The latter can only be detected if black holes with masses less than 1E5 Msun are involved. Using these systems and events we can probe the sphere of influence of the IMBH and determine the black hole mass dynamically.Currently, there are strong indications for the existence of IMBHs, but dynamical evidence, the irrefutable proof of their existence, is still lacking. Whereas the unequivocal detection of an IMBH will be a breakthrough discovery in itself, it has also important consequences for searches of dark matter annihilation signals, it will provide a baseline for the rate predictions of gravitational wave radiation events involving IMBHs, and the properties of a population of IMBHs provides important constraints on the growth of supermassive black holes and galaxies. Finally, if we discover IMBHs in hyper-compact star clusters it validates numerical relativity simulations that predict that merging black holes receive a recoil kick.My membership of Gaia's Data Processing and Analysis Consortium gives me a distinct advantage in analysing and interpreting Gaia data that, through the superb angular resolution, immediate spectroscopic observations and all-sky coverage, provides unique capabilities ideally suited for answering the question whether IMBHs exist.My proposed project is the first to recognize the potential of Gaia (WP1&2) as well as the implications of having red supergiant mass donors in some ultra-luminous X-ray sources (WP3) for answering the question on the existence of IMBHs.

Project End Date: **8/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
321334	**DUSTYGAL**	**PE9 - Universe Sciences**

Principal Investigator: **Dr. Ian Smail**
ian.smail@durham.ac.uk

Host Institution: University Of Durham, UK

The formation of massive galaxies: the roles of dust-obscured starbursts and AGN activity

I propose an integrated programme to determine the role of dust-obscured starburst activity and AGN growth in the formation and evolution of galaxies. This programme will exploit three, new cutting-edge observational facilities: the SCUBA-2 submillimetre camera, which will provide the first panoramic surveys of luminous, but highly obscured, sources out to the highest redshifts; the Atacama Large Millimeter Array (ALMA), which will provide sub-kpc imaging of the distribution of dust and gas within these sources to understand the physics of their activity; the e-MERLIN radio telescope, which will map the distribution of star formation and AGN activity at sub-kpc scales in these systems. I lead major international surveys on all three facilities and I propose to develop and combine these projects to provide a single focused programme to understand the processes which trigger obscured activity at high redshifts and their role in determining the properties of galaxies at the present day.

Project End Date: **12/31/2018**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647939	**CosmicDust**	**PE9 - Universe Sciences**

Principal Investigator: **Dr. Haley Gomez**
gomezh@cardiff.ac.uk

Host Institution: Cardiff University, UK

Lighting up the dark - the evolution of dust throughout cosmic time

After more than two decades of infrared astronomy, we still know very little about the origin and evolution of cosmic dust in galaxies, responsible for obscuring half of all starlight since the Big Bang. This obscured starlight is re-radiated in a region of the electromagnetic spectrum that is still relatively unexplored. Herschel provides a unique opportunity to resolve this by revealing the 90% of dust too cold to be detected before, yet only a tiny fraction of the largest survey of the sky carried out with Herschel has been exploited. This project aims to unravel the dust and gas content of galaxies in the local universe and over cosmic time. I will produce the first statistical census of dust in galaxies, pushing out to earlier cosmic epochs than previously possible. This also provides us with an opportunity to detect unusual objects not seen in other surveys, including a population of extremely dusty galaxies found in Herschel with blue optical colours and very different properties to more evolved spirals typical of the Milky Way. I will use our multi-wavelength data to investigate the emissivity, gas and star formation conditions on resolved spatial scales. Our Herschel data will also expose the role of environment in the interstellar content of early-type and spiral galaxies. I propose a novel approach to resolve the controversy of whether dust forms in exploding stars using polarized light. This could have implications for the detection of polarized signals in the relic radiation from the Big Bang, currently attributed to primordial gravitational waves. Our polarized dust maps of nearby supernova will reveal whether this could be a major contaminant to cosmological signals. This project is timely due to the availability of final Herschel data products and new facilities in 2015-16 in combination with tools and techniques that we have tried and tested. This ERC award will provide me with the resources to continue to lead this emerging field.

Project End Date: **8/31/2020**

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**
s.matt@exeter.ac.uk

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: **6/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716532	**PUNCA**	**PE9 - Universe Sciences**

Principal Investigator: **Dr. Baojiu Li**
baojiu.li@durham.ac.uk

Host Institution: University Of Durham, UK

Preparing for Unveiling the Nature of the Cosmic Acceleration

In less than a decade, various large cosmological surveys, such as Euclid, DESI and eROSITA, will start collecting data. These aim to bring ground-breaking changes to our understanding of the accelerated cosmic expansion - one of the grand challenges in physics today - by improving the precision in determining key cosmological parameters to percent level and testing the various theoretical models, such as dark energy and non-standard gravity. They will, for the first time, allow General Relativity to be tested to such precision beyond the local Universe. However, such exciting goals can only be achieved if the accuracy of theory predictions is greatly improved to match that of observations. I propose to tackle this challenge by using state-of-the-art numerical techniques to study the leading theoretical models beyond standard LCDM in unprecedented accuracy, thereby preparing for their tests by 3 most promising cosmological probes - weak lensing, redshift space distortions and galaxy clusters. This numerically very demanding project is made possible by our recent developments of efficient simulation and analysis pipelines for each of these probes. I will build the PUNCA team which has a wide expertise to study constraints by these probes using accurate theoretical predictions from my planed simulations, and which will work closely to assess the power of novel joint constraints. To link model predictions to observations, and to understand critically their systematics, I will make realistic mock galaxy catalogs using simulations of unprecedented resolution and sophisticated galaxy formation models. The results will have important implications for fully exploiting the potential of upcoming surveys (e.g. Euclid, DESI, of which I am an active member, and eROSITA) in testing models. The pipelines and expertise developed will be useful for analysing real data from those surveys. Given the starting times (2017-20) of the latter, this project (2016-21) is extremely timely.

Project End Date: **2/28/2022**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695075	**SOLMAG**	**PE9 - Universe Sciences**

Principal Investigator: **Dr. Sami Solanki**
solanki-office@mps.mpg.de

Host Institution: Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Solar magnetic field and its influence on solar variability and activity

For life on Earth, the Sun is the most important astrophysical object in the universe. For astrophysicists, the atmosphere of the Sun presents an intriguing, complex and extremely varied environment generated by continuous dynamic, small-scale interactions between plasma and intricately structured magnetic fields. The purpose of this proposal is to elucidate the physics underlying the structure and dynamics of the solar magnetic field that is responsible for the Sun's varied activity and its variability. This goal is to be achieved by following an integral approach combining new observational facilities, novel instruments developed in the group of the PI, the next generation of inversion techniques for data analysis and state-of-the-art magnetohydrodynamic simulations. This wide range of expertise present in the group of the PI is unique and well suited to such an approach. The research proposed here will provide measurements of the Sun's magnetic field at high spatial and temporal resolution at unprecedented sensitivity to Zeeman splitting and to magnetic flux. Also, the use of a novel polarimetric hyperspectral imager, combined with the next generation of inversion techniques will allow following the 3D structure of the magnetic field and of other physical parameters in time through a sequence of snapshots. This will enable following the build-up of magnetic tension and of waves following the field lines and will set important constraints on the heating mechanism of the solar chromosphere and corona. The proposed work, in particular the comparison of measurements with simulations, will also set constraints on the presence and properties of a small-scale turbulent dynamo as well as other fundamental physical processes taking place in the solar atmosphere. The techniques introduced here will enable reliable and robust measurements of chromospheric magnetic fields, shedding new light on this enigmatic but centrally important layer of the solar atmosphere.

Project End Date: **9/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
646702	**CosTesGrav**	**PE9 - Universe Sciences**

Principal Investigator: **Dr. Kazuya Koyama**
Kazuya.Koyama@port.ac.uk

Host Institution: University Of Portsmouth Higher Education Corporation, UK

Cosmological Tests of Gravity

Einstein's theory of General Relativity (GR) is tested accurately within the local universe i.e., the solar system, but this leaves open the possibility that it is not a good description at the largest scales in the Universe. The standard model of cosmology assumes GR as a theory to describe gravity on all scales. In 1998, astronomers made a surprising discovery that the expansion of the Universe is accelerating, not slowing down. This late-time acceleration of the Universe has become the most challenging problem in theoretical physics. Within the framework of GR, the acceleration would originate from an unknown "dark energy." Alternatively, it could be that there is no dark energy and GR itself is in error on cosmological scales. The standard model of cosmology is based on a huge extrapolation of our limited knowledge of gravity. This discovery of the late time acceleration of the Universe may require us to revise the theory of gravity and the standard model of cosmology based on GR. The main objective of my project is to develop cosmological tests of gravity and seek solutions to the origin of the observed accelerated expansion of the Universe by challenging conventional GR. Upcoming surveys will make cosmological tests of gravity a reality in the next five years. There are remaining issues in developing theoretical frameworks for probing gravitational physics on cosmological scales. We construct modified gravity theories as an alternative to dark energy and analyse "screening mechanisms" to restore GR on scales where it is well tested. We then develop better theoretical frameworks to perform cosmological tests of gravity that include non-linear scales by exploiting our theoretical knowledge of the models and our state-of-the-art simulations.This grant will exploit and develop the world-leading position of the group initiated by Kazuya Koyama at the University of Portsmouth funded by the ERC starting grant (2008-2013).

Project End Date: **8/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
646908	**S4F**	**PE9 - Universe Sciences**

Principal Investigator: **Dr. Jes Kristian Jorgensen**
jeskj@nbi.ku.dk

Host Institution: Københavns Universitet, DK

Setting the Stage for Solar System Formation

Low-mass stars like our Sun are formed in the centers of dark clouds of dust and gas that obscure their visible light. Deep observations at infrared and submillimeter wavelengths are uniquely suited to probe the inner regions of these young stellar objects and unravel their structures, as well as the physical and chemical processes involved. These earliest stages are particularly interesting because the properties of the deeply embedded objects reflect the star formation process itself and how it relates to its environment. It is for example during this stage that the final mass of the star and the properties of its disk – and thus ability to form planets – are determined. It is also during these stages that the first seeds for the chemical evolution of the protoplanetary disk are planted and where some complex organic, possibly prebiotic, molecules may be formed. I here apply for an ERC Consolidator Grant that will support an ambitious program to map the physics and chemistry of the early Solar System. The proposed research program intends to use new high resolution, high sensitivity observations from the Atacama Large Millimeter Array (ALMA) - including a number of recently approved large programs – coupled to state-of-the-art radiative transfer tools and theoretical simulations to address some of the key questions concerning the physics and chemistry of the earliest stages of the Solar System: How is the chemistry of the earliest protostellar stages related to the physical structure and evolution of the young stellar object and its surrounding environment? Which complex organic molecules are present in the inner regions of low-mass protostars? What are the chances the rich chemistry of the earliest stages is incorporated into planetary systems such as our own?

Project End Date: **7/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
614264	**OutflowMagn**	**PE9 - Universe Sciences**

Principal Investigator: **Dr. Wouter Vlemmings**
wouter.vlemmings@chalmers.se

Host Institution: Chalmers Tekniska Hoegskola Ab, SE

Magnetic fields and the outflows during the formation and evolution of stars

The outflows of young and old stars play a crucial role in the cycle of matter in galaxies. Stars and planetary systems are formed through complex physical processes during the collapse of gas clouds with outflows a required ingredient. At the end of a stars life, stellar outflows are the main source of heavy elements that are essential for the formation of stars, planets and life. Magnetic fields are one of the key factors governing the in particular the often observed collimated outflow. They might also be a key ingredient in driving stellar mass loss and are potentially essential for stabilizing accretion disks of, in particular, massive proto-stars. Only polarization observations at different spatial scales are able to measure the strength and structure of magnetic fields during the launching of outflows from young and old stars. Because stars in these evolutionary phases are highly obscured by dusty envelopes, their magnetic fields are best probed through observations of molecules and dust at submillimeter and radio wavelengths. In addition to its role, the origin of the magnetic field in these stellar phases is also still unknown and to determine it multi-wavelength observations are essential. The proposed research group will use state of the art submillimeter and radio instruments, integrated with self-consistent radiative transfer and magneto-hydrodynamic models, to examine the role and origin of magnetic fields during star formation and in the outflows from evolved stars. The group will search for planets around evolved stars to answer the elusive question on the origin of their magnetic field and determine the connection between the galactic magnetic field and that responsible for the formation of jets and potentially disks around young proto-stars. This fundamental new work, for which a dedicated research group is essential, will reveal the importance of magnetism during star formation as well as in driving and shaping the mass loss of evolved stars.

Project End Date: **4/30/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
340519	**M2C**	**PE9 - Universe Sciences**

Principal Investigator: **Dr. Monique ARNAUD**
monique.arnaud@cea.fr

Host Institution: Commissariat A L Energie Atomique Et Aux Energies Alternatives, FR

FOLLOWING THE MOST MASSIVE GALAXY CLUSTERS ACROSS COSMIC TIME

Our project aims at testing the standard LCDM scenario for the formation of collapsed structures. Taking advantage of the advent of cluster detection via the SZ effect, we will use the most massive clusters of galaxies and their evolution as laboratory. We build on the Planck SZ survey, the first All Sky survey since the RASS X-ray survey. We will substantially extend the nominal Planck cluster catalogue by developing novel detection techniques based on a simultaneous search of objects in Planck and RASS maps, reaching lower masses and higher redshifts, while keeping a high catalogue purity.

For the first time, we will have the sample size, redshift leverage, and completeness, for a decisive test of the standard LCDM model of the dark matter gravitational collapse on cluster scale. The test will be provided by a full statistical analysis of the dark matter profiles and their evolution. The X-ray technique to derive mass profile will be extended to the full cluster population. This will be made possible by an integrated approach involving systematic confrontation of observations with tailor-made numerical simulations.

Using multi-wavelength data and simulations, we will also assess the dynamical behaviour of the baryons as they collect in dark matter potential. We will i) provide the first complete census of the dark matter, hot and cold baryons and its evolution ii) quantify the thermo- dynamical state up to z~1 as a probe of hierarchical structure formation and gravitational heating iii) probe the link between non-thermal and thermal components.

The project will either cement our current understanding of the dark matter collapse, a prerequisite to any assessment of the specific baryon physics, or points towards the need for revision of the current paradigm, with important cosmological implications. The new detection techniques will be applicable to future surveys. Lastly, we will provide a ‘gold sample’ of galaxy clusters, ideal for cosmological parameter estimate.

Project End Date: **3/31/2019**

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Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
724602	**RECAP**	**PE10 - Earth System Science**

Principal Investigator:	**Dr. Philip Stier** philip.stier@physics.ox.ac.uk
Host Institution:	The Chancellor, Masters And Scholars Of The University Of Oxford, UK

constRaining the EffeCts of Aerosols on Precipitation

Precipitation is of fundamental importance so it is vital to understand its response to anthropogenic perturbations. Aerosols have been proposed to significantly affect precipitation [e.g. Ramanathan et al., 2001]. However, despite major research efforts evidence for a systematic aerosol effect on precipitation remains “ambiguous” [IPCC AR5, Stocker et al., 2013]. The vast majority of prior research [even an entire World Meteorological Organisation assessment report: Levin and Cotton, 2009] has taken a process-driven approach: trying to infer aerosol effects on precipitation through modelling/observing the chain of microphysical processes: from aerosols acting as cloud condensation / ice nuclei via cloud microphysics to precipitation formation of individual clouds. However, this relies on a complete understanding of a very complex and uncertain process chain and there exist no clear strategies to scale the response of individual clouds or cloud systems to larger scales. RECAP will break this deadlock, introducing a radically different approach to aerosol effects on precipitation. RECAP will systematically constrain the energetic control of aerosol effects on precipitation across scales, delivering the first comprehensive and physically consistent assessment of the effect of aerosols on precipitation across scales, uniting energetic and process-driven approaches.

Project End Date: **4/30/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
670462	**COMTESSA**	**PE10 - Earth System Science**

Principal Investigator: **Dr. Andreas Stohl**
ast@nilu.no

Host Institution: Norsk Institutt For Luftforskning, NO

Camera Observation and Modelling of 4D Tracer Dispersion in the Atmosphere

COMTESSA will push back the limits of our understanding of turbulence and plume dispersion in the atmosphere by bringing together full four-dimensional (space and time) observations of a (nearly) passive tracer (sulfur dioxide, SO2), with advanced data analysis and turbulence and dispersion modelling.Observations will be made with six cameras sensitive to ultraviolet (UV) radiation and three cameras sensitive to infrared (IR) radiation. The UV cameras will be built specifically for this project where high sensitivity and fast sampling is important. The accuracy of UV and IR retrievals will be improved by using a state-of-the art-3D radiative transfer model. Controlled puff and plume releases of SO2 will be made from a tower, which will be observed by all cameras, yielding multiple 2D images of SO2 integrated along the line of sight. The simultaneous observations will allow - for the first time - a tomographic reconstruction of the 3D tracer concentration distribution at high space (< 1 m) and time (>10 Hz) resolution. An optical flow code will be used to determine the eddy-resolved velocity vector field of the plume. Special turbulent phenomena (e.g. plume rise) will be studied using existing SO2 sources (e.g. smelters, power plants, volcanic fumaroles).Analysis of the novel campaign observations will deepen our understanding of turbulence and tracer dispersion in the atmosphere. For instance, for the first time we will be able to extensively measure the concentration probability density function (PDF) in a plume not only near the ground but also at higher altitudes; quantify relative and absolute dispersion; estimate the value of the Richardson-Obukhov constant, etc. We will also use the data to evaluate state-of-the-art LES and Lagrangian dispersion models and revise their underlying parameterizations.COMTESSA's vision is that the project results will lead to large improvements of tracer transport in all atmospheric models.

Project End Date: **10/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694509	**CUNDA**	**PE10 - Earth System Science**

Principal Investigator: **Dr. Peter Jan van Leeuwen**
p.j.vanleeuwen@reading.ac.uk

Host Institution: The University Of Reading, UK

Causality Relations Using Nonlinear Data Assimilation

A major problem in understanding complex nonlinear geophysical systems is to determine which processes drive which other processes, so what the causal relations are. Several methods to infer nonlinear causal relations exist, but often lead to different answers, often perform hypothesis testing on causality, need long stationary time series, can be misleading if an unknown process drives the processes under study, or, if a numerical model is used, reflect model causality instead of real-world causality. Furthermore methods that use the governing evolution equations directly lead to intractable high-dimensional integrals.In this proposal I will tackle these problems by firstly embedding causality into a Bayesian framework, moving from testing causality to estimating causality strength and its uncertainty in a systematic way. Knowledge from several causality methods can be combined, new knowledge can be brought in systematically, and time series can be short. Furthermore, new knowledge can be incorporated into the existing knowledge basis, and several methods can be combined in a consistent manner. Secondly, a new formulation to infer causal strength exploring evolution equations that avoids high-dimensional integrals will be explored. Thirdly, numerical models are combined with observations by exploring fully nonlinear data assimilation to study real-world causality.I will test the new techniques on simple models and then apply them to a high-resolution model of the ocean area around South Africa where the Southern Ocean, the Indian Ocean, and the Atlantic Ocean meet.This area plays a crucial role in the global circulation of heat and salt by bringing warm and salty Indian Oceanwater into the Atlantic in a highly turbulent manner. The techniques allow to infer what sets this interocean transport, the turbulent local dynamics or the global climate-related dynamics, crucial for understanding the functioning of the ocean in the climate system.

Project End Date: **8/31/2021**

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**
corinna.hoose@kit.edu

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: **3/31/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
639003	**DEEP TIME**	**PE10 - Earth System Science**

Principal Investigator:	**Dr. Karin Sigloch** karin.sigloch@earth.ox.ac.uk
Host Institution:	The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Dynamic Earth Evolution and Paleogeography through Tomographic Imaging of the Mantle

DEEP TIME will unearth a record of geological time that is buried thousands of kilometres deep. The seafloor that covers two-thirds of the earth's surface is a tiny fraction of all seafloor created during its history – the rest has sunk back into the viscous mantle. Slabs of subducted seafloor carry a record of surface history: how continents and oceans were configured over time and where their tectonic plate boundaries lay. DEEP TIME will follow former surface oceans as far back in time as the convecting mantle system will permit, by imaging subducted slabs down to the core with cutting-edge seismological techniques. Current tectonic plate reconstructions incorporate little if any of this deep structural information, which probably reaches back 300+ million years; they are based on present-day seafloor, which constrains only the past 100-150 million years.

DEEP TIME will match deep slab structure to the geological surface record of subduction – volcanic arcs and other crustal slivers that stayed afloat, survived collisions, and form the world's largest mountain belts. Integrating these two direct records of subduction, the project will

* Add paleo-trenches to existing plate reconstructions and extend them 2-3 times longer into the past.
* Produce a 3-D atlas of the mantle that matches subducted seafloor with paleo-oceans inferred by land geology.
* Rigorously test the hypothesis of vertical slab sinking, which may yield an absolute mantle reference frame.

Tomographic models and geological land records will be synthesized into quantitative and testable paleogeographic reconstructions that complement and extend existing ones, especially in paleo-oceanic areas. This is likely to transform our understanding of the earth's physical surface environment and biosphere during Mesozoic times, as well as the formation of natural resources. It also will put observational constraints on elusive mantle rheologies. Nearly every subdiscipline of the earth sciences could benefit.

Project End Date: **7/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677898	**MARCAN**	**PE10 - Earth System Science**

Principal Investigator: **Dr. Aaron Micallef**
aaron.micallef@um.edu.mt

Host Institution: Universita Ta Malta, MT

Topographically-driven meteoric groundwater – An important geomorphic agent

Topographically-driven meteoric (TDM) recharge is a key driver of offshore groundwater systems because sea level has been lower than at present for 80% of the last 2.6 million years. Groundwater has been implicated as an important agent in the geomorphic evolution of passive continental margins and the canyons that incise them. However, the geomorphic efficacy of groundwater remains dubious, and a diagnostic link between landscape form and groundwater processes remains poorly quantified, especially for bedrock and cohesive sediments. Obstacles that prevent going beyond the current state-of-knowledge include: (i) a focus on terrestrial contexts and a lack of mechanistic understanding of groundwater erosion/weathering; (ii) limited information on offshore groundwater architecture, history and dynamics. By addressing the role of TDM offshore groundwater in the geomorphic evolution of the most prevalent types of continental margins, MARCAN is expected to open new scientific horizons in continental margin research and bring about a step-change in our understanding of some of the most widespread and significant landforms on Earth. The project's methodology is rooted in an innovative, multi-scale and multidisciplinary approach that incorporates: (i) the most detailed 3D characterisation of TDM offshore groundwater systems and their evolution during an integral glacial cycle, based on state-of-the-art marine data and hydrogeologic models, and (ii) the development of a comprehensive continental margin geomorphic evolution model, based on realistic laboratory simulations, accurate field measurements and advanced numerical solutions. By placing better constraints on past fluid migration histories, MARCAN will also have strong applied relevance, primarily by improving assessment and exploitation of offshore freshwater as a source of drinking water.

Project End Date: **12/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
678106	**INTERTRAP**	**PE10 - Earth System Science**

Principal Investigator:	**Dr. Alida GABOR** alida.timar@ubbcluj.ro
Host Institution:	Universitatea Babes Bolyai, RO

Integrated absolute dating approach for terrestrial records of past climate using trapped charge methods

The practice of tuning different climate proxies prevents the observation of regional response times of terrestrial archives to global changes. Thus, it is imperative to develop correlation protocols based on absolute chronologies. Loess-palaeosol deposits are continental archives of Quaternary paleoclimates and loess is generally considered an ideal material for the application of luminescence dating. The agreement obtained for 10-20 ka ages using different techniques has given us confidence in using the state of the art measurement protocols for young deposits, as confirmed by comparison with independent age control. INTERTRAP proposes detailed investigations of loess samples from three continents collected in close proximity to the transition to the recent soil, with the purpose of obtaining a temporal quantification of the ending of the Late Tardiglacial and the beginning of the Holocene. However, a series of recent luminescence investigations carried out on quartz of different grain sizes extracted from Romanian and Serbian loess yielded severe age discrepancies for ages >~40 ka. While the cause of this observation is hitherto not fully explained, our ongoing studies on Chinese loess prove that it is a general effect, potentially affecting deposits worldwide, and raising doubts on previous chronologies. Methodological studies within INTERTRAP will develop an integrated approach using optically stimulated luminescence, thermoluminescence and electron spin resonance investigations. This part of the study aims at unravelling the mechanism responsible for the observed discrepancies and developing innovative trapped charge dating measurement protocols based on quartz that will yield reliable ages for and beyond the last interglacial glacial cycle.

Project End Date: **3/31/2021**

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** d.parsons@hull.ac.uk
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: **4/30/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682707	**ECOHERB**	**PE10 - Earth System Science**

Principal Investigator: **Dr. Daniel Metcalfe**
dbmetcalfe@gmail.com

Host Institution: Lunds Universitet, SE

Drivers and impacts of invertebrate herbivores across forest ecosystems globally.

Forests slow global climate change by absorbing atmospheric carbon dioxide but this ecosystem service is limited by soil nutrients. Herbivores potentially alter soil nutrients in a range of ways, but these have mostly only been recorded for large mammals. By comparison, the impacts of the abundant invertebrates in forests have largely been ignored and are not included in current models used to generate the climate predictions so vital for designing governmental policies

The proposed project will use a pioneering new interdisciplinary approach to provide the most complete picture yet available of the rates, underlying drivers and ultimate impacts of key nutrient inputs from invertebrate herbivores across forest ecosystems worldwide. Specifically, we will: (1) Establish a network of herbivory monitoring stations across all major forest types, and across key environmental gradients (temperature, rainfall, ecosystem development).

(2) Perform laboratory experiments to examine the effects of herbivore excreta on soil processes under different temperature and moisture conditions.

(3) Integrate this information into a cutting-edge ecosystem model, to generate more accurate predictions of forest carbon sequestration under future climate change. The network established will form the foundation for a unique long-term global monitoring effort which we intend to continue long after the current funding time scale. This work represents a powerful blend of several disciplines harnessing an array of cutting edge tools to provide fundamentally novel insights into an area of direct and urgent importance for the society.

Project End Date: **2/28/2021**

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**
razvan.caracas@ens-lyon.fr

Host Institution: Centre National De La Recherche Scientifique, 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: **8/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
615922	**BLACARAT**	**PE10 - Earth System Science**

Principal Investigator: **Dr. Martin Gysel Beer**
martin.gysel@psi.ch

Host Institution: Paul Scherrer Institut, CH

Black Carbon in the Atmosphere: Emissions, Aging and Cloud Interactions

Atmospheric aerosol particles have been shown to impact the earth's climate because they scatter and absorb solar radiation (direct effect) and because they can modify the microphysical properties of clouds by acting as cloud condensation nuclei or ice nuclei (indirect effects). Radiative forcing by anthropogenic aerosols remains poorly quantified, thus leading to considerable uncertainty in our understanding of the earth's climate response to the radiative forcing by greenhouse gases. Black carbon (BC), mostly emitted by anthropogenic combustion processes and biomass burning, is an important component of atmospheric aerosols. Estimates show that BC may be the second strongest contributor (after CO2) to global warming. Adverse health effects due to particulate air pollution have also been associated with traffic-related BC particles. These climate and health effects brought BC emission reductions into the political focus of possible mitigation strategies with immediate and multiple benefits for human well-being. Laboratory experiments aim at the physical and chemical characterisation of BC emissions from diesel engines and biomass burning under controlled conditions. A mobile laboratory equipped with state-of-the-art aerosol sensors will be used to determine the contribution of different BC sources to atmospheric BC loadings, and to investigate the evolution of the relevant BC properties with atmospheric aging during transport from sources to remote areas. The interactions of BC particles with clouds as a function of BC properties will be investigated with in-situ measurements by operating quantitative single particle instruments behind a novel sampling inlet, which makes selective sampling of interstitial, cloud droplet residual or ice crystal residual particles possible. Above experimental studies aim at improving our understanding of BC's atmospheric life cycle and will be used in model simulations for quantitatively assessing the atmospheric impacts of BC.

Project End Date: **2/28/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682602	**BIGSEA**	**PE10 - Earth System Science**

Principal Investigator:	**Dr. Eric Galbraith** eric.d.galbraith@gmail.com
Host Institution:	Universitat Autonoma De Barcelona, ES

Biogeochemical and ecosystem interactions with socio-economic activity in the global ocean

The global marine ecosystem is being deeply altered by human activity. On the one hand, rising concentrations of atmospheric greenhouse gases are changing the physical and chemical state of the ocean, exerting pressure from the bottom up. Meanwhile, the global fishery has provided large economic benefits, but in so doing has restructured ecosystems by removing most of the large animal biomass, a major top-down change. Although there has been a tremendous amount of research into isolated aspects of these impacts, the development of a holistic understanding of the full interactions between physics, chemistry, ecology and economic activity might appear impossible, given the myriad complexities. This proposal lays out a strategy to assemble a team of trans-disciplinary expertise, that will develop a unified, data-constrained, grid-based modeling framework to represent the most important interactions of the global human-ocean system. Building this framework requires solving a series of fundamental problems that currently hinder the development of the full model. If these problems can be solved, the resulting model will reveal novel emergent properties and open the doors to a range of previously unexplored questions of high impact across a range of disciplines. Key questions include the ways in which animals interact with oxygen minimum zones with implications for fisheries, the impacts fish harvesting may have on nutrient recycling, spatio-temporal interactions between managed and unmanaged fisheries, and fundamental questions about the relationships between fish price, fishing cost, and multiple markets in a changing world. Just as the first coupled ocean-atmosphere models revealed a wealth of new behaviours, the coupled human-ocean model proposed here has the potential to launch multiple new fields of enquiry. It is hoped that the novel approach will contribute to a paradigm shift that treats human activity as one component within the framework of the Earth System.

Project End Date: **6/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
638703	**COALA**	**PE10 - Earth System Science**

Principal Investigator: **Dr. Mikael Ehn**
mikael.ehn@helsinki.fi

Host Institution: Helsingin Yliopisto, FI

Comprehensive molecular characterization of secondary organic aerosol formation in the atmosphere

Key words: Atmospheric secondary organic aerosol, chemical ionization mass spectrometry

The increase in anthropogenic atmospheric aerosol since the industrial revolution has considerably mitigated the global warming caused by concurrent anthropogenic greenhouse gas emissions. However, the uncertainty in the magnitude of the aerosol climate influence is larger than that of any other man-made climate-perturbing component. Secondary organic aerosol (SOA) is one of the most prominent aerosol types, yet a detailed mechanistic understanding of its formation process is still lacking. We recently presented the ground-breaking discovery of a new important compound group in our publication in Nature: a prompt and abundant source of extremely low-volatility organic compounds (ELVOC), able to explain the majority of the SOA formed from important atmospheric precursors. Quantifying the atmospheric role of ELVOCs requires further focused studies and I will start a research group with the main task of providing a comprehensive, quantitative and mechanistic understanding of the formation and evolution of SOA. Our recent discovery of an important missing component of SOA highlights the need for comprehensive chemical characterization of both the gas and particle phase composition. This project will use state-of-the-art chemical ionization mass spectrometry (CIMS), which was critical also in the detection of the ELVOCs. We will extend the applicability of CIMS techniques and conduct innovative experiments in both laboratory and field settings using a novel suite of instrumentation to achieve the goals set out in this project.We will provide unprecedented insights into the compounds and mechanisms producing SOA, helping to decrease the uncertainties in assessing the magnitude of aerosol effects on climate. Anthropogenic SOA contributes strongly to air quality deterioration as well and therefore our results will find direct applicability also in this extremely important field.

Project End Date: **2/29/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
637776	**ALKENoNE**	**PE10 - Earth System Science**

Principal Investigator:	**Dr. Jaime Toney** jaime.toney@glasgow.ac.uk
Host Institution:	University Of Glasgow, UK

Algal Lipids: the Key to Earth Now and aNcient Earth

Alkenones are algal lipids that have been used for decades to reconstruct quantitative past sea surface temperature. Although alkenones are being discovered in an increasing number of lake sites worldwide, only two terrestrial temperature records have been reconstructed so far. The development of this research field is limited by the lack of interdisciplinary research that combines modern biological and ecological algal research with the organic geochemical techniques needed to develop a quantitative biomarker (or molecular fossil) for past lake temperatures. More research is needed for alkenones to become a widely used tool for reconstructing past terrestrial temperature change. The early career Principal Investigator has discovered a new lake alkenone-producing species of haptophyte algae that produces alkenones in high abundances both in the environment and in laboratory cultures. This makes the new species an ideal organism for developing a culture-based temperature calibration and exploring other potential environmental controls. In this project, alkenone production will be manipulated, and monitored using state-of-the-art photobioreactors with real-time detectors for cell density, light, and temperature. The latest algal culture and isolation techniques that are used in microalgal biofuel development will be applied to developing the lake temperature proxy. The objectives will be achieved through the analysis of 90 new Canadian lakes to develop a core-top temperature calibration across a large latitudinal and temperature gradient (Δ latitude = 5°, Δ spring surface temperature = 9°C). The results will be used to assess how regional palaeo-temperature (Uk37), palaeo-moisture (δDwax) and palaeo-evaporation (δDalgal) respond during times of past global warmth (e.g., Medieval Warm Period, 900-1200 AD) to find an accurate analogue for assessing future drought risk in the interior of Canada.

Project End Date: **3/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681450	**VERTEBRATE HERBIVORY**	**PE10 - Earth System Science**

Principal Investigator:	**Dr. Thomas Tütken** tuetken@uni-mainz.de
Host Institution:	Johannes Gutenberg Universitaet Mainz, DE

Evolution of herbivory in vertebrates: developing combined isotope (Ca, Sr) and dental surface texture analysis as deep time diet proxies

Diet is a key factor driving vertebrate evolution. Exploring dietary traits and trophic relationships in fossil food webs is fundamental for understanding radiation and extinction events. This project aims to constrain the evolution of herbivory (plant feeding) and trophic interaction of extinct vertebrates at different spatiotemporal scales by analysing their teeth with isotopic and dental wear techniques. A new approach of combined Ca and stable Sr isotope as well as 3D surface texture (3DST) analysis will be developed and applied to fossil teeth of mammal-ancestors and dinosaurs. Teeth record time-series of diet-related isotope compositions in their enamel while their surface tracks short-term food abrasion. These diet proxies will be calibrated on extant vertebrates with well-known diets from wild animals and controlled feeding experiments simulating diet and trophic level switches. Both Ca isotopes and enamel surface textures have a high preservation potential in fossil teeth and enable micro sampling of enamel for Ca isotope and non-destructive 3DST analysis. For the first time, I will combine Ca isotope and 3DST analysis to reconstruct the diet of extinct key vertebrate taxa and their trophic level in fossil food webs. This multi-proxy approach will provide a versatile toolset to test independently feeding hypotheses that mostly hinge on tooth and skeletal morphology, leading to fundamental new insights into the palaeoecology, dietary flexibility and niche partitioning of fossil vertebrates. The aim is to reconstruct the evolution of herbivory in vertebrates. Here, major objectives are: 1) to infer ontogenetic and evolutionary diet changes by combined Ca isotope and 3DST analysis of fossil teeth, 2) explore stable and radiogenic Sr isotopes as combined proxies for trophic level and habitat use, and 3) pioneer 3DST analysis for reptiles. Beyond the field of palaeontology these dietary proxies will be broadly applicable in archaeology, anthropology and ecology.

Project End Date: **8/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
617329	**INTENSE**	**PE10 - Earth System Science**

Principal Investigator: **Dr. Hayley Fowler**
h.j.fowler@ncl.ac.uk

Host Institution: University Of Newcastle Upon Tyne, UK

INTENSE: INTElligent use of climate models for adaptatioN to non-Stationary climate Extremes

The research proposed here will use a novel and fully-integrated data-modelling approach to provide a step-change in our understanding of the nature and drivers of global precipitation extremes and change on societally relevant timescales. Extreme precipitation is increasing globally and theoretical considerations suggest this will continue with global warming, but opportunistic datasets indicate that sub-daily precipitation extremes will intensify more than is anticipated. Determining the precise response of precipitation extremes is hampered by coarse climate models which cannot adequately resolve cloud-scale processes and a lack of sub-daily observations. INTENSE will comprehensively analyse the response of precipitation extremes to global warming by constructing the first global sub-daily precipitation dataset, enabling substantial advances in observing current and past changes. Together with other new observational datasets and high-resolution climate modelling, this will quantify the nature and drivers of global precipitation extremes and their response to natural variability and forcing across multiple timescales. Specifically the project will examine the influence of local thermodynamics and large-scale circulation modes on observed precipitation extremes using new statistical methods which recognise the non-stationary nature of precipitation, and use these to identify climate model deficiencies in the representation of precipitation extremes. The recurrence of extreme hydrological events is notoriously hard to predict, yet successful climate adaptation will need reliable information which better quantifies projected changes. INTENSE will provide a new synergy between data, models and theory to tackle the problem using a process-based framework; isolating the precursors for extreme precipitation and intelligently using detailed modelling as a tool to understand how these extremes will respond to a warming world and the implications for adaptation strategy.

Project End Date: **1/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
695101	**14Constraint**	**PE10 - Earth System Science**

Principal Investigator:	**Dr. Susan Trumbore** trumbore@bgc-jena.mpg.de
Host Institution:	Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Radiocarbon constraints for models of C cycling in terrestrial ecosystems: from process understanding to global benchmarking

The overall goal of 14Constraint is to enhance the availability and use of radiocarbon data as constraints for process-based understanding of the age distribution of carbon in and respired by soils and ecosystems. Carbon enters ecosystems by a single process, photosynthesis. It returns by a range of processes that depend on plant allocation and turnover, the efficiency and rate of litter decomposition and the mechanisms stabilizing C in soils. Thus the age distribution of respired CO2 and the age of C residing in plants, litter and soils are diagnostic properties of ecosystems that provide key constraints for testing carbon cycle models. Radiocarbon, especially the transit of 'bomb' 14C created in the 1960s, is a powerful tool for tracing C exchange on decadal to centennial timescales. 14Constraint will assemble a global database of existing radiocarbon data (WP1) and demonstrate how they can constrain and test ecosystem carbon cycle models. WP2 will fill data gaps and add new data from sites in key biomes that have ancillary data sufficient to construct belowground C and 14C budgets. These detailed investigations will focus on the role of time lags caused in necromass and fine roots, as well as the dynamics of deep soil C. Spatial extrapolation beyond the WP2 sites will require sampling along global gradients designed to explore the relative roles of mineralogy, vegetation and climate on the age of C in and respired from soil (WP3). Products of this 14Constraint will include the first publicly available global synthesis of terrestrial 14C data, and will add over 5000 new measurements. This project is urgently needed before atmospheric 14C levels decline to below 1950 levels as expected in the next decade.

Project End Date: **11/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
336718	**ISoSyC**	**PE10 - Earth System Science**

Principal Investigator: **Dr. Vinciane Debaille**
vinciane.debaille@ulb.ac.be

Host Institution: Universite Libre De Bruxelles, BE

Initial Solar System Composition and Early Planetary Differentiation

Meteorites are privileged witnesses of solar system accretion processes and early planetary evolution. Short-lived radioactive chronometers are particularly adapted in dating and understanding these early differentiation processes. This proposal is dedicated to two main questions: (1) what is the initial composition of the solar system and terrestrial planets?; (2) having refined these parameters, how and when silicate bodies differentiated?

Among short-lived chronometers, the system 146Sm-142Nd is particularly adapted to solve these questions. While it is generally assumed that the global bulk composition of Earth and other terrestrial planets is chondritic for refractory elements such as Sm and Nd, it has recently been shown that the 142Nd/144Nd values display a systematic and reproducible bias between all the chondrites and the average composition of the Earth, and also possibly of other planets. Several hypotheses have been proposed: (i) there is an enriched reservoir hidden deep in Earth, with a composition balancing the currently observed terrestrial composition in order to get a global chondritic composition for the Earth. (ii) The Earth and other terrestrial planets are non-chondritic for their composition in refractory elements. (iii) Nucleosynthetic anomalies have modified the isotopic composition measured in chondrites. (iv) The starting parameters of the 146Sm-142Nd system are not well defined. However, this last point has never been carefully evaluated.

The main scientific strategy of this proposal is based on reinvestigating with the best precision ever achieved the starting parameters of the 146Sm-142Nd systematic using the oldest objects of the solar system: Ca-Al inclusions and chondrules. The final goal of the present proposal is to determine if Earth and other planets are chondritic or not, and to understand the implications of their refined starting composition on their geological evolution in terms of early planetary differentiation.

Project End Date: **2/28/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
670115	**ZOOMecular**	**PE10 - Earth System Science**

Principal Investigator: **Dr. Kai-Uwe Hinrichs**
khinrichs@uni-bremen.de

Host Institution: Universitaet Bremen, DE

Read the fine print: Zooming into paleoenvironmental and biogeochemical processes through molecular imaging of biomarker distributions in sediments

Lipid biomarkers provide unique information to disciplines such as paleoceanography, paleoecology and biogeochemistry. Factors limiting their scope include high sample demand and analytical complexity, constraining resolution of time and space to decadal and centimeter scales, respectively. However, dynamic interactions between physical, chemical and biological processes are recorded within sedimentary matrices at finer scales; lipid biomarkers could decode this sedimentary fine print if the limitations of resolution could be overcome. In a recent PNAS paper, we have demonstrated that this can be done and shown that µm-scale molecular images of paleoenvironmental and geobiological processes can be obtained directly on surfaces of cut sediment cores via laser desorption ionization coupled to mass spectrometry. The project ZOOMecular will build on this innovation by interrogating laminated sediment archives of Late Quaternary climate change and dissecting the complex environmental and ecological responses at subannual resolution. Through analysis of spatial associations of lipid biomarkers with the sedimentary matrix, we will provide a new view of the mechanisms underlying delivery to and preservation of molecular signals in sedimentary records. ZOOMecular will seek to examine the microbial habitat niches at sedimentary interfaces that are home to globally important biogeochemical processes but that are largely known from studies of cm3-scale samples. To enable these pioneering studies, we will develop innovative analytical protocols for a suite of informative biomarkers and for the acquisition of congruent molecular and elemental maps of geological samples. ZOOMecular will unlock otherwise inaccessible information of broad geoscientific relevance; its goals go far beyond the state-of-the-art and its outcome has the potential to transform biomarker research. Such a project can be successfully realized only within a frontier research scheme as provided by the ERC.

Project End Date: **10/31/2020**

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** hanna.vehkamaki@helsinki.fi
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: **5/31/2021**

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** t.kitagawa@ucl.ac.uk
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: **1/31/2022**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714905	**CITIZINGLOBAL**	**SH1 - Markets, Individuals and Institutions**

Principal Investigator:	**Dr. Giacomo Antonio Maria Ponzetto** gponzetto@crei.cat
Host Institution:	Centre De Recerca En Economia Internacional (Crei), ES

Citizens, Institutions and Globalization

Globalization has brought the world economy unprecedented prosperity, but it poses governance challenges. It needs governments to provide the infrastructure for global economic integration and to refrain from destructive protectionism; yet it can engender popular discontent and a crisis of democracy. My proposal will study when trade- and productivity-enhancing policies enjoy democratic support; why voters may support instead inefficient surplus-reducing policies; and how political structure reacts to globalization.

Part A studies the puzzling popularity of protectionism and how lobbies can raise it by manipulating information. It will study empirically if greater transparency causes lower trade barriers. It will introduce salience theory to political economics and argue that voters overweight concentrated losses and disregard diffuse benefits. It will show that lobbies can raise protection by channeling information to insiders and advertising the plight of displaced workers.

Part B studies inefficient infrastructure policy and the ensuing spatial misallocation of economic activity. It will show that voters' unequal knowledge lets local residents capture national policy. They disregard nationwide positive externalities, so investment in major cities is insufficient, but also nationwide taxes, so spending in low-density areas is excessive. It will argue that the fundamental attribution error causes voter opposition to growth-enhancing policies and efficient incentive schemes like congestion pricing.

Part C studies how the size of countries and international unions adapts to expanding trade opportunities. It will focus on three forces: cultural diversity, economies of scale and scope in government, and trade-reducing border effects. It will show they explain increasing country size in the 19th century; the rise and fall of colonial empires; and the recent emergence of regional and global economic unions, accompanied by a peaceful increase in the number of countries.

Project End Date: **12/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647314	**Becoming Men**	**SH2 - Institutions, Values, Beliefs and Behaviour**

Principal Investigator:	**Dr. Eileen Moyer** eileenmoyer@hotmail.com
Host Institution:	Universiteit Van Amsterdam, NL

Becoming Men: Performing responsible masculinities in contemporary urban Africa

This anthropological study examines the reconfiguration of masculinities in urban Africa over the last 30 years. Focusing on how practices and discourses of empowerment and equality shape male subjectivities, this study builds upon a significant body of nuanced research on masculinities in Africa. Since the mid-1980s academic and public discourses have depicted African masculinity as both precarious and predatory. Economic insecurity, urbanization, shifting gender norms, and growing gender parity have accompanied claims that African masculinity is 'in crisis'. More recently, new stories of urban men embracing responsible fatherhood, condemning intimate partner violence, and demanding homosexual rights have emerged as exemplars of progressive possibility. To disentangle these seemingly competing claims about African masculinities and shed light on the scientific, political, and economic projects that shape them, this research theorises that the discourses and practices that pathologise and politicise masculinity are simultaneously performing and producing gendered selves on multiple scales in the name of gender equality. Recently, 'male involvement' has become a rallying cry throughout the vast global development assemblage, around which governments, NGOs, research networks, activists, and local communities fight gender inequality to promote health, economic development, and human rights. In this research, a range of male-involvement initiatives provides a lens through which to study how masculinities are diversely imagined, (re)configured, and performed through men's engagements with this assemblage, in both its local and global manifestations. Multi-sited ethnographic research will focus on six cities where the PI has active research ties: Nairobi and Kisumu, Kenya; Johannesburg and Durban, South Africa; and Dar es Salaam and Mwanza, Tanzania.

Project End Date: **8/31/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694632	**PROTEGO**	**SH2 - Institutions, Values, Beliefs and Behaviour**

Principal Investigator:	**Dr. Claudio Radaelli** c.radaelli@ex.ac.uk
Host Institution:	The University Of Exeter, UK

Procedural Tools for Effective Growth (PROTEGO) Patterns, Outcomes and Policy DesignProcedural Tools for Effective Growth: Patterns, Outcomes and policy Design

PROTEGO arises out of a fundamental claim: procedural regulatory instruments have causal effects on the performance of political systems because they trigger accountability towards different stakeholders. The mix of policy instruments may be functional or dysfunctional, depending on how accountability mechanisms are combined. This project provides a theoretical rationale to capture the accountability effects by adopting an extension of delegation theory that considers multiple stakeholders. The theoretical framework will allow us to identify the key social mechanisms that make bureaucracies internalize the preferences of accountees. We will test the observable implications of the framework on outcomes that are crucial to the performance of political systems, such as trust in government, ease of business, control of corruption, sustainability. Empirically, we will collect, validate and analyze original data across the EU and its 28 Member States for the period 2000-2015, distinguishing between instruments that cover central departmental activity and independent regulatory agencies. The new dataset will cover administrative procedure acts, freedom of information, notice and comment, judicial review, impact assessment, environmental appraisal, and non-financial instruments for public spending accountability. These are the procedural instruments that enfranchise accountees. The bivariate relationship between a single instrument and outcomes explains little – because it's the overall ecology or mix of instruments that produces causal effects. These ecologies combine in different sequences and paths associated with the outcome. Hence we will draw on a suitable methodological approach - Qualitative Comparative Analysis (QCA). Causality and diffusion across time will be also explored via event-history analysis and principal component analysis. PROTEGO will contribute to theories of regulation and accountability, and provide a robust operational model of data and analysis.

Project End Date: **8/31/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
639652	**iLABOUR**	**SH2 - Institutions, Values, Beliefs and Behaviour**

Principal Investigator:	**Dr. Vili Lehdonvirta** vili.lehdonvirta@oii.ox.ac.uk
Host Institution:	The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Online Labour: The Construction of Labour Markets, Institutions and Movements on the Internet

World Bank, EC Joint Research Centre, and other bodies have recently highlighted the potential of online labour markets to boost employment and economic growth. While national job markets have stagnated, online labour markets that connect firms with knowledge and service workers around the world have grown up to 60% a year.An overlooked aspect of these markets is that they extricate workers and employers from national institutional frameworks, such as employment law and collective bargaining, and instead impose their own, technologically enforced institutions. For example, a leading marketplace recently instated a global minimum wage of 4.00 USD/h. With over 540,000 employers and 4,000,000 registered workers in 180 countries, this Californian company is making critical labour policy decisions that influence businesses and individuals from Berlin to Manila.The objective of this project is to lay bare the politics and institutions of these next-generation labour markets promoted with discourses of technological progress. Whose interests find expression in their institutions? Some online workers have begun to organize transnationally with the help of digital media. How do online labour movements emerge and assert power on these markets? And finally, to what extent are these relations still reducible to struggles between capital and labour, rather than more ambiguous networked models of production?We will tackle these questions through a combination of conventional social research methods and innovative Internet research methods, on both virtual research sites (online labour markets and workers' online communities) and physical research sites (market operators' premises and worker gatherings). We survey, interview, and observe designers and workers to reconstruct processes through which online markets, institutions, and movements are shaped, and "scrape" online data to quantify their influence. The results will open up important new vistas in labour policy debate.

Project End Date: **8/31/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
337974	**SECURCIT**	**SH2 - Institutions, Values, Beliefs and Behaviour**

Principal Investigator:	**Dr. Rivke Jaffe** r.k.jaffe@uva.nl
Host Institution:	Universiteit Van Amsterdam, NL

Transforming Citizenship through Hybrid Governance: The Impacts of Public-Private Security Assemblages

This project is an anthropological study of how citizenship is being reconfigured through hybrid forms of governance. It will research these transformations by focusing on public-private 'security assemblages', with particular emphasis on the role of the private security industry. Much recent scholarly debate has focused on shifting modes of governance in a context of neoliberal globalization. Specific attention has focused on how governance is increasingly achieved through networks or assemblages of state, corporate and voluntary actors. Such assemblages of state and non-state actors blur the lines between public and private, and between local, national and transnational. This research will extend this debate by investigating the implications this form of governance has for how different groups enact and experience citizenship, concentrating on public-private security assemblages as hybrid, multi-scalar governance structures. It will examine how forms of 'differentiated citizenship' are produced, and how political subjectivities shift, as a result of these forms of security governance. These transformations in citizenship will be analyzed through a multi-sited, comparative analysis of security assemblages in Jerusalem (Israel), Kingston (Jamaica) and Nairobi (Kenya). The project will research the composition, operation and regulation of public-private security assemblages, with special attention to the global mobilities of security experts and expertise. In each setting, the project will study the practices and discourses that structure relations between state and non-state security providers, clients and those seen as threats. It will focus on the 'security encounter' between these different actors, in which new social relationships and subjectivities are produced. The project is expected to lead to the development of an anthropological theory of security governance with both theoretical and applied relevance.

Project End Date: **3/31/2019**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
639070	**SUSTAINABLEOCEAN**	**SH2 - Institutions, Values, Beliefs and Behaviour**

Principal Investigator:	**Dr. Seline Trevisanut** s.trevisanut@uu.nl
Host Institution:	Universiteit Utrecht, NL

Accommodating New Interests at Sea: Legal Tools for Sustainable Ocean Governance

This research project will develop a theoretical framework and legal tools to aid scholars and stakeholders (law and policy-makers, private investors, environmental NGOs) in managing competing interests in the offshore economic sector. The offshore sector is expanding and activities at sea are increasing (e.g., deep seabed mining, oil and gas extraction, renewable energy technologies, etc.). This situation threatens the health of the marine environment and its biodiversity. It also impacts traditional uses of the sea, such as navigation and fishing. New activities pose major challenges for the sustainable management of the oceans, and they highlight competing interests that the law needs to accommodate, such as: - protecting the marine environment and conserving its biodiversity; - mitigating climate change effects; - guaranteeing the continuity of the relevant economic activities; - guaranteeing energy efficiency and security; and- protecting the rights of local communities and populations.This project will answer the following research question: how can the law contribute to the sustainable use of the oceans and strike a balance between competing interests at sea? The law pertaining to ocean governance is fragmented into regimes that are imbued by different interests. The project will begin by analysing three legal frameworks, which are the most relevant for the offshore industry: the law of the sea, climate change law and energy law. It will focus on the operation of the offshore industry and on the competing interests, which have influenced the respective fields of law. This will allow identifying patterns of regime interaction and assessing their impact on the different uses of the sea. The research will ultimately offer a theory of interest- and regime-interaction in ocean governance and thus create a comprehensive framework for the development of legal tools(briefs, recommendation, which will contribute to sustainable ocean governance.

Project End Date: **9/30/2020**

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**
josip.glaurdic@uni.lu

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: **3/31/2022**

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. Károly Takács** takacs.karoly@tk.mta.hu
Host Institution:	Magyar Tudomanyos Akademia Tarsadalomtudomanyi Kutatokozpont, HU

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: **11/30/2020**

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**
klho@sund.ku.dk

Host Institution: Københavns 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: **5/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681018	**EUROSTUDENTS**	**SH2 - Institutions, Values, Beliefs and Behaviour**

Principal Investigator:	**Dr. Rachel Brooks** r.brooks@surrey.ac.uk
Host Institution:	University Of Surrey, UK

Constructing the Higher Education Student: a comparative study of six European countries

There are currently over 35 million students within Europe and yet, to date, we have no clear understanding of the extent to which understandings of 'the student' are shared. This project thus investigates how the contemporary higher education student is conceptualised and the extent to which this differs both within nation-states and across them. This is significant in terms of implicit (and sometimes explicit) assumptions that are made about common understandings of 'the student' across Europe – underpinning, for example, initiatives to increase cross-border educational mobility and the wider development of a European Higher Education Area. It is also significant in relation to exploring the extent to which understandings are shared within a single nation and, particularly, the degree to which there is congruence between the ways in which students are conceptualised within policy texts and by policymakers, and the understandings of other key social actors, such as the media, higher education institutions and students themselves. This proposal outlines plans for a significant body of work that, by the end of the five year period, will have: developed a new theoretical framework for understanding the ways in which the higher education student is conceptualised, based on an innovative and inter-disciplinary comparative approach; generated a comprehensive and cross-national dataset on constructions of the higher education student; and established international networks that will provide a platform for taking forward research in this field after the grant has ended. The proposed work will also have a considerable impact on my own career development, through: consolidating my leadership experience by giving me experience of managing a six-nation comparative research project and mentoring research staff; providing me with dedicated time to publish widely across several academic disciplines; and extending my profile further amongst the international research community.

Project End Date: **7/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647019	**CHILE**	**SH2 - Institutions, Values, Beliefs and Behaviour**

Principal Investigator:	**Dr. Phillip Hellwege** phillip.hellwege@jura.uni-augsburg.de
Host Institution:	Universitaet Augsburg, DE

A Comparative History of Insurance Law in Europe

The objective of the project is to work out interactions between the national developments of insurance law in Europe, to explore the possibility of common historical roots of European insurance law, and to reassess the history of insurance law in Europe. The project does, thereby, aim at creating a historical basis for a European legal scholarship in the field of insurance law. Today's state of research in the field of the history of insurance law is unsatisfactory: with the exception of maritime insurance, modern research focuses on national developments and the history of insurance law is told differently in the European countries. Even though modern research suggests that there have been interactions between the national developments these interactions often appear to be only footnotes to a mainly national development. For the first time, the project takes these points of interactions as a starting point for an in depth research into the history of insurance law in Europe. It is, to take an example involving England and Germany, known that English life and fire insurers where present on the German market since the late 18th century and that those who, in the beginning of the 19th century, were involved in founding the first commercial life and fire insurers in Germany had been working for English insurers. What needs to be explored is what impact this had on the practice and standard contract terms of German insurers. On the basis of the research into this and other points of interactions it will, for the first time, be possible to research into the doctrinal history of insurance law on a European level. The project will help to reassess the history of insurance law in Europe and it will create a historical basis for a European scholarship in the field of insurance law: the harmonization of European insurance contract law is on the agenda. Comparative historical research will help to understand the existing differences between the insurance laws in Europe.

Project End Date: **8/31/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
638259	**EUBorderCare**	**SH2 - Institutions, Values, Beliefs and Behaviour**

Principal Investigator:	**Dr. Vanessa Grotti** Vanessa.Grotti@EUI.eu
Host Institution:	European University Institute, IT

Intimate Encounters in EU Borderlands: Migrant Maternity, Sovereignty and the Politics of Care on Europe's Peripheries

EU Border Care is a comparative study of the politics of maternity care among undocumented migrants on the EU's peripheries. Empirical analysis of personal and institutional relations of care and control in the context of pregnancy and childbirth will support an innovative critique of the moral rationale underpinning healthcare delivery and migration governance in some of Europe's most densely crossed borderlands in France, Greece, Italy and Spain.

Unlike other categories of migrants, undocumented pregnant women are a growing phenomenon, yet few social science or public health studies address EU migrant maternity care. This subject has urgent implications: whilst recent geopolitical events in North Africa and the Middle East have triggered a quantifiable increase in pregnant women entering the EU in an irregular situation, poor maternal health indicators among such women represent ethical and medical challenges to which frontline maternity services located in EU borderlands have to respond, often with little preparation or support from national and European central authorities.

Grounded in long-term ethnographic fieldwork in maternity wards located in French Guiana and Mayotte (Overseas France), the North Aegean and Attica (Greece), Sicily (Italy), and Ceuta and Melilla (Spain), my project will trace the networks of maternity care delivery in peripheries facing an increase of immigration flows, and characterised by structural social and economic underinvestment. My team will investigate migrant maternity from three interlinked research perspectives: migrant women, healthcare delivery staff, and regional institutional agencies. Empirical and desk research, combined with creative audio-visual methods, will document migrant maternity on EU borderlands to address wider questions about identity and belonging, citizenship and sovereignty, and humanitarianism and universalism in Europe today.

Project End Date: **7/31/2020**

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** d.weenink@uva.nl
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: **8/31/2021**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
678266	**RESPONSIVENESS**	**SH2 - Institutions, Values, Beliefs and Behaviour**

Principal Investigator:	**Dr. Christian Goebel** Christian.Goebel@univie.ac.at
Host Institution:	Universitaet Wien, AT

The Microfoundations of Authoritarian Responsiveness: E-Participation, Social Unrest and Public Policy in China

China's success story of the past three decades is seen as an anomaly. Market-based reforms have generated an economic system that can hardly be described as socialist anymore, but the Communist Party of China remains in power. Although social unrest is on the rise, the CCP enjoys the consent of the overwhelming majority of its people. Most agree that China's economic performance is the key to solving this apparent puzzle, but how can extraordinary high rates of public support be maintained in a country where income inequality is so extreme?

We believe that the answer to this question lies in the responsiveness of China's authoritarian one-party regime to popular demands and grievances, a capability that has so far been attributed only to democratic regimes. We further believe that the rapid improvement of e-participation, the opportunity to evaluate public services on the Internet, has greatly facilitated regime responsiveness - China's score in the United Nations e-participation index is higher than the European average. We suggest, however, that as the government increasingly calibrates public policy towards satisfying the demand of China's netizens, the "technologically illiterate" are forced to express their demands in public protests and other forms of social unrest.

The proposed project sheds light on the intended and unintended consequences of enhanced e-participation in China by exploring which social interests China's rulers incorporate into public policy making, and how these decisions influence the propensity of particular social groups to voice their demands by either participating online or taking to the streets. By exploring the "complex system" in which online complaints, social unrest and public policy interact, the project provides insights into the micro-foundations of regime responsiveness in China. It thereby increases our knowledge of how the CCP seeks to defer the antagonism that prompted the revolutions in Egypt, Tunisia and Syria.

Project End Date: **4/30/2021**

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** l.p.cooke@bath.ac.uk
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: **7/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
340430	**MIGPROSP**	**SH2 - Institutions, Values, Beliefs and Behaviour**

Principal Investigator:	**Dr. Andrew Geddes** andrew.geddes@eui.eu
Host Institution:	The University Of Sheffield, UK

Prospects for International Migration Governance

Risk and uncertainty are inherent in any decision-making procedure, but while a substantial body of work on the governance of international migration focuses on challenges posed to governance systems, we know remarkably little about the impact of risk and uncertainty on: (i) the cognitive biases of actors within migration governance systems; (ii) the susceptibility of these biases to change; (iii) the relationship between cognitive bias and broader questions of systemic resilience, vulnerability and adaptation and (iv) the similarities and differences in migration governance between major world regions. Each of these is a significant gap in our knowledge of international migration governance. To address this gap this project will focus on the context of decision to ask: what are the causes and consequences of the cognitive biases concerning risk and uncertainty held by actors in migration governance systems? The project will: (i) test the causes and consequences of the 'frames' held by actors in migration governance systems, specify the scope for these frames to change and to analyse the likely systemic effects of change on migration governance systems in four major world regions. (ii) develop a comparative regional analysis of the micro-political foundations of migration governance and their implications for system adaptation and change. (iii) significantly advance conceptual and methodological understanding of international migration governance through the use of concepts of systemic adaptation, vulnerability and resilience that bridge behavioural theories of choice with theories of institutional and organisational change. (iv) disseminate the results effectively through a range of appropriate outlets and through engagement with a range of users of the results of this work in academia, policy-making communities, NGOs and the wider public.

Project End Date: **3/31/2019**

European Research Council
Executive Agency
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Project ID:	Project Acronym:	Evaluation Panel:
639379	**DATACTIVE**	**SH2 - Institutions, Values, Beliefs and Behaviour**

Principal Investigator:	**Dr. Stefania Milan** s.milan@uva.nl
Host Institution:	Universiteit Van Amsterdam, NL

Data activism: The politics of big data according to civil society

With the diffusion of 'big data', citizens become increasingly aware of the critical role of information in modern societies. This awareness gives rise to new social practices rooted in technology and data, which I term 'data activism'. While activists see massive data collection by governments and businesses as a challenge to civil rights, big data also offer new opportunities for collective action.This research will investigate civil society's engagement with massive data collection by addressing three research questions: How do citizens resist massive data collection by means of technical fixes (re-active data activism)? How do social movements use big data to foster social change (pro-active data activism)? How does data activism affect the dynamics of transnational civil society, and transnational advocacy networks in particular?The project will develop a multidisciplinary conceptual framework integrating social movement studies, science and technology studies and international relations. It will analyze organizational forms, action repertoires and the enabling role of software in data activism, and will identify emerging structures and strategies of transnational advocacy networks. Data will be collected via qualitative (interviews with activists, field observations, infrastructure ethnography on software platforms) and computational methods (such as data mining in online repositories). This research is groundbreaking in four ways: 1) by analyzing civil society's engagement with massive data collection, it evaluates risks and promises of big data; 2) by addressing an uncharted but rapidly growing field of human action, it sets the basis for understanding future civic engagement; 3) by integrating adjacent disciplines that seldom interact, it magnifies their ability to understand the interplay between society, information, technology and power; 4) by developing dedicated data collection tools, it adds to methodological innovation in big-data analytics.

Project End Date: **8/31/2020**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
680009	**SNSNEWS**	**SH2 - Institutions, Values, Beliefs and Behaviour**

Principal Investigator: **Dr. Shira Dvir Gvirsmam**
shirad@post.tau.ac.il

Host Institution: Tel Aviv University, IL

The new flow of news : how social network sites transform news organization and citizens political behavior

News industry is undergoing a major transition: Traditional news consumption is on the decline, while citizens increasingly turn their attention to social network sites (SNSs). To accommodate this trend, news industry has been incorporating SNSs into its platforms, changing news into a social product. The project will explore this process and reveal its implications for news production and audiences' political behavior. I develop a new model anchored in network logic and involving three key actors in news creation and distribution: news organizations, which are adapting news production to the logic of sharing; news feeders – users who select and disseminate news stories, thereby serving as a bridge between their online followers and news organizations; and news feedees – individuals whose news consumption is limited to stories fetched for them by feeders in their SNSs. The model points to some long-term effects on individuals' political beliefs and behavior as a consequence of acting as feeders or feedees. Multiple innovative methods will be employed, some of which will be implemented in the field of media and political studies for the first time. The methods are mutually complementary, combining 'big data' analysis with small-N in-depth designs. To study news organizations, I will interview news editors and analyze traffic data juxtaposing it against content analysis. To study users' behavior and identify feeders and feedees, I will conduct a laboratory observation in which surfing behavior and physiological attention indices will be measured unobtrusively. Long-term political effects will be tested using a combination of survey panel data and web-based behavioral data spanning a period of two years. The proposal is theoretically and empirically innovative and can impact future research by providing novel conceptualization of news distribution, consumption and influence, as well as by introducing a new methodological 'golden standard' to audience research.

Project End Date: **3/31/2021**

European Research Council
Executive Agency
Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714993	**NEEDS**	**SH2 - Institutions, Values, Beliefs and Behaviour**

Principal Investigator:	**Dr. Marco Helbich** m.helbich@uu.nl
Host Institution:	Universiteit Utrecht, NL

Dynamic Urban Environmental Exposures on Depression and Suicide

19% of the Dutch population suffer from depression and people affected by depression have a significantly higher suicide risk. Although the World Health Organization attributes modifiable environmental factors including urban environments (i.e. the built, natural and social environments) to health outcomes, they are largely disregarded as either stressors or buffers in scientific debates on depression and suicide. A limitation of current studies is that urban environmental features are often restricted to the neighbourhoods within which people live. This may result in incorrect conclusions about health-influencing factors and inappropriate policies. Human life ultimately unfolds over space-time; people are exposed to multiple urban environments not only during daily life but also over the course of their lives. It is this, not yet assessed spatiotemporal interplay of urban exposures that might revolutionize health assessments.

This research aims to understand the interactions between urban environments, depression and suicide in the Netherlands. The scientific breakthrough will be dynamic health geographies embedded in space-time by two innovative case studies. We will investigate the following research questions: What are the associations between depression and the built, natural and social urban environments along people's daily space-time paths? And what are the associations between suicide and the built, natural and social urban environments of previous residential locations?

A multidisciplinary approach combining health, geographic information science and urban geography will lead to this breakthrough. It will be grounded on cutting-edge smartphone-based human tracking, health register data and spatiotemporal modelling. Knowledge about dynamic urban exposures is key to revealing disease aetiologies, advancing health preventions and formulating policies supporting a healthier urban living.

Project End Date: **3/31/2022**

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. Mordechai (Muki) Haklay** m.haklay@ucl.ac.uk
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: **10/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681546	**FAMSIZEMATTERS**	**SH3 - Environment, Space and Population**

Principal Investigator:	**Dr. Christiaan Monden** christiaan.monden@nuffield.ox.ac.uk
Host Institution:	The Chancellor, Masters And Scholars Of The University Of Oxford, UK

Family size matters: How low fertility affects the (re)production of social inequalities

This is the first comprehensive study on the consequences of low fertility for the (re)production of social inequalities. Inequalities in socio-economic well-being, including gender inequalities and regional inequalities, are reproduced from generation to generation. The family plays a central role in the reproduction of social inequalities. Over the last 5 decades, most societies in Europe and East-Asia moved or started moving towards low fertility regimes where the majority of women bear 0, 1 or 2 children. What does this radical change in family size imply for the (re)production of social inequalities? While demographers focus on determinants rather than consequences of low fertility, social inequality scholars largely ignore fertility trends. I connect these major fields to understand the consequences of low fertility and re-think mechanisms for the reproduction of inequalities. From this perspective I generate new empirical and theoretical questions and I highlight growing but under-researched groups (i.e. childless adults and only-children). I formulate three sets of related innovative questions on the consequences of low fertility for inequalities in (1) children, (2) adults and (3) societies. With regard to children, I investigate multigenerational processes, the changing role of sibling size and the role of only-children in reproducing inequalities. For parents with adult children, I study when and where the 'quality' of children becomes increasingly important and I examine the role of childless adults in the reproduction of inequalities. I take a quantitative comparative approach over time and across societies in Europe and East-Asia using multi-actor multilevel data from the newest data initiatives and reviving underused existing data. The insights from the comparative studies are brought together at the macro level in a simulation study. Gender inequalities are addressed throughout the project: has lower fertility reduced gender inequalities?

Project End Date: **6/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
340510	**GLOBHEALTH**	**SH3 - Environment, Space and Population**

Principal Investigator:	**Dr. Jean-Paul Gaudilliere** gaudilli@vjf.cnrs.fr
Host Institution:	Institut National De La Sante Et De La Recherche Medicale (Inserm), FR

From International to Global: Knowledge, Diseases and the Postwar Government of Health.

This project aims at a socio-historical study of the transition between the two regimes of knowledge and action, which have characterized the government of health after World War II: the regime of international public health, dominating during the first decades of the postwar era, which was centered on eradication policies, nation-states and international UN organizations; the present regime of global health, which emerged in the 1980s and is centered on risk management and chronic diseases, market-driven regulations, and private-public alliances.

The project seeks to understand this transition in terms of globalization processes, looking at the making of knowledge, the production and commercialization of health goods, the implementation of public health programs, and routine medical work. It will focus on four fields of investigations: tuberculosis, mental health, traditional medicine and medical genetics in order to understand how categories, standardized treatment regimens, industrial products, management tools or specific specialties have become elements in the global government of health. The project associates historical and anthropological investigations of practices in both international and local sites with strong interests in: a) the changing roles of WHO; b) the developments taking place in non-Western countries, India in the first place.

The expected benefits of this research strategy are: a) to take into account social worlds including laboratories, hospitals, enterprises, public health institutions and international organizations; b) to approach the global as something translated in and emerging from local practices and local knowledge; c) to explore different levels of circulations beyond the classical question of North-South transfers; d) to deepen our understanding of the transition from the political and economical order of the Cold War into a neo-liberal and multi-centric age of uncertainty.

Project End Date: **7/31/2019**

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** nils.bunnefeld@stir.ac.uk
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: **8/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647224	**SIZE**	**SH3 - Environment, Space and Population**

Principal Investigator:	**Dr. Mark Huijbregts** m.huijbregts@science.ru.nl
Host Institution:	Stichting Katholieke Universiteit, NL

Size matters: scaling principles for the prediction of the ecological footprint of biofuels

There is a major scientific and societal challenge in quantifying and reducing ecological footprints of products. Ecological footprint calculations suffer severely from a limited availability of data, such as the amount of energy and materials associated with the production, use and disposal of products. Furthermore, ecological footprints pertaining to biodiversity are typically biased towards a limited number of well-known species with a focus on relative species richness, leaving out ecosystem service attributes of biodiversity. As it is virtually impossible to collect all the empirical data required for all species, there is an urgent need to develop an operational framework to derive representative ecological footprints with limited data requirements. I propose to develop a novel framework based on a set of unifying scaling principles related to the production size of products and the body size of species. These scaling principles will be developed to predict key characteristics of biofuel production, such as energy return of investment, agricultural land requirements and greenhouse gas emissions, as well as global impact indicators, such as species extinction risks. The focus of the research is on (1) liquid biofuel production (bioethanol and biodiesel) from various first and second generation feedstock as an important but controversial renewable energy source (2) vascular plant diversity, as the common basis of all terrestrial ecosystems, and (3) habitat destruction and climate change, as important drivers of global change. Together with the PI, two PhD students, two Postdocs and a technical assistant will work on different components of the new predictive models, substantially enhancing the scientific understanding of how to provide reliable ecological footprints in practice.

Project End Date: **8/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
646592	**MAGnUM**	**SH3 - Environment, Space and Population**

Principal Investigator:	**Dr. Ludovic Leclercq** ludovic.leclercq@ifsttar.fr
Host Institution:	Institut Francais Des Sciences Et Technologies Des Transports, De L'Amenagement Et Des Reseaux, FR

A Multiscale and Multimodal Modelling Approach for Green Urban Traffic Management

The MAGnUM project aims to (i) create a consistent set of interrelated dynamic and multimodal traffic models able to capture driver behaviours at the different urban scales and (ii) apply this variety of models to design efficient and green traffic management strategies.

Traffic flow dynamics is well reproduced at a local urban scale by the kinematic wave model and its numerous extensions. Even if this model is parsimonious compared to other modelling approaches, it can hardly be applied at larger urban scales for traffic control applications. Very recently, a new modelling approach has been proposed to represent congestion dynamics at large scales. It relates the total travel production to the vehicle accumulation in a traffic network with for now a restrictive condition about network homogeneity. This approach is very promising for designing new traffic management systems but heterogeneous situations should be handled by properly connecting with the local scale to account for the effects of the local distributions and variations of the driver behaviour (demand) and the network structure (supply). Investigating these relationships and proposing a full set of consistent models representing traffic dynamics at several relevant scales (successive spatial and temporal integration) is very challenging with high potential gains for traffic control applications. This is the primary goal of MAGnUM and will be achieved by mixing analytical investigations on idealized but insightful test cases with explanatory approaches based on data gained from dynamic simulations or serious game sessions on more realistic and complex cases.

The second goal of the project concerns the design of innovative traffic management strategies at multiple urban scales. Breakthroughs will be achieved by considering multiple and competitive objectives when optimizing with a tight focus on environment issues and multi-modality.

Project End Date: **8/31/2020**

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**
f.eigenbrod@soton.ac.uk

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: **6/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715842	**OWNERS**	**SH3 - Environment, Space and Population**

Principal Investigator:	**Dr. Borja Martinovic** b.martinovic@uu.nl
Host Institution:	Universiteit Utrecht, NL

'This country is ours': Collective psychological OWNERShip and ethnic attitudes

Even in the absence of legal ownership, people tend to experience objects, places, and ideas as belonging to them ('mine'). This state of mind is called psychological ownership. Research has shown that experiences of ownership are very important for individuals, but can also lead to interpersonal conflicts. What we know almost nothing about is collective psychological ownership (CPO): a shared sense that something is 'ours'. CPO might be especially relevant with regard to territories and in the context of intergroup relations. Statements like 'we were here first' or 'we built this country' are increasingly used by right-wing politicians in immigration countries to claim ownership on historical basis for the dominant ethnic group, and to exclude newcomers. There are also contexts where two established groups disagree about territorial ownership, such as Albanians and Serbs in Kosovo.

While CPO might strengthen solidarity within groups, it might worsen intergroup relations, thus threatening social cohesion. It is important to establish where a sense of CPO comes from, and how it shapes intergroup relations, so that interventions could be implemented. This ground-breaking project examines 1) the extent to which people perceive their ethnic group as historically owning the country, 2) the psychological needs that motivate them to claim collective ownership, and 3) the implications of collective ownership claims for attitudes towards ethnic groups.

My approach is multidisciplinary, combining social psychological theories on intergroup relations with the literature on ownership and territoriality from organizational science and anthropology. I will develop an instrument to measure CPO and provide first empirical evidence about the importance of CPO by collecting representative survey data in European immigration countries (Netherlands, UK, France), settler societies (Australia, New Zealand, USA), and countries with clear territorial disputes (Kosovo, Cyprus, Israel).

Project End Date: **3/31/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
669792	**ALLEGRO**	**SH3 - Environment, Space and Population**

Principal Investigator:	**Dr. Serge Hoogendoorn** s.p.hoogendoorn@tudelft.nl
Host Institution:	Technische Universiteit Delft, NL

unrAvelLing sLow modE travelinG and tRaffic: with innOvative data to a new transportation and traffic theory for pedestrians and bicycles

A major challenge in contemporary traffic and transportation theory is having a comprehensive understanding of pedestrians and cyclists behaviour. This is notoriously hard to observe, since sensors providing abundant and detailed information about key variables characterising this behaviour have not been available until very recently. The behaviour is also far more complex than that of the much better understood fast mode. This is due to the many degrees of freedom in decision-making, the interactions among slow traffic participants that are more involved and far less guided by traffic rules and regulations than those between car-drivers, and the many fascinating but complex phenomena in slow traffic flows (self-organised patterns, turbulence, spontaneous phase transitions, herding, etc.) that are very hard to predict accurately. With slow traffic modes gaining ground in terms of mode share in many cities, lack of empirical insights, behavioural theories, predictively valid analytical and simulation models, and tools to support planning, design, management and control is posing a major societal problem as well: examples of major accidents due to bad planning, organisation and management of events are manifold, as are locations where safety of slow modes is a serious issue due to interactions with fast modes. This programme is geared towards establishing a comprehensive theory of slow mode traffic behaviour, considering the different behavioural levels relevant for understanding, reproducing and predicting slow mode traffic flows in cities. The levels deal with walking and cycling operations, activity scheduling and travel behaviour, and knowledge representation and learning. Major scientific breakthroughs are expected at each of these levels, in terms of theory and modelling, by using innovative (big) data collection and experimentation, analysis and fusion techniques, including social media data analytics, using augmented reality, and remote and crowd sensing.

Project End Date: **10/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
615159	**DEPRIVEDHOODS**	**SH3 - Environment, Space and Population**

Principal Investigator: **Dr. Maarten van Ham**
m.vanham@tudelft.nl

Host Institution: Technische Universiteit Delft, NL

Socio-spatial inequality, deprived neighbourhoods, and neighbourhood effects

The objective of DEPRIVEDHOODS is to come to a better understanding of the relationship between socio-economic inequality, poverty and neighbourhoods. The spatial concentration of poverty within cities is of great concern to national governments, partly based on a belief in neighbourhood effects: the idea that living in deprived neighbourhoods has an additional negative effect on residents' life chances over and above the effect of their own characteristics. This belief has contributed to the development of area-based policies designed to introduce a more 'favourable' socio-economic mix in deprived neighbourhoods. Despite the persistent belief in neighbourhood effects, there is surprisingly little evidence that living in deprived neighbourhoods really affects individual lives. There is little consensus on the importance of neighbourhood effects, the underlying causal mechanisms, the conditions under which they are important and the most effective policy responses. It is likely that most studies claiming to have found that poor neighbourhoods make people poor(er) only show that poor people live in poor neighbourhoods because they cannot afford to live elsewhere. DEPRIVEDHOODS will break new ground by simultaneously studying neighbourhood sorting over the life course, neighbourhood change, and neighbourhood effects, within one theoretical and analytical framework. This project will be methodologically challenging and will be the first integrated, multi-country research project on neighbourhood effects to use unique geo-referenced longitudinal data from Sweden, United Kingdom, Estonia, and The Netherlands. Special attention will be paid to the operationalization of neighbourhoods and how it affects modelling outcomes. Through its integrated and international approach, DEPRIVEDHOODS will fundamentally advance understandings of the ways in which individual outcomes interact with the neighbourhood, which will ultimately lead to more targeted and effective policy measures.

Project End Date: **7/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647860	**LIFECOURSE**	**SH3 - Environment, Space and Population**

Principal Investigator:	**Dr. Inga Dora Sigfusdottir** ingadora@ru.is
Host Institution:	Haskolinn I Reykjavik Ehf, IS

A MULTILEVEL ANALYSIS ON THE EFFECTS OF STRESS ON BIOLOGY, EMOTIONS AND BEHAVIOUR THROUGHOUT CHILDHOOD

The overall objective of the proposed research is to improve our understanding of the interplay between biological, environmental, and social factors that influence the development of harmful behaviours in adolescents. We propose to conduct the first multilevel cohort study of its kind that would combine biological, behavioural, and social data from before birth through adolescence for an entire population birth cohort of adolescents. The program is based in Iceland due to a unique infrastructure for the collection of health and social registry data as well as available access to a whole cohort of adolescents. We will extend our previous work using a multilevel developmental framework to identify both individual and collective level variables to study the independent and interactive effects of biological, environmental, and social determinants of adolescent harmful behaviours, with special emphasis on the influence of stress on substance use, self-inflicted harm, suicidal behaviour, and delinquency. Our retrospective longitudinal database will include existing registry information on maternal, child, and environmental determinants of adolescent harmful behaviours, measured prior to birth, at the time of birth, and during the infant, toddler, preschool, middle-childhood and early adolescent years, for the entire 2000 year birth cohort. We will prospectively measure biomarkers in human saliva and use an existing social survey infrastructure to add to the registry database. We have acquired all necessary ethical and organizational permissions and have carried out a preliminary study that shows registry data compliance of over 90% for all variables we intend to combine. This is a fundamental research project, examining unchartered territory. The results of this project will stimulate international research but more importantly, an understanding that will lead to better policies, planning and quality of life for young people in Europe and beyond.

Project End Date: **6/30/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
336050	**BODYBUILDING**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Matthew Longo** m.longo@bbk.ac.uk
Host Institution:	Birkbeck College - University Of London, UK

Building body representations: An investigation of the formation and maintenance of body representations

The body is ubiquitous in perceptual experience and is central to our sense of self and personal identity. Disordered body representations are central to several serious psychiatric and neurological disorders. Thus, identifying factors which contribute to the formation and maintenance of body representations is crucial for understanding how body representation goes awry in disease, and how it might be corrected by potential novel therapeutic interventions. Several types of sensory signals provide information about the body, making the body the multisensory object, par excellence. Little is known, however, about how information from somatosensation and from vision is integrated to construct the rich body representations we all experience. This project fills this gap in current understanding by determining how the brain builds body representations (BODYBUILDING). A hierarchical model of body representation is proposed, providing a novel theoretical framework for understanding the diversity of body representations and how they interact. The key motivating hypothesis is that body representation is determined by the dialectic between two major cognitive processes. First, from the bottom-up, somatosensation represents the body surface as a mosaic of discrete receptive fields, which become progressively agglomerated into larger and larger units of organisation, a process I call fusion. Second, from the top-down, vision starts out depicting the body as an undifferentiated whole, which is progressively broken into smaller parts, a process I call segmentation. Thus, body representation operates from the bottom-up as a process of fusion of primitive elements into larger complexes, as well as from the top-down as a process of segmentation of an initially undifferentiated whole into more basic parts. This project uses a combination of psychophysical, electrophysiological, and neuroimaging methods to provide fundamental insight into how we come to represent our body.

Project End Date: **1/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
670428	**BRAIN2MIND_NEUROCOMP**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Matthew Lambon Ralph** matt.lambon-ralph@manchester.ac.uk
Host Institution:	The University Of Manchester, UK

Developing and delivering neurocomputational models to bridge between brain and mind.

The promise of cognitive neuroscience is truly exciting – to link mind and brain in order to reveal the neural basis of higher cognitive functions. This is crucial, scientifically, if we are to understand the nature of mental processes and how they arise from neural machinery but also, clinically, if we are to establish the basis of neurological patients' impairments, their clinical management and treatment. Cognitive-clinical neuroscience depends on three ingredients: (a) investigating complex mental behaviours and the underlying cognitive processes; (b) mapping neural systems and their function; and (c) methods and tools that can bridge the gap between brain and mental behaviour. Experimental psychology and behavioural neurology has delivered the first component. In vivo neuroimaging and other allied technologies allow us to probe and map neural systems, their connectivity and neurobiological responses. The principal aim of this ERC Advanced grant is to secure, for the first time, the crucial third ingredient – the methods and tools for bridging systematically between cognitive science and systems neuroscience.The grant will be based on two main activities: (i) convergence of methods – instead of employing each neuroscience and cognitive method independently, they will be planned and executed simultaneously to force a convergence of results; and (ii) development of a new type of neurocomputational model - to provide a novel formalism for bridging between brain and cognition. Computational models are used in cognitive science to mimic normal and impaired behaviour. Such models also have an as-yet untapped potential to connect neuroanatomy and cognition: latent in every model is a kind of brain-mind duality – each model is based on a computational architecture which generates behaviour. We will retain the ability to simulate detailed cognitive behaviour but simultaneously make the models' architecture reflect systems-level neuroanatomy and function.

Project End Date: **12/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
715618	**CALC**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Johann-Mattis List** mattis.list@shh.mpg.de
Host Institution:	Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V., DE

Computer-Assisted Language Comparison: Reconciling Computational and Classical Approaches in Historical Linguistics

By comparing the languages of the world, we gain invaluable insights into human prehistory, predating the appearance of written records by thousands of years. The traditional methods for language comparison are based on manual data inspection. With more and more data available, they reach their practical limits. Computer applications, however, are not capable of replacing experts' experience and intuition. In a situation where computers cannot replace experts and experts do not have enough time to analyse the massive amounts of data, a new framework, neither completely computer-driven, nor ignorant of the help computers provide, becomes urgent. Such frameworks are well-established in biology and translation, where computational tools cannot provide the accuracy needed to arrive at convincing results, but do assist humans to digest large data sets. This project establishes a computer-assisted framework for historical linguistics. We pursue an interdisciplinary approach that adapts methods from computer science and bioinformatics for the use in historical linguistics. While purely computational approaches are common today, the project focuses on the communication between classical and computational linguists, developing interfaces that allow historical linguists to produce their data in machine readable formats while at the same time presenting the results of computational analyses in a transparent and human-readable way. As a litmus test which proves the suitability of the new framework, the project will create an etymological database of Sino-Tibetan languages. The abundance of language contact and the peculiarity of complex processes of language change in which sporadic patterns of morphological change mask regular patterns of sound change make the Sino-Tibetan language family an ideal test case for a new overarching framework that combines the best of two worlds: the experience of experts
and the consistency of computational models.

Project End Date: **3/31/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
336152	**BRAINIMAGES**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator: **Dr. Juha Silvanto**
j.silvanto@westminster.ac.uk

Host Institution: The University Of Westminster Lbg, UK

How do we keep apart internally generated mental images from externally induced percepts? Dissociating mental imagery, working memory and conscious perception.

Conscious experiences normally result from the flow of external input into our sensory systems. However, our minds are also able to create conscious percepts in the absence of any sensory stimulation; these internally generated percepts are referred to as mental images, and they have many similarities with real visual percepts; consequently, mental imagery is often referred to as "seeing in the mind's eye". Mental imagery is also believed to be closely related to working memory, a mechanism which can maintain "offline" representations of visual stimuli no longer in the observer's view, as both involve internal representations of previously seen visual attributes. Indeed, visual imagery is often thought of as a conscious window into the content of memory representations. Imagery, working memory, and conscious perception are thus thought to rely on very similar mechanisms. However, in everyday life we are generally able to keep apart the constructs of our imagination from real physical events; this begs the question of how the brain distinguishes internal mental images from externally induced visual percepts. To answer this question, the proposed work aims to isolate the cortical mechanisms associated uniquely with WM and imagery independently of each other and independently of the influence of external conscious percepts. Furthermore, by the use of neuroimaging and brain stimulation, we aim to determine the cortical mechanisms which keep apart internally generated and externally induced percepts, in both health and disease. This is a question of great clinical interest, as the ability to distinguish the perceived from the imagined is impoverished in psychotic disorders. In addition to revealing the mechanisms underlying this confusion, the present project aims to alleviate it in psychotic patients by the use of brain stimulation. The project will thus significantly improve our understanding of these cognitive processes and will also have clinical implications.

Project End Date: **1/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677270	**SOCIAL ROBOTS**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Emily Cross** e.cross@bangor.ac.uk
Host Institution:	Bangor University, UK

Mechanisms and Consequences of Attributing Socialness to Artificial Agents

Understanding how we perceive and interact with others is a core challenge of social cognition research. This challenge is poised to intensify in importance as the ubiquity of artificial intelligence and the presence of humanoid robots in society grows. By innovatively combining psychology, neuroscience and robotics, the SOCIAL ROBOTS project helps prepare us for this future by (1) establishing a new approach for understanding how the human brain processes and responds to interactive robots; (2) delineating the factors influencing how representations of robots and humans are shared at brain and behavioural levels; and (3) exploring how these findings inform the now-rapid development of social robots. To achieve this, we first investigate how young adults perceive and interact with humans vs. robots, the role of physical features and training experience, and the extent to which brain regions mediating social interaction with humans also support robot interaction. Next, to test the role of experience-dependent plasticity on social cognition, we assess how brain and behavioural flexibility toward robots manifests among young children and older adults. Finally, we explore cultural influences on shared representations of humans and robots by extending the first project phase to Japan, the world's most robotics-rich nation. The SOCIAL ROBOTS project tests a dominant hypothesis of social cognition and is expected to lead to a novel conception of the neurocognitive architecture supporting human-robot interaction. Neuroimaging and behavioural measures will offer detailed and nuanced insights into how brain mechanisms supporting social engagement with people are used when interacting with robots, and how different kinds of experience (e.g., training, lifespan, cultural) influence such engagement. The planned studies and those generated during the project will enable the SOCIAL ROBOTS team to become a world-leading group bridging social cognition, neuroscience and robotics.

Project End Date: **9/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714150	**FASTPARSE**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Carlos Gómez Rodríguez** cgomezr@udc.es
Host Institution:	Universidade Da Coruna, ES

Fast Natural Language Parsing for Large-Scale NLP

The popularization of information technology and the Internet has resulted in an unprecedented growth in the scale at which individuals and institutions generate, communicate and access information. In this context, the effective leveraging of the vast amounts of available data to discover and address people's needs is a fundamental problem of modern societies. Since most of this circulating information is in the form of written or spoken human language, natural language processing (NLP) technologies are a key asset for this crucial goal. NLP can be used to break language barriers (machine translation), find required information (search engines, question answering), monitor public opinion (opinion mining), or digest large amounts of unstructured text into more convenient forms (information extraction, summarization), among other applications. These and other NLP technologies rely on accurate syntactic parsing to extract or analyze the meaning of sentences. Unfortunately, current state-of-the-art parsing algorithms have high computational costs, processing less than a hundred sentences per second on standard hardware. While this is acceptable for working on small sets of documents, it is clearly prohibitive for large-scale processing, and thus constitutes a major roadblock for the widespread application of NLP. The goal of this project is to eliminate this bottleneck by developing fast parsers that are suitable for web-scale processing. To do so, FASTPARSE will improve the speed of parsers on several fronts: by avoiding redundant calculations through the reuse of intermediate results from previous sentences; by applying a cognitively-inspired model to compress and recode linguistic information; and by exploiting regularities in human language to find patterns that the parsers can take for granted, avoiding their explicit calculation. The joint application of these techniques will result in much faster parsers that can power all kinds of web-scale NLP applications.

Project End Date: **1/31/2022**

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** erno.hermans@donders.ru.nl
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: **8/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
335536	**CREAM**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Jean-Julien Aucouturier** aucouturier@gmail.com
Host Institution:	Centre National De La Recherche Scientifique, FR

Cracking the emotional code of music

This project aims to "crack" the emotional code of music, i.e. to provide, for the first time, a precise characterization of what type of music signal is able to activate one emotion or another. Research into this problem so far has been mainly correlating indistinct emotional reactions to uncontrolled musical stimuli, with much technical sophistication but to little avail. Project CREAM builds on the PI's unique bi-disciplinary career spanning both computer science and cognitive neuroscience, to propose a radically novel approach: instead of using audio signal processing to simply observe musical stimuli a posteriori, we will harvest a series of recent developments in the field to build powerful new tools of experimental control, able to engineer musical stimuli that can activate specific emotional pathways (e.g. music manipulated to sound like expressive speech, or to sound like survival-relevant environmental sounds). By combining this creative use of new technologies with a well-concerted mix of methods from experimental psychology and cognitive neuroscience (incl. psychoacoustics, fNIRS brain imaging, EEG/ERP paradigms, intercultural studies, infant studies), project CREAM will yield the first functional description of the neural and cognitive processes involved in the induction of emotions by music, and establish new avenues for interdisciplinary research between the life sciences and the information sciences. But most spectacularly, the fundamental breakthroughs brought by project CREAM will unlatch the therapeutic potential of musical emotions. Music will become a cognitive technology, with algorithms able to "engineer" it to mobilize one neuronal pathway or another, non-intrusively and non-pharmacologically. Within the proposed 5-year plan, support from the ERC will allow to implement a series of high-impact clinical studies with are direct applications of our findings, e.g. for the linguistic rehabilitation of aphasic stroke victims.

Project End Date: **9/30/2019**

European Research Council
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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**
k.koldewyn@bangor.ac.uk

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: **3/31/2022**

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Project ID:	Project Acronym:	Evaluation Panel:
337573	**MADVIS**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Olivier Collignon** olivier.collignon@uclouvain.be
Host Institution:	Universite Catholique De Louvain, BE

Mapping the Deprived Visual System: Cracking function for prediction

One of the most striking demonstrations of experience-dependent plasticity comes from studies of blind individuals showing that the occipital cortex (traditionally considered as purely visual) massively changes its functional tuning to support the processing of non-visual inputs. These mechanisms of crossmodal plasticity, classically considered compensatory, inevitably raise crucial challenges for sight-restoration. The neglected relation between crossmodal plasticity and sight-recovery will represent the testing ground of MADVIS in order to gain important novel insights on how specific brain regions become, stay and change their functional tuning toward the processing of specific stimuli. The main goal of MADVIS is therefore to make a breakthrough on two fronts: (1) understanding how visual deprivation at different sensitive periods in development affects the functional organization and connectivity of the occipital cortex; and (2) use the fundamental knowledge derived from (1) to test and predict the outcome of sight restoration. Using a pioneering interdisciplinary approach that crosses the boundaries between cognitive neurosciences and ophthalmology, MADVIS will have a large impact on our understanding of how experience at different sensitive periods shapes the response properties of specific brain regions. Finally, in its attempt to fill the existing gap between crossmodal reorganization and sight restoration, MADVIS will eventually pave the way for a new generation of predictive surveys prior to sensory restoration.

Project End Date: **3/31/2019**

European Research Council
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Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679092	**Sense of Commitment**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator: **Dr. John Michael**
j.michael.2@warwick.ac.uk

Host Institution: The University Of Warwick, UK

An Integrative Framework for Modeling the Sense of Commitment

The phenomenon of commitment is a cornerstone of human social life. Commitments make individuals' behavior predictable in the face of fluctuations in their desires and interests, thereby facilitating the planning and coordination of joint actions involving multiple agents. Moreover, commitments make people willing to perform actions that they would not otherwise perform. For example, an investor may be willing to purchase government bonds because a central banker has made a commitment to maintaining that country's currency. In general, social objects and institutions such as jobs, money, government and marriage depend for their origin and stability upon the credibility of commitments. Despite the crucial importance of commitment for characteristically human forms of sociality, it is not well understood how people identify and assess the level of their own and others' commitments. The SENSE OF COMMITMENT will develop a theoretical framework for research on commitment, and create a suite of experimental paradigms for testing predictions generated by the theoretical framework. By focusing on joint actions involving pairs of agents, it will illuminate the fundamental mechanisms underlying large-scale human social phenomena. The SENSE OF COMMITMENT will generate basic scientific knowledge that will be relevant to many disciplines in the social sciences, cognitive sciences, and humanities. The insights gained will create a new perspective for:

1) social robotics, by specifying factors that will be useful in designing robots (e.g. for senior citizens' homes and rescue operations) that participate in commitments with humans;
2) research on pathological conditions such as borderline personality disorder, in which individuals find it difficult to commit to or to rely upon others;
3) identifying factors relevant in sustaining people's commitment to beneficial long-term programs (skills training for workers, exercise or rehabilitation programs for patients, etc.).

Project End Date: **6/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
636458	**CogSoCoAGE**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Heather Ferguson** H.ferguson@kent.ac.uk
Host Institution:	University Of Kent, UK

Tracking the cognitive basis of social communication across the life-span

A vital part of successful everyday social interaction is the ability to infer information about others (e.g. their emotions, visual perspective, and language). Development of these social skills (termed Theory of Mind, ToM) has been linked to improvements in more general cognitive skills, called Executive Functions (EF). However, to date very little is known of how this link varies with advancing age, and no model exists to explain the relationship. Thus, the key aim of the proposed research is to systematically explore the cognitive basis of social communication and how this changes across the life-span. The research will address three complementary objectives: (1) to what degree can variations in ToM ability across the life-span be accounted for by changes in EF skills, (2) how do ToM ability and EF skill change over time in different age groups (using longitudinal methods, i.e. test-retest of the same participants), and (3) can ToM ability be enhanced through training specific EF skills, and how do these training effects differ across the life-span. Contrary to traditional studies of social communication, I will employ an interdisciplinary approach that links theory and practice from cognitive, social, developmental, and clinical (neuro)psychology to study the relationship between ToM and EF across a broad and dynamic age range (10 to 80+ yrs old). I will use cutting-edge combinations of techniques (eye-tracking and EEG) and paradigms, alongside sophisticated statistical methods to track the timecourse of social understanding, and model how it relates to EF and more general cognitive/social skills (eg. IQ, language) within and between individuals. This research will open up new horizons in ToM research by developing an intervention programme to enhance the quality of social communication in older adults (thus improving their mental health and well-being), which has the potential to be applied in other individuals with social communication deficits (eg. autism).

Project End Date: **8/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
726090	**COGTOM**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator: **Dr. Mate Lengyel**
LengyelM@ceu.edu

Host Institution: Kozep-Europai Egyetem, HU

Cognitive tomography of mental representations

Internal models are fundamental to our understanding of how the mind constructs percepts, makes decisions, controls movements, and interacts with others. Yet, we lack principled quantitative methods to systematically estimate internal models from observable behaviour, and current approaches for discovering their mental representations remain heuristic and piecemeal. I propose to develop a set of novel 'doubly Bayesian' data analytical methods, using state-of-the-art Bayesian statistical and machine learning techniques to infer humans' internal models formalised as prior distributions in Bayesian models of cognition. This approach, cognitive tomography, takes a series of behavioural observations, each of which in itself may have very limited information content, and accumulates a detailed reconstruction of the internal model based on these observations. I also propose a set of stringent, quantifiable criteria which will be systematically applied at each step of the proposed work to rigorously assess the success of our approach. These methodological advances will allow us to track how the structured, task-general internal models that are so fundamental to humans' superior cognitive abilities, change over time as a result of decay, interference, and learning. We will apply cognitive tomography to a variety of experimental data sets, collected by our collaborators, in paradigms ranging from perceptual learning, through visual and motor structure learning, to social and concept learning. These analyses will allow us to conclusively and quantitatively test our central hypothesis that, rather than simply changing along a single 'memory strength' dimension, internal models typically change via complex and consistent patterns of transformations along multiple dimensions simultaneously. To facilitate the widespread use of our methods, we will release and support off-the-shelf usable implementations of our algorithms together with synthetic and real test data sets.

Project End Date: **4/30/2022**

European Research Council
Executive Agency

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Project ID:	Project Acronym:	Evaluation Panel:
639445	**NewEat**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Jens Blechert** jens.blechert@sbg.ac.at
Host Institution:	Paris-Lodron-Universitat Salzburg, AT

Transdiagnostic views on eating disorders and obesity and new approaches for treatment

Eating disorders such as Anorexia Nervosa (AN), Bulimia Nervosa (BN), Binge Eating Disorder (BED) and overweight/obesity are highly prevalent in the EU and worldwide. They cause tremendous suffering, elevate suicide rates, and account for multiple organic effects that increase all-cause mortality. Etiological and maintenance factors are not well understood and transdiagnostic theoretical models across eating and weight disorders are largely missing. The present project aims to develop an integrated theoretical framework by studying psychological factors that contribute to non-homeostatic eating across the full spectrum of eating-related disorders. It is proposed that high levels on psychological traits such as restraint eating (i.e., chronic dieting behaviour), emotional eating (i.e., eating in response to negative emotional events rather than hunger), craving/food addiction (i.e., intense and chronic urge to consume palatable foods), impulsivity (i.e., inadequate food consumption planning and low self-control), and low self-esteem influence neural systems that balance appetitive (mostly bottom-up) with regulatory (mostly top-down) processes. This model is tested in the four patient groups and healthy controls utilizing an integrated set of assessment methods, involving psychometric testing, smartphone based ambulatory assessment, and neurocognitive laboratory measurement. Derived from this model, novel behavioural interventions such as smartphone based stimulus control and cognitive inhibition training will be developed.
Results will have implications for theoretical models of eating and weight disorders as well as for neuroaffective models of appetite regulation. Smartphone technology might usefully complement current interventions in supporting an effective transfer to daily life and help alleviate the burden for patients with eating-related mental and physical diseases.

Project End Date: **6/30/2020**

European Research Council
Executive Agency

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Project ID:	Project Acronym:	Evaluation Panel:
614244	**P-CYCLES**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Rufin VanRullen** rufin.vanrullen@cnrs.fr
Host Institution:	Centre National De La Recherche Scientifique, FR

Perceptual Cycles: Exploring and controlling the perceptual consequences of brain rhythms

Many current theories implicate brain oscillations in perception, attention, consciousness or memory. This, however, has one critical implication that is often overlooked in cognitive sciences: if a perceptual function relies on an oscillatory basis, then it should operate periodically, as a sequence of successive episodes or 'snapshots', with more or less favourable moments recurring at a well-defined periodicity. The present project aims to explore the validity and the consequences of this groundbreaking notion of "rhythmic perception". Whereas current research links perceptual functions to relatively slow changes of oscillatory amplitude, we propose to investigate the perceptual consequences of brain rhythms at the rapid time scale of the oscillatory cycle –the notion of "perceptual cycles". In work-package (WP) 1, we will explore the range of perceptual and cognitive operations that depend on oscillatory neural implementations, and reveal their cyclic behaviour. In WP2, we will relate these perceptual and cognitive cycles to the underlying neural activities by means of brain imaging techniques (EEG, fMRI, TMS); a key innovation is a proposed novel fMRI method to visualize the spatio-temporal propagation of perceptual cycles. In WP3, we will utilize this knowledge to control the power, frequency and phase of perceptual rhythms and thus dynamically manipulate, improve or prevent perception. In WP4, we will bridge the gap between lower- and higher-frequency perceptual cycles (from ~2 to ~100Hz) by experimental studies of cross-frequency coupling and computational models of visual information multiplexing. The project as a whole will characterize the rhythmic dynamics of perception, their neural basis and their functional implications, bringing us closer to understanding perception itself. The idea that sensory perception and cognition might follow a succession of snapshots rather than a continuous stream could spark a major transformation in cognitive sciences.

Project End Date: **8/31/2019**

European Research Council
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Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725025	**AgeConsolidate**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Anders Martin Fjell** andersmf@psykologi.uio.no
Host Institution:	Universitetet I Oslo, NO

The Missing Link of Episodic Memory Decline in Aging: The Role of Inefficient Systems Consolidation

Which brain mechanisms are responsible for the faith of the memories we make with age, whether they wither or stay, and in what form? Episodic memory function does decline with age. While this decline can have multiple causes, research has focused almost entirely on encoding and retrieval processes, largely ignoring a third critical process– consolidation. The objective of AgeConsolidate is to provide this missing link, by combining novel experimental cognitive paradigms with neuroimaging in a longitudinal large-scale attempt to directly test how age-related changes in consolidation processes in the brain impact episodic memory decline. The ambitious aims of the present proposal are two-fold:

(1) Use recent advances in memory consolidation theory to achieve an elaborate model of episodic memory deficits in aging

(2) Use aging as a model to uncover how structural and functional brain changes affect episodic memory consolidation in general

The novelty of the project lies in the synthesis of recent methodological advances and theoretical models for episodic memory consolidation to explain age-related decline, by employing a unique combination of a range of different techniques and approaches. This is ground-breaking, in that it aims at taking our understanding of the brain processes underlying episodic memory decline in aging to a new level, while at the same time advancing our theoretical understanding of how episodic memories are consolidated in the human brain. To obtain this outcome, I will test the main hypothesis of the project: Brain processes of episodic memory consolidation are less effective in older adults, and this can account for a significant portion of the episodic memory decline in aging. This will be answered by six secondary hypotheses, with 1-3 experiments or tasks designated to address each hypothesis, focusing on functional and structural MRI, positron emission tomography data and sleep experiments to target consolidation from different angles.

Project End Date: **4/30/2022**

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Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694722	**Metacontrol**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Bernhard Hommel** hommel@fsw.leidenuniv.nl
Host Institution:	Universiteit Leiden, NL

Cognitive control in context: Neural, functional, and social mechanisms of metacontrol

Human behavior is commonly understood as emerging from a struggle between will and habit, i.e., between "intentional" processes driven by the current goal and "automatic" processes driven by available stimuli. This scenario suggests that it is mainly the goal-related processes that render behavior adaptive. Based on a novel theoretical framework (the Metacontrol State Model, combined with the Theory of Event Coding) that is motivated by recent behavioral and neuroscientific observations, I suggest an alternative view and argue that people can control the relative contributions of goal-driven and stimulus-driven processes to decision-making and action selection. In particular, people regulate the interaction between these processes by determining the ratio between (goal) persistence and flexi-bility, depending on task, situation, and personal experience—a process that I refer to as "metacontrol". The project aims to identify and trace individual "metacontrol policies" (biases towards persistence or flexibility) and task- and condition-specific changes therein by means of behavioral, computational, and neuroscientific techniques, and by using virtual-reality methods. I shall study, account for, and try predicting individual differences in the choice and implementation of such policies, identify and explain the cognitive and social consequences of adopting a particular policy, and investigate whether and how people can adopt meta¬control policies from others—either intentionally or automati-cally. I shall also study whether and to what degree people use situational cues to automatize the implementation of suitable policies, and whether often-used, highly practiced policies can become chron-ified and turn into a trait-like processing style, as suggested by cultural studies.

Project End Date: **11/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
341196	**CDAC**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Paul Verschure** paul.verschure@upf.edu
Host Institution:	Universitat Pompeu Fabra, ES

The role of consciousness in adaptive behavior: A combined empirical, computational and robot based approach

Understanding the nature of consciousness is one of the grand outstanding scientific challenges and two of its features stand out: consciousness is defined as the construction of one coherent scene but this scene is experienced with a delay relative to the action of the agent and not necessarily the cause of actions and thoughts. Did evolution render solutions to the challenge of survival that includes epiphenomenal processes? The Conscious Distributed Adaptive Control (CDAC) project aims at resolving this paradox by using a multi-disciplinary approach to show the functional role of consciousness in adaptive behaviour, to identify its underlying neuronal principles and to construct a neuromorphic robot based real-time conscious architecture. CDAC proposes that the shift from surviving in a physical world to one that is dominated by intentional agents requires radically different control architectures combining parallel and distributed control loops to assure real-time operation together with a second level of control that assures coherence through sequential coherent representation of self and the task domain, i.e. consciousness. This conscious scene is driving dedicated credit assignment and planning beyond the immediately given information. CDAC advances a comprehensive framework progressing beyond the state of the art and will be realized using system level models of a conscious architecture, detailed computational studies of its underlying neuronal substrate focusing, empirical validation with a humanoid robot and stroke patients and the advancement of beyond state of the art tools appropriate to the complexity of its objectives. The CDAC project directly addresses one of the main outstanding questions in science: the function and genesis of consciousness and will advance our understanding of mind and brain, provide radically new neurorehabilitation technologies and contribute to realizing a new generation of robots with advanced social competence.

Project End Date: **1/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
648082	**SCANS**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Lydia Krabbendam** lydia.krabbendam@vu.nl
Host Institution:	Stichting Vu, NL

Social Cognition in Adolescents: Brain Networks and Social Networks

The forming of social bonds is an evolutionary imperative, and a rich target for empirical research. Social scientists have scrutinized the structure of the elaborate social networks that characterize today's society. Neuroscientists have elucidated the brain mechanisms underlying our ability to navigate this social world. Yet, these research lines have been largely separated. This proposal aims to integrate social network research and social brain research, focusing on adolescence as the most dynamic phase shaping the interplay between social networks and the social brain. Social development in adolescents is clearly driven by maturation of specific social-cognitive functions; yet these functions are manifest in, and moulded by, interpersonal relationships within social networks. I aim to clarify how changes in the social brain relate to changes in social network position and structure during adolescent development. This can be achieved by using the quantitative tools of social network analysis in conjunction with the experimental approach of social neuroscience. I plan to investigate a cohort of approximately 1000 adolescents nested in 50 classes in a longitudinal design with 6 measurements over 3 years; fMRI investigating task-related functional activation and connectivity is conducted yearly in a subsample of 100. The neural and behavioural correlates of social cognition are investigated using experimental tasks tapping i) understanding others and ii) interacting with others; social behaviour is charted through ecological momentary assessment techniques; social networks are mapped using surveys and digital information acquired routinely via mobile phones (mobile sensing). This approach clarifies how during a crucial developmental phase the social brain shapes the social environment, and vice versa, the social environment influences maturation of the social brain.

Project End Date: **1/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681296	**CLASS**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Ben Ambridge** Ben.Ambridge@Liverpool.ac.uk
Host Institution:	The University Of Liverpool, UK

Cross-Linguistic Acquisition of Sentence Structure: Integrating Experimental and Computational Approaches

How children acquire their native language remains one of the key unsolved problems in Cognitive Science. This project will answer a question that lies at the heart of this problem: How do children acquire the abstract generalizations that allow them to produce novel sentences, while avoiding the ungrammatical utterances that result from across-the-board application of these generalizations (e.g., *The clown laughed the man)? Previous single-process theories (the entrenchment, preemption and verb semantics hypotheses) fail to explain all of the current English data, and do not begin to address the issue of how learners of other languages solve this learnability problem. The aim of the present project is to solve this problem by developing and testing a new unified cross-linguistic account of the development of sentence structure. In addition to the overarching theoretical question set out above, the research will address four key questions: (1) What do learners bring to the task in terms of cognitive-semantic universals?; (2) How do children form linguistic generalizations in the first place?; (3) Why are languages the way they are; would other types of systems be difficult or impossible to learn?; (4) What is the nature of development?. These questions will be addressed by means of four Work Packages (WPs). WP1 uses grammaticality judgment and elicited production paradigms developed by the PI to investigate the acquisition of basic transitive and intransitive sentence structure (e.g., The man broke the window/The window broke) across six typologically different languages: English, K'iche' Mayan, Japanese, Hindi, Hebrew and Turkish (at ages 3-4, 5-6, 9-10 and 18+ years). WP2 uses the same paradigms to investigate idiosyncratic language-specific generalizations within three of these languages. WP3 uses Artificial Grammar Learning to focus on the issue of language evolution. WP4 uses computational modeling to investigate and simulate development.

Project End Date: **8/31/2020**

European Research Council
Executive Agency

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Project ID:	Project Acronym:	Evaluation Panel:
313398	**INTERACT**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Antonia Hamilton** a.hamilton@ucl.ac.uk
Host Institution:	University College London, UK

Understanding Mechanisms of Human Social Interaction using Interactive Avatars

Human social interaction depends on non-verbal unconscious behaviour as much as on verbal signals. Mimicry (unconscious copying of actions) is a good example of a social behaviour which is caused by and has consequences for our evaluation of others. However, studying mimicry with traditional methods is hard because of the trade-off between good experimental control and realistic social interaction. INTERACT will (1) establish a new approach to the science of mimicry, bringing together methods from social psychology, cognitive neuroscience and computer science, and (2) use this approach to understand the information processing mechanisms underlying mimicry of hand actions. First, we will develop interactive avatars which can mimic a participant's hand actions or be mimicked by the participant in the context of a simple drum rhythm task. Using computer-generated avatars allows us to precisely control and measure movement timing and structure during mimicry, and to record how participants interact with avatars with different socially-relevant features (age / attractiveness or even aliens). Thus, the INTERACT system will enable high-resolution, well-controlled studies of how people detect and control mimicry. Second, we will use the interactive avatars to examine mimicry in unprecedented detail, studying how the timing and structure of an action and form of the avatar impact on the control and detection of mimicry in typical adults. Building on this, we will define the brain mechanisms of mimicry and why mimicry might go wrong in adults with autism spectrum condition. The results will test current hypotheses of mimicry and will reveal the information processing mechanisms underlying human mimicry and its relationship to other social processes. Completion of the project will benefit research and practice in social neuroscience, developmental and educational psychology, computer science and robotics, and all researchers interested in human social behaviour.

Project End Date: **12/31/2018**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
639291	**VARIKIN**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator: **Dr. Fiona Jordan**
fiona.jordan@bristol.ac.uk

Host Institution: University Of Bristol, UK

Cultural Evolution of Kinship Diversity: Variation in Language, Cognition, and Social Norms Regarding Family

Why do human societies differ in whom they class as family? Why are cousins classed with siblings in some societies but not others? Accounting for the variable ways that cultures classify kin is an enduring puzzle. The VARIKIN project takes a cultural evolutionary approach to variety and unity and engages different fields–cultural phylogenetics, corpus linguistics, and cross-cultural child development. VARIKIN-Evolution asks how and why does kinship diversity evolve across cultures and over time? Using comparative phylogenetic modeling of cultural evolution we investigate the dynamics of how kinship terminologies and family norms change in eight language families. Are there "universal" patterns of change, or does local cultural history and context determine changes in family organisation? How do social norms drive change in kinship terminology? VARIKIN-Usage investigates how people use kinship language by using corpus linguistics, surveys, and interviews to quantify patterns of usage in spoken and written language. How frequently are kinship terms used in different contexts and what meanings are more prevalent? Do patterns vary between languages, and can the patterns of usage at the individual level be linked to historical processes of change? VARIKIN-Development investigates how children acquire and understand kinship across cultures. Using participant observation and elicitation tasks, we characterise children's social learning of kinship in a small-scale, non-Western community. Are there cross-cultural patterns of acquisition? Can socialisation produce constraints on the kinds of kinship children can learn? These three research directions are united by a coherent framework for the integration of macro- and micro-evolutionary processes. With a highly multidisciplinary background, the Applicant is uniquely positioned to direct this vanguard project towards a comprehensive understanding of diversity in how we classify our social worlds.

Project End Date: **6/30/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
676786	**PERFORM**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Alexander Schütz** a.schuetz@uni-marburg.de
Host Institution:	Philipps Universitaet Marburg, DE

Calibration and integration of peripheral and foveal information in human vision

Human visual perception is one of the best-studied areas of research on the human mind. However, 99% of that research is concentrated on the central region making up less than 1% of our visual field. This is the region that gets mapped onto the fovea, where vision is best. However, information from the peripheral parts of a scene is highly important. Mediated by attention and eye movements, it is essential for guiding us through our environment. In the brain, the foveal and peripheral parts of the visual field undergo vastly different processing regimes. Since objects normally do not change their appearance, whether we view them foveally or peripherally, our visual system must integrate and calibrate peripheral information before an eye movement with foveal information after an eye movement.

We are planning to address these processes in four series of experiments. First, we will study the perception of basic visual features, such as orientation, numerosity and colour across the visual field and their integration in peripheral and foveal vision across eye movements. Second, we will investigate how this integration is supported by attention and memory resources. Third, since the integration requires learning and plasticity, we will track changes across the life span and study how healthy subjects can learn to compensate for artificial changes of peripheral and foveal vision. And fourth, we will explore whether we can manipulate the integration process for the optimal guidance of eye movements in complex natural search tasks.

The project will provide insights how the brain achieves a stable and homogeneous representation of the visual environment despite the ever changing sensory input and the inhomogeneity of processing across the visual field. We will reveal the basic learning mechanisms that allow a continuous calibration of peripheral and foveal vision, and that could be used in the long run for behavioural training of patients suffering from vision impairments.

Project End Date: **3/31/2021**

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**
h.a.slagter@uva.nl

Host Institution: Universiteit Van Amsterdam, 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: **7/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
677819	**BBRhythms**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Barbara Haendel** barbara.haendel@uni-wuerzburg.de
Host Institution:	Julius-Maximilians Universitaet Wuerzburg, DE

Brain and body rhythms: on the relationship between movement and percept

Exciting findings from animal electrophysiological research in the last years suggest that an increased rate of body movements results in an enhanced response of neurons within the visual system despite the absence of visual changes. It is unclear why such modulation occurs in areas which process visual input. In humans, little is known about the influence of body movements on sensory brain areas mainly due to the technical challenges of measuring brain responses during pronounced muscle activity. However, psychophysical studies in humans show that also percept and perceptual demands are connected to the rate of movements. These two lines of evidence suggest a general link between rhythmic body movements and perceptual processes.

The main aim of the proposed research is to decode the relationship between body movements and percept and to identify the underlying mechanism. To this end human non-invasive recordings from electro- and magnetoencephalography (EEG, MEG) as well as invasive human and animal multi-electrode recordings collected during movement execution will be analyzed. Directly relating perceptual processes and their underlying neuronal oscillations to rhythmic body movements offers an approach circumventing some of the methodological problems.

This research could uncover a new mechanism of how our system modulates perceptual processes through body movements. The proof of such a mechanism would constitute a ground-breaking step in understanding perception during natural behavior. We need to keep in mind that in the awake state our body is constantly in motion. However, up to now, the vast majority of studies which investigate sensory brain responses are conducted under strict movement suppression. Besides facilitating exciting new insights, this research can strengthen the assumption that the knowledge we have gathered about artificial situations generalizes to our natural behavior.

Project End Date: **6/30/2021**

European Research Council
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Project ID:	Project Acronym:	Evaluation Panel:
340718	**RADICAL**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Axel Cleeremans** axcleer@ulb.ac.be
Host Institution:	Universite Libre De Bruxelles, BE

The Radical Plasticity Thesis: How we learn to be conscious

RADICAL explores the idea that consciousness is something that the brain learns to do rather than a static property of certain neural states vs. others. Here, considering that consciousness is extended both in space and in time, I adopt a resolutely dynamical perspective that mandates an experimental approach focused on change, at different time scales. I suggest that consciousness arises as a result of the brain's continuous attempts at predicting not only the consequences of its actions on the world and on other agents, but also the consequences of activity in one cerebral region on activity in other regions. By this account, the brain continuously and unconsciously learns to redescribe its own activity to itself, so developing systems of metarepresentations that characterise and qualify the target first order representations. Such learned redescriptions form the basis of conscious experience. Learning and plasticity are thus constitutive of consciousness. This is what I call the "Radical Plasticity Thesis". In a sense, this is the enactive perspective, but turned both inwards and (further) outwards. Consciousness involves "signal detection on the mind"; the conscious mind is the brain's (non-conceptual, implicit) theory about itself. Theoretically, RADICAL offers the possibility of unifying Global Workspace Theory with higher-order Thought Theory by showing how the former can be built through mechanisms that flesh out the latter. Empirically, RADICAL aims at testing these ideas in three domains: (1) the perception action loop, (2) the self-other loop, and (3) the inner loop. 20 experiments leveraging behavioural experimentation, brain imaging, and computational modeling are proposed to test and further develop RADICAL. The overarching goal of the project is to characterize the computational principles that differentiate conscious from unconscious cognition, based on a bold, original, and innovative theory in which learning and plasticity play central roles.

Project End Date: **4/30/2019**

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** zhangj73@cardiff.ac.uk
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: **2/28/2022**

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Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
339490	**Cortic_al_gorithms**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Pieter Roelfsema** p.roelfsema@nin.knaw.nl
Host Institution:	Koninklijke Nederlandse Akademie Van Wetenschappen - Knaw, NL

Cortical algorithms for perceptual grouping

Why do we perceive objects? Visual perception starts with localized filters that subdivide the image into fragments that undergo separate analyses. Our visual system has to reconstruct the objects that surround us. It has to bind image fragments of the same object and to segregate them from other objects and the background. The standard view in psychology is that perceptual grouping is achieved by a parallel, pre-attentive process that relies on Gestalt grouping cues. My work has started to challenge this view by demonstrating that the visual cortex also implements a serial, attention-demanding algorithm for perceptual grouping. This grouping process may represent the first serial brain algorithm that can be understood at the psychological, neurophysiological and computational level. The present proposal therefore has the potential to revolutionize our view of visual cognition. Understanding feature binding would represent a breakthrough in cognitive neuroscience. Different brain areas represent distinct visual features. How is activity in these areas integrated? We propose that perceptual grouping relies on two complementary processes, “base-grouping” and “incremental grouping”. We hypothesize that base-grouping is pre-attentive and relies on feed-forward connections from lower to higher areas that activate neurons and determine their stimulus selectivity. In contrast, we propose that incremental grouping relies on feedback and horizontal connections, which propagate enhanced neuronal activity to highlight all the features that belong to the same perceptual object. The present proposal will determine the role of attention in feature binding, the interactions between brain areas for grouping with fMRI in humans and with electrophysiology in non-human primates to reveal the algorithms for perceptual grouping as they are implemented in our brains.

Project End Date: **4/30/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
680002	**HBIS**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Joshua Tybur** j.m.tybur@vu.nl
Host Institution:	Stichting Vu, NL

The Human Behavioral Immune System: Consequences for Health and Innovation

Modern innovations such as soap, condoms, and indoor plumbing have allowed billions of people to reduce their contact with viruses and bacteria and, as a result, dramatically increase length and quality of life. But how did members of the genus homo avoid pathogens for the two million years that preceded these technological innovations and, more broadly, discoveries that infectious disease is caused by microbes? And, importantly, how do any natural behavioral defenses against pathogens impact our behavior in the modern world? Recent research and theory in the field of evolutionary psychology suggests that natural selection has shaped a human behavioral immune system (HBIS)—a suite of psychological mechanisms, ranging from aspects of our olfactory systems (e.g., that detect specific chemical compounds) to our emotion systems (e.g., the emotion disgust) and our learning systems (e.g., conditioned aversions to foods) that are coordinated for a common function: to detect and motivate the avoidance of pathogens. Given that myriad universal human behaviors connote some pathogen risk—including interpersonal contact, mating, and eating—gaining a holistic understanding of the HBIS has the potential to offer critical new insights into multiple fundamental aspects of human nature. Here, I utilize an interdisciplinary approach to answer three foundational, yet currently opaque questions concerning the nature of the HBIS, including: (1) Where does trait variation in HBIS activation come from? (2) What effect does the HBIS have on behavior when cues to pathogens are detected? and (3) How does the HBIS facilitate learning of avoidance and rejection? To answer these questions, I propose an array of methodologically diverse studies to investigate how trait HBIS activation shapes rejection versus acceptance of innovations, how state HBIS activation can be harnessed to promote the use of health-promoting technologies, and how the HBIS can be leveraged for shaping dietary behavior.

Project End Date: **6/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
671084	**INSOMNIA**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator: **Dr. Eus Van Someren**
e.van.someren@nin.knaw.nl

Host Institution: Koninklijke Nederlandse Akademie Van Wetenschappen - Knaw, NL

Insomnia's Negative Sequelae On Mood: from Neuroscience to Intervention in the Aged

Major depression is among the most burdening health hazards. Its prevalence is 1-3%, an additional 8-16% have clinically significant symptoms, and prognosis is poor. Unfortunately, less than 20% of the cases are detected and treatment effectiveness is moderate. The Global Consortium for Depression Prevention stresses that our best chance to combat the global burden of depression is provide preventive intervention to identified people at risk. This project targets the strongest modifiable risk factor: insomnia. With prevalence estimates up to 40%, insomnia is among the most frequent disorders in the elderly population. Meta-analysis shows that no less than 13% of people with insomnia develop depression. This extreme risk and the very high prevalence of insomnia in the ageing population, shows the urgency and promise of: (1) early identification of these 13%, (2) finding mechanisms by quantification of how they differ from insomniacs that do not develop depression with respect to brain structure and function, psychological traits, behavioural habits and environmental exposures; and (3) enrolling them in intervention protocols aimed at sleep improvement and prevention of depression. The project extends recent findings emerging from the applicant's pioneering, unconventional and innovative approach to insomnia; the proposal that distinct subtypes exist and can be discriminated data-driven by means of multivariate trait analysis and brain imaging. Ignorance of this heterogeneity has obstructed progress in mechanistic understanding and rational treatment. In an unprecedented interdisciplinary way the project (1) identifies the insomnia subtype that develops depression; (2) profiles mechanisms involved; and (3) optimizes effectiveness of internet-supported home-applicable interventions to improve sleep and prevent depression. This approach will identify risks and mechanisms, and facilitate immediate implementation of risk-based prevention strategies and policies.

Project End Date: **10/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
323606	**Parietalaction**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator: **Dr. Guy Orban**
guy.orban@kuleuven.be

Host Institution: Universita Degli Studi Di Parma, IT

The human Parietal Lobe

We will use univariate and multivariate functional Magnetic Resonance Imaging (fMRI) techniques, surface and stereo EEG, and in depth single cell recording to investigate the role of human parietal lobe in the monocular or stereoscopic observation of actions performed by conspecifics either using their biological effectors or artificial implements (tools, spears, bicycle, microphone, etc). The fMRI techniques will provide evidence for segregated processing of different types of observed actions within the parietal cortex. The EEG techniques will provide the time course of the electric activity in the parietal regions in comparison to the events and dynamic changes in the video and the time course in other parts of the action observation network. The stereo EEG also provides a more precise localization than fMRI, serving as an important confirmation of the fMRI results. The single cell recordings are crucial to demonstrate the selectivity of the neuronal processes for actions observed, their postural or kinematic parameters or localization in the visual field. This selectivity is crucial to show the presence of mirror neurons for the different types of actions and the use of tools, to document the contribution of the parietal neurons to discrimination between actions, and to assess the benefits of stereoscopic viewing. This project should yield a comprehensive view of the role of parietal lobe in action planning and understanding, including using artificial implements, and pave the way for understanding how higher-order parietal cognitive processes are rooted in the simpler action planning and understanding capacities.

Project End Date: **12/31/2018**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
635356	**COOPERATION**	**SH4 - The Human Mind and Its Complexity**

Principal Investigator:	**Dr. Daniel Balliet** d.p.balliet@vu.nl
Host Institution:	Stichting Vu, NL

Releasing Prisoners Of The Paradigm: Understanding How Cooperation Varies Across Contexts In The Lab And Field

Cooperation is essential for mitigating conflict between individual and collective interests in relationships and groups, such as providing public goods and conserving resources. Most research testing psychological and economic theory of cooperation has applied a highly specific lab method (e.g., the prisoner's dilemma) that unnecessarily constrains the applicability of research findings. The discrepancies between cooperation observed in the lab and field can be due to variation in interdependence. Two limitations of lab studies to generalizing findings to the field are that (1) lab studies contain interdependence that differs from reality and (2) in the field people lack knowledge about their objective interdependence with others – and must infer their interdependence. I propose two inter-related research programs that test hypotheses derived from Functional Interdependence Theory on how objective and perceived interdependence affect cooperation. Project 1 applies meta-analysis to test hypotheses about how variation in objective interdependence across lab studies moderates the effectiveness of strategies to promote cooperation. Because Project 2 involves a pioneering effort to catalogue and analyze the 60 year history of research on cooperation, I will apply these efforts to develop an international, multidisciplinary institution and open access database for cataloguing studies in a way that facilitates scientific progress. Project 2 (a) develops a measure of perceived interdependence, (b) observes the interdependence people encounter in their daily lives, (c) tests two models of how people think about interdependence, and (d) innovates and applies a method to test hypotheses about factors that influence accuracy and bias in perceptions of interdependence. To maximize the ecological validity of research findings, I study cooperation in different samples (students, romantic couples, and employees) with the use of multiple methods (survey, experimental, and field).

Project End Date: **7/31/2020**

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** agnieszka.wykowska@iit.it
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: **4/30/2022**

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** pms45@cam.ac.uk
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: **3/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
676804	**MORALIST INTL**	**SH5 - Cultures and Cultural Production**

Principal Investigator:	**Dr. Kristina Stoeckl** kristina.stoeckl@eui.eu
Host Institution:	Universitaet Innsbruck, AT

Moral conservative traditionalists, Russian Orthodoxy and Transnational Alliances: towards a political theory of moral conflicts.

The MORALIST INTERNATIONAL project proposes the study of a hitherto under-researched phenomenon in the field of religion and politics: the rise of traditionalists, i.e. religious actors who rely on the conservative religious and political establishment in their respective home-countries, co-opt political and civil society actors, and forge transnational alliances, thereby inaugurating a new kind of religious politics which has not yet been studied and theorized in depth. The project will explore the agenda and transnational networks of traditionalist moral conservative actors from the perspective of the Russian Orthodox Church and its connections with the Russian political establishment on the grounds that it is necessary to understand the role and the resources of Russian politics and Orthodox religion in order to assess correctly the scope of this "moralist international" and the challenge it poses to liberal democracy. The research will analyse traditionalist actors and their ideas with regard to the three main areas where religious-moral conflicts emerge – religious symbols & free speech, sexuality & gender, and bioethics & biotechnology – and across four international institutional settings – the United Nations Human Rights Council, the Council of Europe, the European Court of Human Rights, and forums of inter-religious dialogue like the World Council of Churches. Adopting a contextualized political theory approach, the project will develop on the basis of the empirical and theoretical insights drawn from this case-study a reflexive political pluralist model of moral conflicts. This model offers an innovative extension to political liberalism inasmuch as it assesses within the political liberal framework the new reality of majoritarian, transnational traditionalist politics.

Project End Date: **4/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
680192	**SACRIMA**	**SH5 - Cultures and Cultural Production**

Principal Investigator:	**Dr. Chiara Franceschini** Chiara.Franceschini@lmu.de
Host Institution:	Ludwig-Maximilians-Universitaet Muenchen, DE

The Normativity of Sacred Images in Early Modern Europe

What is a sacred image? This is a crucial question for multicultural Europe – today as well as in the past. Between 1450-1650 Europe underwent, at the same time, an impressive artistic development and a dramatic religious crisis during which the status of the sacred image was repeatedly contested. Focusing on a comparison between five major areas that, remaining inside Catholicism, responded differently to the challenge imposed by the Reformation, SACRIMA will investigate the relations between art, religion and geography proposing to break ground in two main ways. First, by using and developing the concept of 'normativity' in a double sense: institutional normativity and visual normativity. Second, by adopting a comparative approach at the crossroads of the history of art, the history of religion and cultural geography. Starting from a new systematic survey of image-based material in ecclesiastical archives, it proposes: 1) A comparative survey of contested images in the Italian peninsula and islands, France, Iberia, the Low Countries and Southern Germany. 2) An investigation of 'visual norms' through focus on three complementary aspects: styles (in particular, the limits of realistic effects), iconographic norms, and the role of reproduction, restoration and reframing. 3) An exploration of the geography of reactions to art transfer aiming at reconstructing a cross-border cartography of visual norms in Europe and the Mediterranean. The proposed focus on the capacity of art to impose new normative visions of sacred subjects as well as to produce reactions which are often geographically differentiated opens new perspectives on the relations between art, religion and cultural transfer, shedding new light on previously explored notions of 'image censorship', the 'power of images' or the 'performance of images'. The overall project will contribute to the understanding of dynamics of cultural integration, differentiation and local negotiation in early modern Europe.

Project End Date: **5/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
337344	**NOVELSAINTS**	**SH5 - Cultures and Cultural Production**

Principal Investigator: **Dr. Koen De Temmerman**
koen.detemmerman@ugent.be

Host Institution: Universiteit Gent, BE

Novel Saints. Ancient novelistic heroism in the hagiography of Late Antiquity and the early Middle Ages

The novel is today the most popular literary genre worldwide. Its early history has not been written yet. In order to enhance our understanding of this history (both conceptually and cross-culturally), this project offers the first comprehensive reconstruction and interpretation of the persistence of ancient novelistic material in hagiographical narrative traditions in the Mediterranean in Late Antiquity and the early Middle Ages (4th-12th cent.). This period constitutes a blind spot on the radar of scholars working on the history of the novel, who conceptualize it, much to the detriment of the study of narrative in subsequent periods, as an 'empty' interim period between the latest ancient representatives of the genre (ca. 3rd-4th cent.) and its re-emergence in 11th/12th-century Byzantium and 11th-century Persia. This project, on the other hand, advances the hypothesis that different hagiographical traditions throughout Late Antiquity and the early Middle Ages were impacted (directly or indirectly) by ancient novelistic influences of different kinds and adopted, rehearsed, re-used and adapted them to various degrees as tools for the representation of saints as heroes/heroines. In this sense, constructions of heroism in these traditions should be understood to varying degrees as 'novelistic' and raise crucial issues about fictionalization and the texts' own implicit conceptualizations of fiction. Three stages of the project will test different aspects of this hypothesis. Firstly, the project will chart for the first time all novelistic influences in the hagiographical corpus texts. Secondly, it will analyze the impact of these influences on constructions of heroism in specific hagiographical traditions (mainly Latin, Greek and Syriac Martyr Acts, hagiographical romances and saints' Lives) and examine implications for notions of fictionalization and/or strategies for enhancing verisimilitude and authenticity. Finally, diachronic and cross-cultural dimensions of the research hypothesis will be articulated through the study of continuity of hagiographical traditions (and their constructions of heroism) in narrative genres from the 11th and 12th centuries in the West (medieval romance), Byzantium (novels) and the East (Persian romance). By generating an improved understanding of the impact of ancient novelistic material in different hagiographical traditions throughout Late Antiquity and the early Middle Ages, this project aims to contribute not just to the history of the idea of fiction but also to the study of hagiography, the early history of the novel and to all disciplines that study these literary genres.

Project End Date: **1/31/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
636983	**PLATINUM**	**SH5 - Cultures and Cultural Production**

Principal Investigator:	**Dr. Maria Chiara Scappaticcio** mariachiara.scappaticcio@unina.it
Host Institution:	Universita Degli Studi Di Napoli Federico Ii., IT

Papyri and LAtin Texts: INsights and Updated Methodologies.Towards a philological, literary, and historical approach to Latin papyri

The aim of PLATINUM is to scrutinize Latin texts on papyrus from several points of view in order to highlight their substantial contribution to our knowledge of innovations in ancient Roman literature, language, history, and society, especially in the multilingual and multicultural contexts of the Eastern part of the Empire between the 1st century B.C. and 8th century A.D. The first phase of the project will consist in assembling, updating and publishing critical editions, in order to present a new and more accurate corpus of Latin papyri on an easily accessible online platform. The second phase will be focused on providing the texts with a specific, pluridisciplinary commentary that gives new insights on Roman culture.

Coming mainly from Egypt and other Roman provinces (as well as Herculaneum and Ravenna), Latin papyri deserve more scholarly attention not only from papyrologists and paleographers, but also from scholars of Latin language, as well as intellectual and cultural historians of Rome. Latin papyri, tablets, and ostraka (potsherds) are constantly increasing in number through archaeological discoveries. Because they are so rare, they are even more valuable than the Greek papyri, which have garnered much attention. The Latin papyri have hitherto represented a border-line field of study that has not been fully exploited either by papyrologists or by scholars of Latin literature. Moreover, the obsolete bibliography and the considerable number of unpublished texts make the study of Latin papyri (and bilingual Latin-Greek, Latin-Coptic, Latin-Punic texts) - whether literary (e.g. Cicero, Vergil, law), paraliterary (grammar, medicine, magic), or documentary (letters, official registers, receipts) – a pioneering and challenging task. A more through study will reveal the untapped potential of Latin texts on papyrus for renewing our knowledge of the circulation and reception of Latin language and education, as a cultural engine in Mediterranean societies.

Project End Date: **3/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
637747	**RiP**	**SH5 - Cultures and Cultural Production**

Principal Investigator: **Dr. José Filipe Pereira da Silva**
filpas.mail@gmail.com

Host Institution: Helsingin Yliopisto, FI

Rationality in Perception: Transformations of Mind and Cognition 1250-1550

The project RiP aims to provide a groundbreaking new interpretation of late medieval theories of mind and cognition by focusing on the influence higher cognitive (rational) powers exert on lower (sensory) ones in the neglected tradition of Augustinian philosophy of perception. Due to increasing difficulties in explaining the unity and objectivity of perceptual experience, late medieval authors came to question the dominant Aristotelian theory, with its passive account of perception and emphatic separation between sensory and intellectual functions. This led to a resurfacing of the Augustinian tradition, which is characterized by an emphasis on activity and top-down processing, built around the notions of intentionality and self-awareness. The project investigates the hypothesis that perception changes from being explained on the basis of a model of the soul that is metaphysically composite of really distinct clusters of functions to a model in which rationality permeates the functions previously attributed to lower cognitive capacities. It is the 'flow of reason', an expression found in a late sixteenth-century textbook. The project has therefore two main objectives:
(1) to offer the first systematic study of late medieval theories of perception, focusing on the relation between the senses and intellect
(2) to retrace the shift in late medieval philosophy of perception that led to (a) a progressive questioning of direct realism in cognition and (b) the incremental reduction of all psychological functions to the mind. The results of the project will allow a better understanding of the philosophical assumptions of late medieval theories of cognition, shedding new light on the historical background of early modern and contemporary conceptions of rationality.

Project End Date: **3/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
335949	**ARISTOTLE**	**SH5 - Cultures and Cultural Production**

Principal Investigator: **Dr. Marco Sgarbi**
marco.sgarbi@unive.it

Host Institution: Universita Ca' Foscari Venezia, IT

Aristotle in the Italian Vernacular: Rethinking Renaissance and Early-Modern Intellectual History (c. 1400–c. 1650)

From the twelfth to the seventeenth century, Aristotle's writings lay at the foundation of Western culture, providing a body of knowledge and a set of analytical tools applicable to all areas of human investigation. Scholars of the Renaissance have emphasized the remarkable longevity and versatility of Aristotelianism, but their attention has remained firmly, and almost exclusively, fixed on the transmission of Aristotle's works in Latin. Scarce attention has gone to works in the vernacular. Nonetheless, several important Renaissance figures wished to make Aristotle's works accessible and available outside the narrow circle of professional philosophers and university professors. They believed that his works could provide essential knowledge to a broad set of readers, and embarked on an intense programme of translation and commentary to see this happen. It is the argument of this project that vernacular Aristotelianism made fundamental contributions to the thought of the period, anticipating many of the features of early modern philosophy and contributing to a new encyclopaedia of knowledge. Our project aims to offer the first detailed and comprehensive study of the vernacular diffusion of Aristotle through a series of analyses of its main texts. We will thus study works that fall within the two main Renaissance divisions of speculative philosophy (metaphysics, natural philosophy, mathematics, and logic) and civil philosophy (ethics, politics, rhetoric, and poetics). We will give strong attention to the contextualization of the texts they examine, as is standard practice in the best kind of intellectual history, focusing on institutional contexts, reading publics, the value of the vernacular, new visions of knowledge and eclecticism. With the work of the PI, two professors, 5 post-docs and two PhD students we aim to make considerable advances in the understanding of both speculative and civil philosophy within vernacular Aristotelianism.

Project End Date: **4/30/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694559	**DevelopingTheatre**	**SH5 - Cultures and Cultural Production**

Principal Investigator:	**Dr. Christopher Balme** balme@lmu.de
Host Institution:	Ludwig-Maximilians-Universitaet Muenchen, DE

Developing Theatre: Building Expert Networks for Theatre in Emerging Countries after 1945

This research project proposes a fundamental re-examination of the historiography of theatre in emerging countries after 1945 . It investigates the institutional factors that led to the emergence of professional theatre in the post-war period throughout the decolonizing world. The particular focus will be on the massive involvement of internationally coordinated 'development' and 'modernization' programs both East and West. The project will introduce the concepts of epistemic community, expert networks and techno-politics to theatre historical research as a means to historicize theatre within transnational and transcultural paradigms and examine its imbrication in globalization processes. This institutional and transnational approach will enable theatre studies to overcome its still strong national and local focus on plays and productions and connect it to current discourses on transnational history.

The main objectives of this project are to:

• examine how a global 'epistemic community' centred around theatre emerged in the post-war period;

• investigate how 'expert networks' composed of government bodies, private foundations, transnational corporate philanthropy, local elites and individual artists sought to institutionalize particular forms and practices of professional theatre as an interconnected, transnational phenomenon;

• develop a new interdisciplinary approach to theatre historiography by focusing on institutional structures, path dependencies and transnational imbrications rather than on works and authors.

The principal investigator will bring to this project two decades of internationally recognized research into intercultural and global theatre. With its combination of institutional historiography and innovative research methods the project will provide a new foundation for current discussions of cultural policy and sustainability in emerging societies.

Project End Date: **9/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714166	**NARMESH**	**SH5 - Cultures and Cultural Production**

Principal Investigator: **Dr. Marco Caracciolo**
marco.caracciolo@ugent.be

Host Institution: Universiteit Gent, BE

Narrating the Mesh: Ecology and the Non-Human in Contemporary Fiction and Oral Storytelling

Today's ecological crisis prompts us to rethink our attitude towards physical and natural realities that have traditionally been seen as opposed to human subjectivity and agency. What emerges from this "non-human turn" is a sense of our interdependence on things like the bacteria in our intestines or the carbon atoms supporting life on Earth. Ecological theorist Timothy Morton uses the metaphor of the "mesh" to express this idea of human/non-human interconnectedness. This project will map the formal and thematic strategies through which contemporary narrative practices engage with the non-human and envisage this interconnectedness.

Storytelling is an indispensable tool for making sense of experience by establishing temporal and causal relations. But it is also biased towards the human-scale realities of action and social interaction. How can narrative overcome this bias? How does it convey phenomena that challenge our belief in the ontological and material self-sufficiency of the human?

Comparing fictional narratives in print (novels and short stories) and conversational storytelling, we will systematically explore the ways in which narrative can forge connections across levels of reality, weaving together the human and the non-human into a single plot. The assumption is that narrative is a field where fictional practices are in constant dialogue with the stories told in everyday conversation—and with the culture-wide beliefs and concerns those stories reflect.

Through its three sub-projects, the proposed research charts this complex dialogue while greatly advancing our understanding of how stories can be used to heighten people's awareness of the mesh and its significance. The project builds on a combination of methods (close readings of novels, qualitative analysis of interviews), aiming to open up a new field of study at the intersection of literary scholarship and the social sciences—with narrative theory serving as a catalyst for the interdisciplinary exchange.

Project End Date: **1/31/2022**

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** r.gleave@exeter.ac.uk
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: **8/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
614791	**PerformEast**	**SH5 - Cultures and Cultural Production**

Principal Investigator:	**Dr. Sylvia Sasse** sylvia.sasse@uzh.ch
Host Institution:	Universitaet Zuerich, CH

Performance-Art in Eastern Europe (1950-1990): History and Theory

The aim of this project is to provide, for the very first time, an overview of the historical and transnational development of performance art (performances, actions, happenings) in Eastern Europe during the dictatorship period. Performance art shall not only be presented as an object of study, but also as a central art genre implicitly and explicitly involved both in the investigation of cultural practices and in the creation of alternative ways of action. The project focuses, for one, on the artistic exploration of totalitarian or real-socialist practices, rituals, and gestures, but also on artistic ways of action developed in the course of underground activity. Eastern European performance art came to life under conditions in which it was from the very start considered as dubious both aesthetically and contentwise. However, tolerance, hindrance, and sometimes even prohibition led to a heightened degree of self-reflection, minimalism, abstraction, and analysis; in other words, to characteristics representative of the specificity of East European performance art between 1950 and 1990.

At the same time, the proposed project is to be understood as an archaeological one, for it sets out to reconstruct correlations and interactions between unofficial artistic production and official cultural practice. Moreover, it aims to make available to a broader public artistic endeavours that until now could not be centred on in research fields like art history, theatre-, and cultural studies in an Eastern European context. The project will concentrate on the following four research areas:

1. Territorial interrelationships (between the Eastern European countries, between East and West)
2. Specificity of practice in Eastern European performance art (subversive affirmation, minimalism, abstraction)
3. Interrelationships between artistic action and political activism in the underground
4. Self-reflection in Eastern European performance art (self-archivisation, self-commentary)

Project End Date: **9/30/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
615545	**RECIRC**	**SH5 - Cultures and Cultural Production**

Principal Investigator:	**Dr. Marie-Louise Coolahan** marielouise.coolahan@nuigalway.ie
Host Institution:	National University Of Ireland, Galway, IE

The Reception and Circulation of Early Modern's Women's Writing, 1550-1700

This project will produce a large-scale, quantitative analysis of the ways in which women's writing was received and circulated in the early modern period. By exploring the phenomenon of early modern literary reception in a rigorous and comprehensive way, the project will allow us to see more clearly the importance and function of reception; specifically how the field of reception articulates and develops critical and aesthetic engagements, how it reveals the extent to which gender shapes ideas about authorship, and how it historicizes our current debates about intellectual impact and gender. Existing reception scholarship has focused on qualitative case studies and tended to prioritize print culture; the field requires a quantitative approach that takes full account of the realities of textual transmission in a period when manuscript circulation retained its broad appeal. RECIRC overcomes the logistical challenges by focusing on the category of the manuscript miscellany and on networks as centres of textual circulation, producing new knowledge about transmission and book ownership. The project will test the hypothesis that the attribution of texts to anonymous, pseudonymous and gender-designated authors is revelatory regarding how gender determined reception.

RECIRC's specific objectives are: to challenge assumptions that women's penetration of the literary field in this period was limited by focusing on textual reception rather than production; to transform current thinking on the nature of impact and the quality of reception by classifying and analysing the modes of textual engagement in new ways; to provoke a new understanding of the invention of the author in this period by approaching the question via reception, grounding it in a gendered understanding of the complex constructions of authorship that includes the exploitation of anonymity and pseudonymity; and to advance current discourses about scholarly impact by opening up and critiquing their historical contexts.

Project End Date: **6/30/2019**

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** peter@riedlberger.de
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: **4/30/2021**

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**
liviaholden@insightsproduction.net

Host Institution: Universita Degli Studi Di Padova, IT

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 or defendants 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: **9/30/2021**

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** jari.kaukua@jyu.fi
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: **8/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681884	**TIDE**	**SH5 - Cultures and Cultural Production**

Principal Investigator:	**Dr. Nandini Das** ndas@liverpool.ac.uk
Host Institution:	The University Of Liverpool, UK

Travel, Transculturality and Identity in England, c.1550 – 1700

The central research question this project will pose is: how did mobility in the great age of travel and discovery (c.1550–1700) shape English perceptions of human identity based on cultural identification and difference? The role of those marked by transcultural mobility was central to this period. Our current world is all too familiar with the concepts that surfaced or evolved as a result: 'foreigners', 'strangers', 'aliens', 'converts', 'exiles', or even 'translators', 'ambassadors' and 'go-betweens'. There is an urgent need to consolidate our fragmented understanding of this crucial issue, which continues to shape current debates. TIDE offers a direct and timely response to this challenge, combining established methodologies with a set of ambitious and innovative approaches. By bringing together multiple discourses that tackled the fraught question of human identity in this era, ranging across literature, trade, diplomacy, governance, law, religion and ethnography, it will open a new perspective on cross-cultural encounters. It will put pressure on our understanding of cultural difference, transculturality and identity, and generate a new understanding of key terms, concepts, and debates. It will produce new knowledge about the unique role played by literature, and break fresh ground through the combination of academic research with new writing. Its returns would be significant: a fundamental improvement to our current understanding of cultural differentiation and assimilation, as well as a lasting and creative insight into their consequences.

Project End Date: **9/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
667526	**K4U**	**SH5 - Cultures and Cultural Production**

Principal Investigator: **Dr. Adrian Harris**
admin.k4u@durham.ac.uk

Host Institution: University Of Durham, UK

Knowledge For Use [K4U]: Making the Most of Social Science to Build Better Policies

'Research is an investment in our future' says Horizon 2020. That's only true if you know what to do with it. When it comes to social policy, we don't really know how to put our research results to use. K4U aims to remedy this. K4U will construct a radically new picture of how to use social science to build better social policies. This picture will be founded on an ambitious philosophical study of the technology of social science including a thorough reconceptualisation of objectivity, deliberation and the role of values in the science/society interface. Current work, primarily by the evidence-based policy and practice movement, focusses on knowledge production: encouraging high quality studies and vetting them. Little attention goes to knowledge use: How is social science knowledge to be used in policy design and deliberation – how should it be used so that policy outcomes are more effective and more reliably predictable and competing values and points of view are respected in policy choice and implementation? K4U will provide not just a theoretical but a practical understanding— for users: intelligible and practically helpful to those who need to estimate and balance the effectiveness, the evidence, the chances of success, the costs, the benefits, the winners and losers, and the social, moral, political and cultural acceptability of proposed policies. The philosophical approach of K4U is broadly Popperian. It views 'science and technology as a means of understanding social problems and responding to them' and it emphasises the concrete and detailed, where the real content of general philosophical concepts and claims is embodied and interrogated. K4U is a showcase for the kind of philosophy that makes a difference to real life -- philosophy for practice. And it will launch an entire new field in philosophy: the philosophy of social technology.

Project End Date: **10/31/2020**

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** silvana.mandolessi@arts.kuleuven.be
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: **6/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
679528	**POSTDATA**	**SH5 - Cultures and Cultural Production**

Principal Investigator:	**Dr. Elena González Blanco García** egonzalezblanco@flog.uned.es
Host Institution:	Universidad Nacional De Educacion A Distancia, ES

Poetry Standardization and Linked Open Data

This project aims at bridging the digital gap among traditional cultural assets and the growing world of data. It is focused on poetry analysis, classification and publication, applying Digital Humanities methods of academic analysis -such as XML-TEI encoding- in order to look for standardization. Interoperability problems between the different poetry collections are solved by using semantic web technologies to link and publish literary datasets in a structured way in the linked data cloud. The advantages of making poetry available online as machine-readable linked data are threefold: first, the academic community will have an accessible digital platform to work with poetic corpora and to contribute to its enrichment with their own texts; second, this way of encoding and standardizing poetic information will be a guarantee of preservation for poems published only in old books or even transmitted orally, as texts will be digitized and stored as XML files; third: datasets and corpora will be available and open access to be used by the community for other purposes, such as education, cultural diffusion or entertainment. To accomplish such a ground-breaking approach, I have a hybrid profile, combining a strong philological background, specialized in poetry and metrics, with a deep knowledge of Digital Humanities proven by my leadership and experience in interdisciplinary projects. Since 2011, I am the Principal Investigator of the first Digital Repertoire of Medieval Spanish Poetry (ReMetCa), an innovative project that combines traditional metrical analysis with digital text encoding, and since 2014 I am the Academic Director of LINHD, The Digital Humanities Innovation Lab created at UNED as a research interdisciplinary centre.

Project End Date: **4/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681202	**OurMythicalChildhood**	**SH5 - Cultures and Cultural Production**

Principal Investigator:	**Dr. Katarzyna Marciniak** kamar@al.uw.edu.pl
Host Institution:	Uniwersytet Warszawski, PL

Our Mythical Childhood... The Reception of Classical Antiquity in Children's and Young Adults' Culture in Response to Regional and Global Challenges

The project aims at developing a pioneering approach to the reception of Classical Antiquity in children's and young adults' contemporary culture. This newly identified research field offers valuable insights into the processes leading to the formation of the culture recipients' identities along with their initiation into adulthood. However, the most vital potential of this phenomenon remains unexploited, for the research is still selective, focused mainly on Western culture. With my project, I intend to overcome these limitations by applying regional perspectives without the pejorative implication of regional as parochial or inferior. I recognize regions as extremely valuable contexts of the reception of Antiquity, which is not only passively taken in, but also actively reshaped in children's and young adults' culture in response to regional and global challenges. Thus, the essence of this innovative approach consists in comparative studies of differing reception models not only across Europe but also America, Australia & New Zealand and – a bold but necessary step – in parts of the world not commonly associated with Graeco-Roman tradition: Africa and Asia. The shared heritage of Classical Antiquity, recently enhanced by the global influence of popular culture (movies, Internet activities, computer games inspired by the classical tradition), gives a unique opportunity – through the reception filter – to gain deeper understanding of the key social, political and cultural transformations underway at various locations. The added value of this original research, carried out by an international team of scholars, will be its extremely broad impact on the frontiers of scholarship, education and culture: we will elaborate a supra-regional survey of classical references, publish a number of analyses of crucial reception cases, and prepare materials on how to use ancient myths in work with disabled children, thus contributing to integration and stimulating cultural exchange.

Project End Date: **9/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694893	**SENSOTRA**	**SH5 - Cultures and Cultural Production**

Principal Investigator:	**Dr. Helmi Järviluoma** helmi.jarviluoma@uef.fi
Host Institution:	Ita-Suomen Yliopisto, FI

Sensory Transformations and Transgenerational Environmental Relationships in Europe, 1950–2020

This project aims at producing new understandings of the changes in people's sensory environmental relationships in three European cities during a particular period in history, 1950–2020. It will offer a focused window on cultural transformations of the sensory by introducing a new transgenerational methodology, ethnographic "sensobiography". Why now? Firstly, innovative and thoroughly researched information about sensory environmental relationships is in great demand. If the findings are successful, their challenge to several conventional dichotomies will provide results whose interdisciplinary impact extends beyond cultural, sound, and music studies to areas of psychology, human geography, environmental aesthetics, and media history and theory. The research is urgent: at present we are still able to study people ethnographically who were born in the 1930s and 1940s,who therefore lived their early years without digital technologies. The moment is also ideally suited for studying generations born straight into the digital world, where there is a need to enable young and older people to maintain a many-faceted relationship with their environments. The project's three research strands are (1) transformations in mediations of sensory experience, (2) embodied remembering and senses, and (3) sensory commons. These strands will be studied via a research strategy linking individuals and groups to broader social, cultural, and political issues in the medium-sized European cities of Brighton (UK), Ljubljana (Slovenia), and Turku (Finland). Temporally and spatially tightly focused dynamic ethnography makes it possible to examine multiple modes of past and present sensory experiencing. The study of artists as "sensewitnesses" will become one of the pivotal endeavours. The project facilitates a significant step from earlier methodologies toward large-scale, multisensory, transgenerational investigation, providing significant insights into culture with a sustainable future.

Project End Date: **7/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682711	**PENELOPE**	**SH5 - Cultures and Cultural Production**

Principal Investigator:	**Dr. Ellen Harlizius-Klück** e.harlizius-klueck@deutsches-museum.de
Host Institution:	Deutsches Museum Von Meisterwerken Der Naturwissenschaft Und Technik, DE

A study of weaving as technical mode of existence

The PENELOPE project builds on the hypothesis that there was a significant but tacit contribution of textile technology involved in the advent of science in ancient Greece. Bruno Latour recently claimed that technologies require an original mode of existence that accounts for their particular form of detour. I agree and propose the technological labyrinth of threads in weaving as a paradigm for this mode. In contrast to the well-known but insufficient idea of hylemorphism (a form/idea applied to material) I suggest the concept of penemorphism (a co-existence of shifting and un-shifting threads, "pene" in Greek) that enables to describe the integration of various levels and elements that are included in each and every technology, especially the digital ones. I focus in theory and practice on the technological principles of ancient weaving. In archaic Greece, we find a veridiction, a very particular way of telling the truth in weaving terms that is hidden behind the relations of metaphor and concept or mythos and logos. I detect this veridiction in all sorts of ancient texts, be they philosophical, poetical, mythographic, cosmological, or mathematical. Ancient weaving contains framing features that are lost in modern clothing technology but were decisive for their use as a model of cosmic order. For this investigation I set up a PENELOPEan laboratory where I 1. Detect the models and topologies of weaves (ancient and modern) 2. Develop codes to make them virtually explorable, and 3. Compare different types of coding and their scope with regard to their dependence on specific systems. The laboratory work is accompanied by a comparative investigation of archaic Greek texts, a selective investigation of scientific theories that employ concepts analogous to my weaving paradigm, and an anthropological investigation of the relation of codes, notations and conditions for the development of notation systems.

Project End Date: **11/30/2021**

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**
sarah.green@helsinki.fi

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: **8/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
725319	**SloMo**	**SH5 - Cultures and Cultural Production**

Principal Investigator:	**Dr. Wöllner Clemens** clemens.woellner@uni-hamburg.de
Host Institution:	Universitaet Hamburg, DE

Slow motion: Transformations of musical time in perception and performance

Slow motion is widely employed in popular media such as emotional movie scenes or in the broadcasting of momentous bodily and physical actions. Slow motion functions as a counterpoint to the perceived acceleration of life, and non-profit organisations and meditation practices promote its virtues. Slow motion is used as a beneficial rehearsal strategy in music, dance, and other movement-based arts and sports. This research proposal shifts existing boundaries by hypothesizing that the time-stretching mechanism of slow motion is a) associated with high emotional significance, b) beneficial for interpersonal coordination, c) relevant in cross-modal approaches with augmented feedback such as the sonification of human movements, d) reduces cognitive working memory load in learning. It is assumed that music as a temporal-motional art is central for the study of these processes, since music consists of structured time at different hierarchical levels and deeply “moves” people. The musical surface structure (on a note-to-note level) allows synchronisations at higher tempi compared to deeper structural levels (such as strong beats in a measure or phrases). Music may thus transform perceptions of motion and time. The proposed project contains three main phases, first addressing the perception of slow motion in music and dance in relation to the attentional, emotional and aesthetic effects on the audience. In the second phase, performance qualities are studied, addressing cognitive load, imagery, and interpersonal coordination at slow tempi. High-speed cameras, a 3D motion capture system and physiological measures are used to analyse the psychological and bodily processes involved. The final phase aims at the creation of three applications, including a learning app for portable devices, a film with super slow motion sequences based on the studies, and sonifications of Tai Chi movements. These applications present the aesthetic dimensions of slow motion to a wider audience.

Project End Date: **3/31/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
615564	**APARTHEID-STOPS**	**SH5 - Cultures and Cultural Production**

Principal Investigator:	**Dr. Louise Bethlehem** louise.bethlehem@mail.huji.ac.il
Host Institution:	The Hebrew University Of Jerusalem., IL

Apartheid -- The Global Itinerary: South African Cultural Formations in Transnational Circulation, 1948-1990

This proposal proceeds from an anomaly. Apartheid routinely breached the separation that it names. Whereas the South African regime was deeply isolationist in international terms, new research links it to the Cold War and decolonization. Yet this trend does not consider sufficiently that the global contest over the meaning of apartheid and resistance to it occurs on the terrain of culture. My project argues that studying the global circulation of South African cultural formations in the apartheid era provides novel historiographic leverage over Western liberalism during the Cold War. It recasts apartheid as an apparatus of transnational cultural production, turning existing historiography inside out. This study seeks:

• To provide the first systematic account of the deterritorialization of "apartheid"—as political signifier and as apparatus generating circuits of transnational cultural production.

• To analyze these itinerant cultural formations across media and national borders, articulating new intersections.

• To map the itineraries of major South African exiles, where exile is taken to be a system of interlinked circuits of affiliation and cultural production.

• To revise the historiography of states other than South Africa through the lens of deterritorialized apartheid-era formations at their respective destinations.

• To show how apartheid reveals contradictions within Western liberalism during the Cold War, with special reference to racial inequality.

Methodologically, I introduce the model of thick convergence to analyze three periods:

1. Kliptown & Bandung: Novel possibilities, 1948-1960.
2. Sharpeville & Memphis: Drumming up resistance, 1960-1976.
3. From Soweto to Berlin: Spectacle at the barricades, 1976-1990.

Each explores a cultural dominant in the form of texts, soundscapes or photographs. My work stands at the frontier of transnational research, furnishing powerful new insights into why South Africa matters on the stage of global history.

Project End Date: **4/30/2019**

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 Kügle**
karl.kuegle@music.ox.ac.uk

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: **12/31/2020**

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**
e.m.kingma@soton.ac.uk

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: **3/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
617777	**UP-North**	**SH6 - The Study of the Human Past**

Principal Investigator:	**Dr. Rhiannon Stevens** rhiannon.stevens@ucl.ac.uk
Host Institution:	University College London, UK

COLONISATION AND CULTURAL DIVERSIFICATION IN UNFAMILIAR LANDSCAPES

This project explores the relationship between climate change and human behaviour. During the harshest conditions of the last ice age European human populations abandoned northern latitudes, with their range contracting to southern regions. By the time ice sheets retreated and large areas of land became available for resettlement there had been a hiatus of at least 7000 years. This project examines the recolonisation of these Northern regions which took place during a period of rapid climate change, the last major global warming event on earth. As people move eastwards and northwards increasing diversification is seen in their stone and bone tool industries which indicate human development. This project examines whether climate a) drove the human dispersal and development, b) played a more indirect role, or c) was of little significance to humans at this time. State-of-the-art scientific techniques (radiocarbon dating, DNA, stable isotope, clumped isotope and charcoal ring width analyses) will be used to create integrated chronological, palaeoclimatic and palaeoecological frameworks that are directly linked to the Late and Final Palaeolithic archaeological record. Temporal and spatial trends in climate change, prey abundance and behaviour, and technological development will be compared and considered in light of regional and global climate trends and archaeological evidence for hunting strategies, human mobility and landscape use. Such data will provide an insight into the conditions Palaeolithic people experienced and how this influenced their perceptions of the landscape they inhabited and the decisions they made.

Project End Date: **9/30/2019**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714569	**Lawforms**	**SH6 - The Study of the Human Past**

Principal Investigator:	**Dr. Nandini Chatterjee** n.chatterjee@exeter.ac.uk
Host Institution:	The University Of Exeter, UK

Forms of Law in the Early Modern Persianate World, 17th-19th centuries

This project will study concepts and practices of law across the early modern Persianate world, investigating how this specific cultural milieu structured understanding of law, legal expression and efforts to secure rights and justice. It will do so by focusing on the ordinary users of law, rather than on specialists, and by using legal documents written in Persian and associated languages produced in five major linguistic-cultural zones stretching from the Indian subcontinent to Iran and the northern and western Indian Ocean. Working with the surviving record of everyday transactions (legal deeds); formularies that standardised such legal forms; extant adjudication records and relevant jurisprudential literature, we shall pay particularly close attention to language – exploring how translation, multi-lingualism, orality and literacy facilitated processes of vernacularisation of Islamic law, and was actuated through the social and material world of writing. The findings of this project will make significant contributions to several fields, such as: the history of Islamic law and its vernacularisation in various political, cultural and demographic contexts, the history of law and commerce in the Indian Ocean, the history of legal pluralism in Islamic and European empires. This ambitious project will be pursued by an international team of distinguished scholars working under my direction. Together, we will access untapped historical records from archives and collections in India, Pakistan, Tajikistan, Iran, Kuwait, Bahrain, Oman and Tanzania; and read and analyse texts in variations of Persian, in combination with Hindi, Marathi, Bengali, Rajasthani, Gujarati and Arabic. Outputs proposed are: 2 intensive workshops; 2 collective publications including 2 articles by each of the core project team members (1 for the PI); 1 monograph by the PI; and a major digitisation project which will enhance an existing database of Persian-language legal documents.

Project End Date: **4/30/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
681605	**PEGASUS**	**SH6 - The Study of the Human Past**

Principal Investigator: **Dr. Ludovic ORLANDO**
Lorlando@snm.ku.dk

Host Institution: Københavns Universitet, DK

The makeup of the modern horse: a history of the biological changes introduced by human management

The horse provided us with rapid transportation, an almost unrivaled secondary product that tremendously impacted the politico-economical trajectory of our societies, revolutionizing the circulation of ideas, people, languages, religions and communication. Horse chariotry and cavalry also changed warfare and beyond the battlefield new equestrian technologies have stimulated agricultural productivity. However, the 5,500 year long history of horse domestication and management, which transformed the natural evolutionary trajectory of wild horses into the more than 625 domestic breeds living today, is difficult to reconstruct from archaeology, history and modern genetics alone. Yet, with archaeogenetics, one can access the genetic information from past individuals and track in great detail past population trajectories. In this project, I propose to build on the latest advances in the analysis of ancient DNA molecules to gather new genomic, epigenomic and metagenomic information from ancient horses. This will be integrated with archaeozoological, isotopic and historical data to enhance our understanding of the multiple processes underlying the transformation of the animal that perhaps most impacted our history. Starting from the characterization of pre-domestic populations of wild horses, I will evaluate the genomic and dietary impact of early domestication stages and will explore whether horses were independently domesticated in Iberia and the Pontic-Caspian steppe. I will follow how the emergence of chariotry and the development of heavy cavalry impacted the horse's behavioural, physiological and biological makeup. I will reveal the horse characteristics that were preferred in various historical contexts and will investigate a diversity of management strategies and husbandry conditions to reveal their impact on horses, from classical and late antique periods until the recent creation of modern breeds by means of intensive selective breeding.

Project End Date: **11/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682241	**Persia and Babylonia**	**SH6 - The Study of the Human Past**

Principal Investigator: **Dr. Caroline Waerzeggers**
c.waerzeggers@hum.leidenuniv.nl

Host Institution: Universiteit Leiden, NL

Persia and Babylonia: Creating a New Context for Understanding the Emergence of the First World Empire

The Persian Empire (539-330 BCE) represented a new political order in world history. At its height, it united a territory stretching from present-day India to Libya. It was three times as large and twice as long-lived as the previously most successful polity (Assyria), and it would take 2,000 years before significantly larger empires emerged in early modern Eurasia. What explains Persia's success? This question eludes scholarship due to a lack of evidence and a lack of engagement. Since this Empire unified for the first time in history millions of people under its rule – a condition that became a recurring experience of humanity – understanding Persia's success transcends its intrinsic relevance to the period in question. The principal reason why an effective engagement with this question is presently impossible is the lack of data. The PERSIA AND BABYLONIA project presents a substantial new data set that allows us, for the first time, to contextualize the emergence of the Persian Empire as a complex social process, shifting away from understandings of the Empire as a one-dimensional, state-initiated construct. This data derives from cuneiform textual sources that were produced in Persia's most important periphery – Babylonia. A key analytical device in our work will be to compare Persian responses to those of the Assyrians, who were unable to establish control of Babylonia a century earlier. By combining a long-term with a deeply contextualized perspective, we will be able to draw out the distinctive efficiency of Persian rule, within the long history of this particular region. In addition to making a significant step towards understanding the emergence of Ancient Persia, we will develop a much-needed research tool for historians of empire and society in the ancient world.

Project End Date: **12/31/2021**

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**
philipp.stockhammer@lmu.de

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: **6/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
676828	**VAMOS**	**SH6 - The Study of the Human Past**

Principal Investigator: **Dr. Katharina Rebay-Salisbury**
Katharina.Rebay-Salisbury@oeaw.ac.at

Host Institution: Oesterreichische Akademie Der Wissenschaften, AT

The value of mothers to society: responses to motherhood and child rearing practices in prehistoric Europe

Analysing the link between reproduction and women's social status, this project explores social responses to pregnancy, birth and childrearing from the late Neolithic to the late Iron Age (c.3000-15 BC) through case studies in central Europe. Motherhood and childrearing, often seen as natural, mundane and inevitable parts of women's lives, are also cultural and historically contingent practices that build the foundations of societies. Exploring the value of mothers to society will aid in understanding important long-term developments such as social stratification, increasing population density and the entrenching of gender roles during the three millennia under investigation. Bringing together the latest developments in archaeological science, including palaeo-pathology, ancient DNA and isotope analyses, with innovative interpretative approaches, this project will explore if all women were expected to become mothers, highlight alternative lifeways, evaluate risks and consequences of becoming a mother and analyse the social value of reproductive success. It is the first study that aims to systematically predict the probability of whether or not a woman has given birth using palaeo-pathological markers combined with individual age information and population-specific demographic data. It will contextualize the findings with an in-depth status analysis of women's graves. Graves of pregnant women, double burials of women and children as well as infant burials will provide further data. The study extends to childrearing (care, feeding, but also abuse, neglect and infanticide) and explores how children were treated after death for insights into their significance. Current political discourses about mothers in society and workforce frequently refer to 'natural' and 'ancient' childrearing practices. This project will contribute significantly to our understanding of motherhood and counter naive narratives of childrearing in prehistory with science-based information.

Project End Date: **6/30/2021**

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** holmp@tcd.ie
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: **12/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694476	**EMoBookTrade**	**SH6 - The Study of the Human Past**

Principal Investigator:	**Dr. Angela Nuovo** angela.nuovo@uniud.it
Host Institution:	Universita Degli Studi Di Udine, IT

The Early Modern Book Trade: An Evidence-based Reconstruction of the Economic and Juridical Framework of the European Book Market

This project will explore the idea – and gather the evidence to prove it – that the so-called printing revolution does not consist in a change in book-making technology but in the process, prolonged over the entire course of the early modern age, of the formation of the printed book market and the creation of readers as purchasers and consumers of books. In order to demonstrate this, the project will reconstruct the economic and legal framework of the European book market by applying an interdisciplinary approach to the economic study of book history. By using unique and hitherto unexplored documentary evidence, this project addresses four fundamental questions relating to the growth of a fully developed book trade and the rise of a society of book consumers within the social and religious context of early modern Europe: the economic issue of book prices; the juridical and political issue of the book privilege system (which in turn influenced the process of book pricing); the management of the bookselling business (focusing on businesses in two major cities in the European book trade, Venice (Bernardino Giunti) and Antwerp (Christopher Plantin)); the technique of building and managing a transnational network for book distribution and sale (analyzing groundbreaking new evidence, an entire year (1522) of correspondence from a Venetian wholesale bookseller, Giovanni Bartolomeo Gabiano). These four research areas will feed into an overarching project which will examine the impact of books and the access of readers to them, together with the development in patterns of cultural consumption which meant that printed books lost the luxury status which they had had throughout the incunabula period to become transformed into 'popoluxe' goods.

Project End Date: **8/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716211	**GRETPOL**	**SH6 - The Study of the Human Past**

Principal Investigator: **Dr. Peder Roberts**
peder.roberts@abe.kth.se

Host Institution: Kungliga Tekniska Hoegskolan, SE

Greening the Poles: Science, the Environment, and the Creation of the Modern Arctic and Antarctic

This project investigates how and why environmental concerns have become so important to our conceptions of the polar regions today. Through a historical study of both the Arctic and Antarctic from 1945 to the turn of the past century, the project explores the connections between how environments are described - particularly through the natural sciences and economics - and the judgments made about how those environments should be administered. The key hypothesis of this project is that the process of describing an environment cannot be separated from the process of controlling and managing it. Changing perceptions of concepts such as development, ecological fragility, and wilderness have provided frames for describing and understanding the polar regions. Why has natural resource extraction been deemed appropriate (or even necessary) in some contexts, and wholly forbidden in others? Why did the concept of sustainable development become important during the 1980s? Can we think of scientific research programs as instruments of colonialism? And why did national parks and conservation agreements become politically useful? GRETPOL will produce a new understanding of how far from being the passive frames for human action, environments (in the polar regions but indeed also beyond) are constructed by human agency. As anthropogenic climate change reduces polar ice extent and threatens the entire globe, the question has never been timelier.

Project End Date: **1/31/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
714679	**ECHOES**	**SH6 - The Study of the Human Past**

Principal Investigator: **Dr. Michael Dee**
m.w.dee@rug.nl

Host Institution: Rijksuniversiteit Groningen, NL

Exact Chronology of Early Societies

Chronology is fundamental to all study of the past. Social and cultural change is incomprehensible without clear information on the ordering and duration of events. However, the exact chronology of the Old World only extends as far back as the mid-1st millennium BC, even though state-level societies in both the Western and the Eastern Hemispheres emerged several millennia before this time. In the New World, the situation is even worse, with none of the pre-Columbian societies currently fixed in calendrical time. No scientific method has so far been able to provide historians of early society with the levels of precision considered essential by their modern counterparts. Indeed, if the 20th century AD were dated at the same resolution as the 20th century BC, the two World Wars would be indistinguishable in time; and the Montgomery Bus Strike might post-date the release of Mandela. ECHOES pioneers the first technique capable of providing ancient history with the same clarity as modern history. The new approach is based on past solar events that initiated sudden increases in the atmospheric concentration of radiocarbon. The enriched concentrations would have been absorbed by all growing plants at the time. Crucially, fossil wood archives already exist in which the growth year of each tree-ring is exactly known, enabling the events to be easily dated. Moreover, the uplifts will also be present in all artefacts that were fashioned from contemporary plant material, such as papyrus documents. Matching the enrichments in such cultural items with the tree-ring archives will also date them to the exact year. ECHOES aims to produce a myriad of such connections to secure key early societies in calendrical time. This will lay the foundations for a globally synchronous, chronological lattice that will allow the flow of technology and ideas to be understood in a way that has never before been previously possible, as each cultural record will be fixed to the same time frame.

Project End Date: **1/31/2022**

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**
emp9@st-andrews.ac.uk

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: **8/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
687567	**PAThs**	**SH6 - The Study of the Human Past**

Principal Investigator:	**Dr. Paola Buzi** paola.buzi@uniroma1.it
Host Institution:	Universita Degli Studi Di Roma La Sapienza, IT

Tracking Papyrus and Parchment Paths: An Archaeological Atlas of Coptic Literature.Literary Texts in their Geographical Context: Production, Copying, Usage, Dissemination and Storage

PAThs aims to provide an in-depth diachronical understanding and effective representation of the geography of Coptic literary production, which is the corpus of writings, almost exclusively of religious contents, produced in Egypt between the 3rd and the 11th centuries in the Coptic language.PAThs takes an original and pluridisciplinary approach, combining, for the first time in this field, philology, codicology, archaeology and digital humanities, in order to explore the process of production, copying, usage, dissemination, and storage of Coptic works in relation to the concrete geographical contexts of origin of both the texts themselves and their related writing supports.By analysing texts and contents, paratexts (titles and colophons) and linguistic layers (style and dialects), the literary products will be strictly related not only to the places where they have been copied, but also to the single intellectual milieux responsible for their creation. Cultural orientations and literary tastes in specific areas of Egypt will be singled out, while changes in the manufacture of codices will emerge, in a manuscript tradition that offers the oldest witnesses for the use of codex. An exhaustive digital atlas of late antique and early medieval Egypt will be produced, based upon an interactive, flexible and versatile tool that will allow detailed and focused research and correlation of chronological, regional and thematic data. This will illustrate, as never before, the relationship between settlements, as revealed by the archaeological investigations, and intellectual production, as revealed by manuscripts, and will provide a new comprehensive perspective on the spread and development of Coptic literature and manuscript culture.A portal will integrate the atlas with several by-products, consisting of databases for collecting information on authors, works, manuscripts, and sites: an altogether new achievement in Coptic studies.

Project End Date: **10/31/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
670518	**Lost Frontiers**	**SH6 - The Study of the Human Past**

Principal Investigator: **Dr. Vincent Gaffney**
v.gaffney@bradfoprd.ac.uk

Host Institution: University Of Bradford, UK

Europe's Lost Frontiers: exploring climate change, settlement and colonisation of the submerged landscapes of the North Sea basin using ancient DNA, seismic mapping and complex systems modelling

The only lands on Earth that have not been explored in any depth by science are those that have been lost to the oceans. Global warming at the end of the last Ice Age led to the inundation of vast landscapes that had once been home to thousands of people. These lost lands hold a unique and largely unexplored record of settlement and colonisation linked to climate change over millennia. Amongst the most significant is Doggerland. Occupying much of the North Sea basin between continental Europe and Britain it would have been a heartland of human occupation and central to the process of re-settlement and colonisation of north Western Europe during the Mesolithic and the Neolithic. Within this submerged landscape lies fragmentary yet valuable evidence for the lifestyles of its inhabitants including the changes resulting from both the encroaching sea and the introduction of Neolithic technologies.This inundated landscape cannot be explored conventionally, however pioneering work by the applicant's research group has led to the rediscovery of Doggerland through the creation of the first detailed topographic maps relating to human occupation in the Early Holocene. Within this project world-leading innovators in the fields of archaeo-geophysics, molecular biology and computer simulation will develop a ground-breaking new paradigm for the study of past environments, ecological change and the transition between hunter gathering societies and farming in north west Europe. It will:1) use the latest seismic reflectance data available to generate topographical maps of the whole of early Holocene Doggerland that are as accurate and complete as possible.2) reconstruct and simulate the palaeo-environments of Doggerland using ancient DNA extracted directly from sediment cores.3) explore the Mesolithic landscapes and also identify incipient Neolithic signals indicating early contact and development within the region of Doggerland.

Project End Date: **11/30/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
648498	**OTTOCONFESSION**	**SH6 - The Study of the Human Past**

Principal Investigator: **Dr. Tijana Krstic**
krstict@ceu.edu

Host Institution: Kozep-Europai Egyetem, HU

The Fashioning of a Sunni Orthodoxy and the Entangled Histories of Confession-Building in the Early Modern Ottoman Empire, 15th-17th Centuries

How and why did the Ottoman Empire evolve from a fourteenth-century polity where "confessional ambiguity" between Sunnism and Shiism prevailed into an Islamic state concerned with defining and enforcing a "Sunni orthodoxy" by the early sixteenth century? Recent historiography attributes this new concern with "orthodoxy" in the Ottoman Empire to the rise of the rival Shii Safavid Empire at the turn of the sixteenth century. However, the OTTOCONFESSION project is based on the premise that the evolution of Ottoman discourse on Sunni orthodoxy can be understood only in a longer perspective that spans the fifteenth and seventeenth centuries, and that it was shaped by religio-political dynamics not only in the Safavid Empire but also within the Christian communities in the Ottoman Empire and in Europe as well.The project sets out to demonstrate that although the polarization between Sunni and Shii Islam on the one hand, and Catholic and Protestant Christianity on the other, resulted from the dynamics specific to the Turco-Iranian world and Europe, respectively, the subsequent processes of confession- (and in come cases state-) building were related and constitute an entangled history of confessionalization that spanned Europe and the Middle East. This entanglement resulted in particular from: the Ottomans' concomitant competition with the Safavids, Habsburgs, and Venetians, and the shared political theologies this entailed; the spread of various Muslim and Christian communities across imperial borders; and the Ottomans' permissiveness towards Catholic, Lutheran and Calvinist missionary activities among the Empire's (mostly Orthodox) Christians. The project will investigate the evolution of the confessional discourses in the Ottoman Empire in both community-specific and entangled, cross-communal perspectives between the fifteenth and seventeenth centuries by focusing on a) agents and strategies; b) textual genres; and c) sites of confessionalization.

Project End Date: **8/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
682081	**COTCA**	**SH6 - The Study of the Human Past**

Principal Investigator: **Dr. Jeremy Taylor**
Jeremy Taylor

Host Institution: The University Of Nottingham, UK

Cultures of Occupation in Twentieth-century Asia

How has foreign occupation shaped culture? What has been the lasting cultural legacy of foreign occupation in those societies where it represented the usual state of affairs for much of the modern era? These are key questions which, in light of ongoing cases of occupation around the world, remain crucial in the 21st century. Cultures of Occupation in Twentieth-century Asia (COTCA) will answer these questions by analysing how occupation—be it under colonial, wartime or Cold War powers—gave rise to unique visual, auditory and spatial regimes in East and Southeast Asia. The core objective of this important project is to produce a paradigm shift in the study of occupation, and to challenge the 'collaboration'/'resistance' dichotomy which has defined the field thus far. It will adopt a transnational, intertextual and comparative approach to the study of cultural expression produced under occupation from the 1930s to the 1970s. It will also break new methodological ground by drawing on and contributing to recent developments in visual, auditory and spatial history as a means of highlighting intersections and cultural convergences across different types of occupation. By doing so, COTCA will, for the first time, determine what occupation looked, sounded and felt like in twentieth-century Asia. The COTCA team will consist of the PI, 2 postdoctoral researchers and 3 PhD students, and will run along 3 streams: (i) Representations of occupation; (ii) sounds of occupation; and (iii) spaces of occupation. Case studies based on hitherto rarely examined examples will be undertaken in each stream. These include: A visual history of Japanese-occupied China; soundscapes of the US naval bases in the Philippines; and, spaces of occupation in late-colonial Malaya. COTCA will also build a Digital Archive which will enable researchers to trace the development of narratives, tropes and motifs common to 'occupation' cultural expression in Asia across national and temporal borders.

Project End Date: **6/30/2021**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
716538	**MedPub**	**SH6 - The Study of the Human Past**

Principal Investigator: **Dr. Samu Niskanen**
samu.niskanen@helsinki.fi

Host Institution: Helsingin Yliopisto, FI

Medieval Publishing from c. 1000 to 1500

Without written transmission, the communication of any learned topic from ancient and medieval times, from theology and philosophy to medicine, science and history, would be snapped and broken. Transmission relies on the fact of 'publication'. But what does 'publishing' mean in the context of a manuscript culture, in which books were copied slowly and singly by hand? What did it mean to 'publish' a book in Western Europe in the Middle Ages? MedPub attempts to understand in breadth and depth, for the first time, the medieval act of publishing. The question it seeks to answer is how did Latin authors publish original works during the period from c. 1000 to 1500. The project's research hypothesis is that publication strategies were not a constant but were liable to change, and that different social, literary, institutional, and technical milieux fostered different approaches to publishing. The act of publishing, therefore, evolved over time, reacting to changes in the wider world. This is a new proposition and opens a new field of study. Results from the project will make a major contribution to our perception of medieval Latin literature—which is the largest surviving body of evidence for the Middle Ages—and even medieval European societal dynamics. The time-frame, c. 1000–1500, embraces Latin literary culture in its high-medieval maturity and its more complex late-medieval developments, ending with a transitional period characterized by the co-existence of the manuscript book and the printed book and witnessing the emergence in Europe of what was to become modern publishing.

Project End Date: **3/31/2022**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
647467	**JEWSEAST**	**SH6 - The Study of the Human Past**

Principal Investigator: **Dr. Alexandra Cuffel**
alexandra.cuffel@rub.de

Host Institution: Ruhr-Universitaet Bochum, DE

Jews and Christians in the East: Strategies of Interaction between the Mediterranean and the Indian Ocean

This project analyzes Jews in Eastern Christian communities and Eastern Christian sources, beyond the Byzantine context, namely, relations between Jews and Christian communities in the Middle East Central Asia, the Caucasus, Ethiopia, and South India. In order to obtain a truly accurate understanding of the dynamics of Jewish-Christian relations in the non-Latin world during the Middle Ages, these various regions and traditions must be studied together because they were all profoundly interconnected through the exchange and translation of texts, artistic motifs and techniques, and other goods, via long-distance trade along the "silk road", the Mediterranean, and the Indian Ocean, which, of course, also entailed the movement and encounter of peoples, Jews and Christians among them. The research team endeavors to answer four intertwined questions: 1) what we can know about actual "real-life" interactions between Jews and a variety of Eastern Christian communities; 2) what were the meanings and functions of invented or rhetorical Jewish identities; 3) what is the significance of Jewish-Christian polemics, both written and visual, in lands or among communities where: a) there were supposedly few to no Jews, or Jewish identity was "invented"; b) there were Jewish and Christian communities who had the opportunity to be in regular contact with one another; 4) how were Christian stories, laws, biblical interpretations, or motifs in which Jews featured prominently, or Jewish tales and motifs about Christians transformed as they were transported from one cultural milieu to another? Because scholars have examined Jewish relations with Christians, and even Muslims primarily in the context of uneven power relationships; namely Jewish-Christian relations in Western Europe or Byzantium, or Jewish-Muslim relations in the Islamic one leaving Jewish-Christian relations untouched apart from shared communal structures, this project opens a new field.

Project End Date: **8/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
648055	**WEIGHTANDVALUE**	**SH6 - The Study of the Human Past**

Principal Investigator:	**Dr. Lorenz Rahmstorf** lorenz.rahmstorf@uni-goettingen.de
Host Institution:	Georg-August-Universitaet Goettingen Stiftung Oeffentlichen Rechts, DE

Weight metrology and its economic and social impact on Bronze Age Europe, West and South Asia

This project explores the economical and societal transformations provoked by weights and measures during the Bronze Age in Western Eurasia. The impact and significance of weight-based measures for value assessments during the Bronze Age is largely unknown und understudied. My objective is to unravel this empirical and intellectual gap in studies of the prehistoric and ancient economy. The project will uncover new sources for the reconstruction of trade and exchange networks due to the identification of a mostly overlooked or ignored class of artefacts: early balance weights. This opens up a new understanding of the nature and extent of the earliest commercial economies in the world. The ambitious project aims to document for the first time potential weights, often of unexpected simple shape, as well as canonical weights, frequently not sufficiently documented in a selection of cases studies between the Atlantic and the Indus. Further focus will be on potential mass-related finished metal objects, standardization and pre-coinage currencies, contributing to the debate on the origins of money. Specific statistical methods and 3D scanning provide a novel tool package to verify assumptions in a rigorous way. Hypotheses to be tested include identifying the potential correlation of the emergence of weight metrology to elucidating the first extensive trade in raw material (like silver, tin), the connection of weights to other administrative and commercial tools like seals and script, and their impact of early conceptions of value. The early dissemination of weights and weighing systems will be analysed systematically on evidence from the Bronze Age in Western Eurasia. The proposed research starts with identifying and documenting potential balance weights and mass related objects by archaeological indications and the rigorous application of various statistical methods, but progresses to developing and testing models of exchange and transfer of innovations.

Project End Date: **7/31/2020**

European Research Council
Executive Agency

Established by the European Commission

Project ID:	Project Acronym:	Evaluation Panel:
694817	**BodyCapital**	**SH6 - The Study of the Human Past**

Principal Investigator:	**Dr. Christian Bonah** bonah@unistra.fr
Host Institution:	Universite De Strasbourg, FR

The healthy self as body capital: Individuals, market-based societies and body politics in visual twentieth century Europe.

From testicular grafting (1920s) to step counting watches (2014), the perceptions and practices of health seeking individuals have been marked by continuities and profound changes during a twentieth century largely shaped by the advent of a communication society. Visuals can be a source to understand transformations by postulating an interactive, performative power of mass media in societies. Which roles did visuals play in changes from public health and human capital collective understandings of the healthy self to new (sometimes debated) perceptions and practices of our bodies as forms of individual capital in an increasing market-economized world?Pursuing these questions, the project focuses on four fields of investigation -food/nutrition; movement/exercise/sports; sexuality/reproduction/infants and dependency/addiction/overconsumption- in Germany, France and Great Britain studied with an entangled history framework.Within this scope the project aims at understanding (1)how visuals shape our health related self-understandings and practices in a continuity/discontinuity from the bio-political to the bio-economic logic. (2) The project will explore and explain how and why understandings of body capital differ or overlap in European countries. (3) The project will analyse if and how visual media serve as a promotion-communication hyphen for twentieth century preventive-self understanding.With a visual perspective on a long twentieth century, the project seeks to better understand changes and continuities in the history of health intertwined with the history of media. This will provide new insights into how the internalization of bodycapital has evolved throughout the past century, how transformations in the media world (from film to TV to internet) play out at the individual level and how health challenges and cultural differences in body perceptions and practices persist in producing social distinction in an age of global information and advanced health systems.

Project End Date: **8/31/2021**