THEME 1: CHEMISTRY FOR LIFE

Symposium 1.1: Chemistry for the generation of artificial biological systems

Cells represent the smallest structural and biological units of all living organisms. However, these entities display an enormous complexity, whose understanding can be approached in different ways. A relevant approach focuses on chemistry and its philosophy of building. Constructing molecules and molecular systems gives the opportunity of exploring the features and the recognition/reactive patterns that characterize molecules, networks and systems of increasing complexity. Moreover, it allows designing and tailoring reaction pathways, modelling specific aspects of living systems, and producing novel biosystems or hybrid bio-chemical systems. Such a vision, fundamentally linked to chemistry, is now emerging as a branch of synthetic biology - often called bottom-up synthetic biology. In this context, two emerging topics are under strong expansion: (1) cell-free systems and (2) expansion of the genetic code. Both heavily relies on chemistry-biology integration.

(1) Cell-free systems have been traditionally used in biochemistry to unveil mechanistic details of biological processes. Chemical synthetic biology uses cell-free systems as powerful alternatives to living cells to engineer systems for specific purposes. Cell-free systems are versatile tools for fundamental and applied studies. They can be realized in the test-tube or can be micro-compartmentalized (e.g., in microfluidic devices or microcompartments) to achieve new promising technologies such as the bio-organic synthesis of drugs, proteins and peptides from non-natural amino acids, biochemical chip based on genetic circuits, biosensors, and ultimately the construction of synthetic cells for nanomedicine or to face the Grand Challenge of life origin on Earth. Cell-free technologies calls for a new blend of chemistry, biochemistry, microfluidics and numerical modelling, and promise applications in the medium-short term. Genetic circuits of increasing sophistication have been reported and characterized in all details. The combination of cell-free systems with micro-compartment aims for the construction of "minimal cells" in the laboratory, with several already-reported important examples. No doubts current efforts on cell-free systems design and construction will impact on next-generation biotechnologies

(2) Natural biopolymers (nucleic acids, proteins, and peptides) represent the fundamental building blocks of biological structures and functions. Chemical modification of natural biopolymers for the crafting of novel entities with hitherto unknown structures and functions has been a central aim of synthetic biology. Technologies such as amber codon suppression and Darwinian *in vitro* evolution have revolutionized the field of synthetic biology. Indeed, a vast diversity of unnatural amino acids could be incorporated into mammalian cells and even into model organisms, providing in cell tools for the monitoring and imaging of the progression of diseases. Moreover, engineered polymerases have been developed to accept a broad range of modified nucleotides which enabled the identification of DNA and RNA sequences capable of binding specifically to targets or catalyse reactions such as the replication of their own encoding sequences. Thus, the symposium will also focus on some aspects of the evolution of proteins and peptide with an expanded genetic code and the generation of chemically nucleic acids displaying properties that markedly deviate from their natural functions.

Overall, this symposium will give an overview of the various chemical approaches currently used in cell-free synthetic biology and in the evolution of unnatural biopolymers.

Keywords:
Synthetic biology, *in vitro* evolution, modified nucleic acids, modified proteins, cell-free systems.

Organizers:

- *Marcel HOLLENSTEIN (Institut Pasteur, Paris, FR)*
- *Vincent NOIREAUX (University of Minnesota, Minneapolis, USA)*
- *Pasquale STANO (University of Salento, Lecce, IT)*

Session 1.1.1: Cell-free synthetic biology for chemistry

Abstract:
Cell-free synthetic biology has arisen as a new research area to accelerate bioengineering and expand the properties of natural biological systems. Cell-free synthetic biology is now used for applied and fundamental applications including chemical engineering, nanotechnologies, medicine, novel biochemistries, synthetic life, gene circuit prototyping. The goal of this session is to highlight the recent advances made in cell-free synthetic biology across many different scales and areas.

Keywords:
Synthetic biology, cell-free systems, single molecules, Fe-clusters, cancer.

Speakers :

- KN: Paul FREEMONT (Imperial College, London, UK)
- IL1: Sven PANKE (ETH, Zurich, CH)
- IL2: Petra SCHWILLE (Max Planck Institute of Biochemistry, Martinsried, DE)

Session 1.1.2: Chemical approaches to expanding the genetic code

Abstract:
Expansion of the genetic code beyond the 20 natural amino acids and the 2 base pair system of DNA is a long-standing goal in synthetic biology. Applications are manifold and include site-selective labeling of biopolymers, development of semi-synthetic organisms, and generation of novel nano and biomaterials. Chemistry plays a central role in the development of this field which will be highlighted in this session.

Keywords:
Expanded genetic code, modified nucleic acids, unnatural amino acids, artificial enzymes, modified proteins, orthogonal ribosome, therapeutic oligonucleotides, Darwinian *in vitro* evolution.

Speakers :

- KN: Jason CHIN (MRC, University of Cambridge, UK)
- IL1: Piet HERDEWYN (KU Leuven, BE)
- IL2: Philipp HOLLIGER (MRC, University of Cambridge, UK)

Symposium 1.2: Chemistry for Translational Medicine

Translational Medicine (TM) is defined by the European Society for Translational Medicine (EUSTM) as "an interdisciplinary branch of the biomedical field supported by three main pillars: benchside, bedside and community". Its ultimate purpose is to improve human health by combining disciplines, resources, expertise, and techniques within these pillars to promote enhancements in prevention, diagnosis, and therapies. Therefore, TM aims at translating fundamental research findings on genes, proteins, cells, tissues, organs and animals into clinical responses to unaddressed medical needs. This multi-faceted rapidly growing discipline brings together people who speak different scientific languages such as physicians, biologists, medicinal chemists, pharmacologists, bioengineers, epidemiologists, patent experts, and many more who have to learn to communicate across disciplines, taking information from one domain and expressing it in another to achieve advances in health care through a highly collaborative approach. Their work is bolstered by quantitative, model-based and mechanistic understanding of disease biology and pharmacology, and consists in leveraging new technology and data analysis tools, in trying to evaluate various biomarkers of pharmacologic responses and assessing the linkage between biomarker responses and clinical endpoints in patients.
Overall, this symposium will give a flavour of the interconnections of the different disciplines such as medicinal chemistry, chemical biology or drug design that play a key role in Translational Medicine, a multi-disciplinary, highly collaborative, "bench-to-bedside" approach to address unmet medical needs.

Keywords:
Chemical space exploration, selective functionalization of biomolecules, in-vivo chemistry, new tools for medicinal chemistry, Chemical biology, Mechanistic probes.

Organizers:

- *Laurent SCHIO (Sanofi, Paris, FR)*
- *Stefan LAUFER (Eberhard-Karls-Universität Tübingen, DE)*
- *Laurent MICOUI (Université Paris Descartes, Paris, FR)*

We have divided this symposium 1.2 dedicated to chemistry for Translational Medicine into three sessions: Chemical reactivity, innovation in drug design and “from chemical biology to therapeutic innovation”

Session 1.2.1: Chemical reactivity : challenges for medical innovation

Abstract:
Exploration of the druggable chemical space requires original tools and new strategies to access novel heterocyclic structures or pseudo peptides that represent challenging bioactive targets. Moreover, these strategies have to be transposable into economically viable industrial chemical processes taking into account intellectual property aspects as well as environmental constraints and high level purity standards.

Keywords:
Chemical space exploration**,** Strategy in synthesis, new reagents, heterocyclic chemistry, click chemistry, antimicrobial peptides, bioactive fungal compounds, selective functionalization of biomolecules.

Thematic honorary lecturer :

- THL: Phil BARAN (Scripps Institute, La Jolla, USA)

Speakers :

- IL1: Frédéric TARAN (CEA, Saclay, FR)
- IL2: Roderich D. SÜSSMUTH (Technical University Berlin, DE)
- IL3: Maxime LAMPILAS (Sanofi, Vitry, FR)

Session 1.2.2: Innovation in drug design

Abstract:
Innovation in human healthcare to provide the patients with original solutions that address unmet medical needs in terms of treatments (new drugs) or prevention (vaccines) implicates the use of drug design. Several examples will be presented to highlight this aspect of translational medicine.

Keywords:
Encoded libraries, in vitro biosynthesis of non-standards peptides, new screening methods, novel classes of targets, successful case study, multistep polysaccharide synthesis, design of new synthetic vaccines.

Speakers :

- KN: Hiroaki SUGA (The University of Tokyo, JP)
- IL1: Laurence MULARD (Institut Pasteur, Paris, FR)
- IL2 : Christa MULLER (University Bonn, DE)

Session 1.2.3: From chemical biology to therapeutic innovation

Abstract:
In this session, challenges in pharmaceutical research and medicinal chemistry's role in addressing them will be presented in different therapeutic area such as cancer or renal failure for example. The translation of fundamental chemical biology findings into therapeutic innovation will be illustrated.

Keywords:
Drug discovery challenges, medicinal chemistry innovation, cancer treatment, fluorescent probes, biological system parameters.

Speakers :

- KN: Karin BRINER (Novartis, Bâle, CH)
- IL1: Raphael RODRIGUEZ (Curie Institute, Paris, FR)
- IL2: Yasuteru URANO (The University of Tokyo, JP)

Symposium 1.3: Nanotechnologies for Health, Food and Beauty

Advanced nanoscale systems for drug delivery have recently received tremendous attention, in particular from the field of nanomedicine. The need for drug nanocarriers that efficiently target diseased areas in the body arises because drug efficacy is often altered by nonspecific cell and tissue biodistribution, and because some drugs, in particular promising biological drugs such as miRNA, are rapidly metabolized or excreted from the body. The passage of the drug molecules and drug delivery system across several physiological barriers (i.e. epithelium, endothelium, cell membrane) represents another important challenge in drug targeting. Due to their huge surface area and many possibilities for surface engineering, nanotechnologies may be used for ex vivo analytical detection of disease markers, too. Owing to impressive progress in materials science and pharmaceutics, a broad range of nanocarriers/nanotechnologies with diverse sizes, architectures and surface properties have been designed. These include liposomes, polymer nanoparticles, micelles, dendrimers, and inorganic nanoparticles as oxides (silica, iron, titanium), quantum dots, gold or metal oxide frameworks. The size of these nanosystems is typically small (from a few tenths to a few hundreds of nanometers) to allow systemic (intravenous) or local (mucosal) administration, to promote drug diffusion within the cell or to perform in vivo or in vitro diagnosis.

In the drug delivery field, current surface functionalization methodologies can impart nanocarriers with the ability to control, at least in part, their pharmacokinetics and biodistribution, whereas delivering drugs to the cells by alternative pathways, allows to overcome certain mechanisms of drug resistance in cancer (incl. multidrug resistance) and infectious diseases which represents an important medical challenge. On-demand drug delivery in spatial-, temporal- and dosage-controlled fashions is also becoming feasible through the design of stimuli responsive systems that recognize their microenvironment and react in a dynamic way, mimicking the responsiveness of living organisms. In this context, synthetic mimics of the Extracellular Matrix (ECM) of different pathological conditions will generate ex vivo human tissue models for pharmacokinetic studies, avoiding the use of animals and moving to a personalized medicine approach. Moreover, the design of « multifunctional » nanomedicines allows combination of various functionalities, by loading in the same nanodevice: (i) two or more drug entities with complementary pharmacological targets or (ii) a chemotherapeutic and an imaging agent for « theranostic » purpose, paving the way for the co-called “personalized” medicine. Apart from drug administration, nanocarriers may also be used for vaccination purposes, in order to elicit a boosted immune response by the delivery of specific antigens. Noteworthy, some nanoformulations have already appeared on the market during the last decade or are in advanced clinical trials (phase III).

Due to the expanding commercialization of products that contain engineered TiO_2 and ZnO nanoparticles in cosmetics and sunscreens for UVR protection, the conditions under which nanoparticles may penetrate the stratum corneum barrier and how their physiochemical properties may influence penetration, systemic translocation and toxicity deserves also to be addressed. It represents an important issue for application in cosmetics and beauty. The symposium will also consider the use of nanodevices for agriculture and food industry.

This symposium will, therefore, contemplate all the aspects related to the use of nanotechnologies for therapy, diagnosis (through in vivo imaging or in vitro detection) and other consumer good applications such as food and cosmetics. The scaling-up and

toxicological issues will be discussed, too. Specifically for nanomedicine, special attention will be focused on how to improve the translation from the bench to the clinic.

Keywords:
Nanomedicine, nanocosmetics, nanodevices for food and agriculture, drug delivery, organic and inorganic nanoparticles, theranostic, nanotoxicology

Organizers:

- *María J. BLANCO-PRIETO (School of Pharmacy, Univ. of Navarra, Pamplona, ES)*
- *Céline FARCET (Advanced Research, L'Oréal Research and Innovation, Aulnay, FR)*
- *Fréderic LAGARCE (INSERM/CNRS, Pharm. Dept., University of Angers, FR)*
- *Francesco STELLACCI (Institute of Materials, EPFL, Lausanne, CH)*

Session 1.3.1: Nanotechnologies for Beauty

Abstract:
The application of nanotechnology to cosmetics provides benefits to consumers such as better UV protection, deeper skin penetration, long-lasting effects, increased colour and finish quality, among others.
The symposium will focus on advanced materials and technologies that interact with skin or hair to enhance cosmetic formulation efficacy, and modify sensory properties or visual effects.

Keywords:
Skin delivery, (bio)surfactants, colloids, foams, polymers, skin/hair surface

Speakers :

- KN: Samir MITRAGOTRI (Eng. & Appl. Sci., U-Harvard, Cambridge, MA, USA)
- IL1: Mark RUTLAND (Dept. Chemistry, KTH, Stockholm, SE)
- IL2: Matteo Gasbarri (EPFL, Lausanne, CH)

Session 1.3.2: Nanotechnologies for Food

Abstract:
There are an increasing number of nanotechnology applications in the food industry. These new applications include nanosystems for delivery of nutrients and supplements, nanosized additives for food, food packaging applications, nanocoatings on food contact surfaces for barrier or antimicrobial properties, etc.
The symposium will focus on progress, opportunities and challenges for nanotechnology-based systems in food.

Keywords:
nanoparticles, functional food, nano-processed food products, nanocoatings.

Speakers :

- KN: Remko BOOM (Agrotechnology & Food Science, University Wageningen, NL)
- IL1: Uri LESMES (Biotechnology & Food Engineering, Technion, Haifa, IL)
- IL2: Liangli (Lucy) YU, (University of Maryland at College Park, MD, USA)

Session 1.3.3: Health

Abstract:
Nanomedicine, the application of nanotechnology to human healthcare, is at the forefront of modern healthcare and disease prevention. Nanoparticles offer a new platform for drug delivery that can greatly increase the targeting and effectiveness of therapy. The current session aims at presenting advances in nanomedicine in relation to the development of novel engineering and advanced tools to treat diseases and improve human health.

Keywords:
Nanomedicine, tissue regeneration, theranostic, drug delivery, stem cells, gene delivery.

Speakers :

- KN: Dan PEER, (Tel-Aviv University, IL)
- IL1: Andreas BERNKOP-SCHNÜRCH (University of Innsbruck, AT)
- IL2: Jesus SANTAMARIA, (Aragon Nanosciences Institute, U-Zaragoza, ES)

Symposium 1.4: Polymers and soft materials for Life Sciences

Polymers are macromolecules composed of many repeated subunits of different nature leading to a broad range of compositions and properties. Both synthetic and natural polymers play a major role in life sciences.

Natural polymers (nucleic acids, proteins, peptides) are the building blocks of biological structures and functions, and the support of genetic and epigenetic events which are essential for the living processes to occur. Subtle modifications in the sequence of these polymers may lead to either improvements of certain biological processes or, in contrast, to their deregulation with the appearance of physiopathological events and diseases.

Polymerization of monomers through various modern synthetic routes (e.g., controlled radical polymerization, ring-opening polymerization, etc;) enables the design of *synthetic polymers* with unique physico-chemical properties, including robustness, viscoelasticity, and a tendency to form glasses and semicrystalline structures rather than crystals. They may be combined to form tailor made supramolecular architectures such as colloids, gels, etc. The versatility of the polymer structures and the resulting properties offer many applications in the medical and pharmaceutical fields. Additionally, some polymers, either natural or synthetic, may also act as drugs by themselves, or be used in many different bio-related applications such as artificial materials for tissue repair and reconstruction, healing devices, biodegradable vascular substitutes, drug excipients, implants, surgical sutures, etc. « Smart » polymers, designed to undergo reversible physical or chemical changes in response to environmental stimuli (such as temperature, light, magnetic or electric field, pH, ionic strength or enzymes) also hold great promise as drug delivery systems, tissue engineering scaffolds, cell culture supports, bioseparation devices, sensors and even actuators systems.

Polymers also represent an important class of ingredients in cosmetic and food science, as many polymers are employed as film formers, rheology modifiers, emulsifiers, stimuli-responsive agents, or even antimicrobial agents. They can eventually be used for the encapsulation of aromas and flavors or on the contrary, as taste maskers. Data storage using synthetic polymers is another emerging topic to be considered.

The symposium will also focus on some aspects of the synthesis of gels and soft matters for biomedical applications and give perspective on the use of these materials for in vitro and in vivo applications. Gels and hydrogels made by polymers or other soft materials fascinate chemists, material scientists and biomedical researchers since their unique properties will allow also 3D printing of fissues and organs. They can consist of a self-supporting, water/solvent-swollen three-dimensional (3D) viscoelastic network, and can possess self-healing properties, reconfigurable structures and interesting transitions between shapeless to shape persistent structures. Many gels have been designed and used for the diffusion and attachment of molecules and cells since their behavior is reminiscent of the extracellular matrix (ECM) and offers native culture condition that traditional 2D surfaces cannot reproduce.

This symposium will give an overview of the importance of polymers and soft materials in life sciences, from fundamental research to applications.

Keywords:
Natural and synthetic polymers, soft matter, 3D-printing, supramolecular chemistry, pharmaceutics, medical devices, regenerative medicine, cosmetics, food.

Organizers:

- *Julien NICOLAS (Institut Galien, CNRS, Université Paris-Sud, FR)*
- *Brent SUMERLIN (University of Florida, Gainesville, USA)*
- *Sebastien PERRIER (U-Warwick, UK, and U-Monash, AU)*

Session 1.4.1: Soft nanosystems for drug delivery applications

Abstract:
Drug efficacy is often altered by nonspecific cell and tissue biodistribution and because some drugs are rapidly metabolized or excreted from the body. Nanoscale systems have recently received tremendous attention as possible means to tackle these issues. In this context, the current session will provide insights on the new trends for design of advanced nanosytems based on polymers and soft materials for drug delivery applications to treat severe diseases including cancer, infections, neurodegenerative disorders, etc.

Keywords:
Polymers, biomaterials, nanoparticles, micelles, drug delivery, nanogels, prodrug, cancer, anticancer activity, bioconjugates, nanocapsules, etc.

Symposium Honorary lecture :

- THL: Krzysztof MATYJASZEWSKI (U-Carnegie-Mellon, Pittsburgh, USA)

Speakers :

- KN: Paula T. HAMMOND (MIT, Cambridge, USA)
- IL1: Sébastien LECOMMANDOUX (ENSCPB, Bordeaux, FR)
- IL2: Yi Yan YANG (National University of Singapore, SG)

Session 1.4.2: Self-assembled and engineered soft materials for life sciences

Abstract:
The engineering of polymers and soft materials, together with the control of their self-assembly to generate complex and smart systems, is currently a topic of great interest, especially for the life sciences. This session will provide insights on chemistry and polymer chemistry to propose advanced materials in the fields of nano- and biomaterials for biotechnology and medicine, smart compartments with life-like features, nanoreactors. actuating systems, artificial materials, sensors, etc..

Keywords*:*
Smart materials, nanoreactors, compartments, life-like, artificial muscles, nanomachines, template synthesis, biomolecular engineering, biohybrids, capsules, etc.

Speakers :

- KN: Molly STEVENS (Imperial College, London, UK)
- IL1: Jan VAN HEST (Radboud University, Eindhoven, NL)
- IL2: Nicolas GIUSEPPONE (Institut Charles Sadron, CNRS, Strasbourg, FR)

Session 1.4.3: Soft materials for biomedical and other life science application

Abstract:
Applications of polymers and soft materials in bio-related areas range a number of applications, including tissue engineering, 3D scaffolds and cell culture, cell delivery, biological arrays, etc. Such building blocks are also important in cosmetics and food science. The current session aims at presenting advanced soft materials and technologies covering these aspects.

Keywords:
Tissue engineering, self-healing, surgical glue, hydrogel, gel, nanogels, food, cosmetics, etc.

Speakers :

- KN: Kristi S. ANSETH (U-Colorado, Boulder, USA)
- IL1: Tanja WEIL (Max-Planck-Institute für Polymerforschung, Mainz, DE)
- IL2: Ben Zhong TANG (Hong Kong University of Science and Technology, CN)