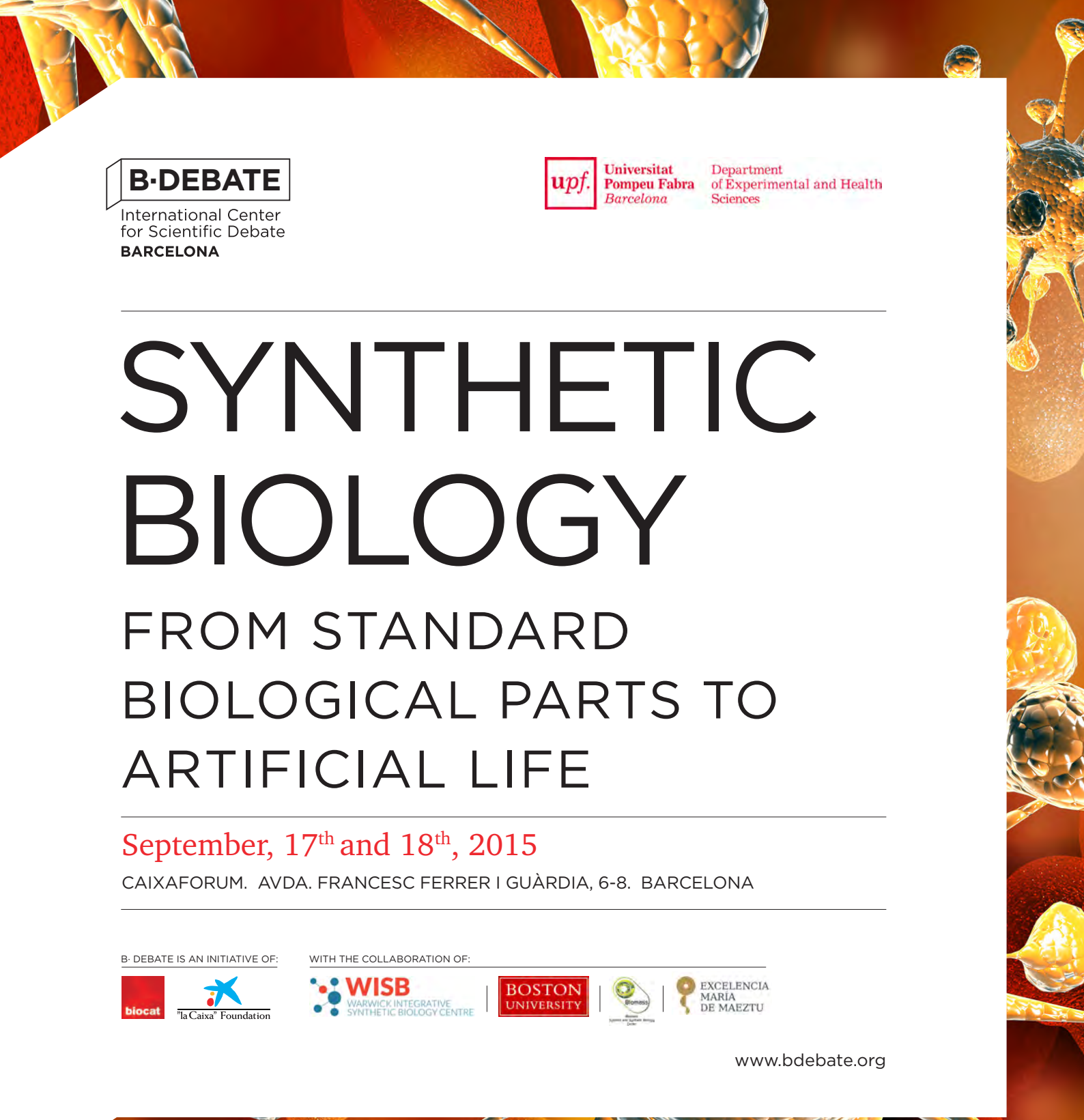

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International Center
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BARCELONA

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Department of Experimental and Health Sciences

SYNTHETIC BIOLOGY

FROM STANDARD BIOLOGICAL PARTS TO ARTIFICIAL LIFE

September, 17th and 18th, 2015

CAIXAFORUM. AVDA. FRANCESC FERRER I GUÀRDIA, 6-8. BARCELONA

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"B·Debate strives to help position Barcelona as a benchmark in generating knowledge and Catalonia as a country of scientific excellence"

B·Debate is an initiative of Biocat with support from "la Caixa" Foundation which aims to drive top-notch international scientific events to foster debate, collaboration and open exchange of knowledge among experts of renowned national and international prestige. The debates are focused on the integration of diverse disciplines of science in order to tackle major scientific and societal challenges.

SYNTHETIC BIOLOGY

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WELCOME

Dear participants,

It is a great pleasure for us to welcome you to the meeting "Synthetic Biology: From Standard Biological Parts to Artificial Life". This event is organized by B·DEBATE (an initiative of Biocat and "la Caixa" Foundation), together with an international consortium of four university research centers: the Warwick Integrative Synthetic Biology Centre (WISB) of the University of Warwick, the Biological Design Center of Boston University, the Biomass Systems and Synthetic Biology Center (BSSB) of the University of Sao Paulo, and the Department of Experimental and Health Sciences of the Universitat Pompeu Fabra.

Synthetic biology is quickly becoming a mature field, involving a variety of approaches that are frequently isolated from each other, including the design of gene and protein circuits from standard biological parts, the development of new genetic codes, and the creation of artificial cells (protocells) and organisms. In addition to this multiplicity of methods, the swift development of the field is being driven by a juxtaposition of different motivations. On the one hand, some researchers uses synthetic biology to increase our understanding of living processes by designing them from the bottom up. In that way, synthetic biology shows us what possible behaviors can arise from combining the building blocks of life in different ways. On the other hand, an increasing number of researchers use synthetic biology to implement novel applications in which engineered organisms perform complex tasks not easily amenable to traditional engineering methods, such as cancer detection and treatment, fuel generation, drug production, and recently even the re-creation of extinct species.

The goal of this meeting is to establish a dialogue between researchers working in the different flavors of synthetic biology, ranging from fundamental science to cutting-edge applications, and including the societal and ethical issues that this new technology is generating on a daily basis. The discussions should help clarify the future directions of the field, and the steps needed to make synthetic biology closer to applications that would effectively address a large variety of societal needs, including healthcare, environmental preservation, and biotechnological process optimization.

We wish you all a most pleasant stay in Barcelona and look forward to two exciting days of lively discussions. Thank you for being here!

Jordi Garcia-Ojalvo, Scientific leader of the event, and B·DEBATE

PROGRAM

Thursday, September, 17th, 2015

9:00	**Welcome** **Enric Banda**, Director of the Department of Science, "la Caixa" Foundation, Barcelona **Laia Arnal**, Head of Research and Scientific Debate, Biocat, Barcelona **Arcadi Navarro**, Director of the Department of Experimental and Health Sciences, UPF, Barcelona **Jordi Garcia-Ojalvo**, Universitat Pompeu Fabra, Barcelona, Spain
9:15	**SESSION 1: EXPANDING THE TOOLBOX** Chair: **John McCarthy**, University of Warwick, Coventry, UK
9:15	**Naturally-Inspired Engineering of Biological Systems** **Ahmad Khalil**, Boston University, USA
9:45	**Synthetic RNA Wires in E. coli** **Alfonso Jaramillo**, University of Warwick, Coventry, UK
10:15	**Multisite Phosphorylation Networks as Tunable Circuit Elements for Synthetic Biology Applications** **Mart Loog**, University of Tartu, Estonia
10:45	**Coffee Break**
11:15	**Synthetic Genomics: from Genetic Parts to Genomes** **Yizhi Cai**, University of Edinburgh, UK
11:45	**How to Assemble Minimal Life Bottom Up?** **Steen Rasmussen**, University of Southern Denmark, Denmark
12:15	**Engineering Synthetic Development: How Many Ways Can You Make a Stripe?** **Mark Isalan**, Imperial College London, UK
12:45	**Open Debate**
13:15	**Lunch**
14:30	**SESSION 2: EXPANDING THE HORIZON** Chair: **Jaume Bertranpetit**, Universitat Pompeu Fabra, Barcelona, Spain
14:30	**Programming and Perturbing Cell Signaling Networks** **Wendell Lim**, University of California San Francisco, USA
15:00	**Transposable Elements: Moving Genomic Islands Around** **Marie-Anne Van Sluys**, University of Sa o Paulo, Brazil
15:30	**A Solution to Conflicts in a Growing Biofilm** **Munehiro Asally**, University of Warwick, Coventry, UK
16:00	**Coffee Break**
16:30	**Synthetic Transitions** **Ricard Solé**, Universitat Pompeu Fabra, Barcelona, Spain
17:00	**Cyborg-ization of Soil Bacteria for Smart Degradation of Environmental Pollutants** **Victor de Lorenzo**, Centro Nacional de Biotecnología, Madrid, Spain
17:30	**Open Debate**

PROGRAM

Friday, September, 18th, 2015

9:15	**SESSION 3: QUANTIATIVE APPROACHES** Chair: **Marta Ibañes**, University of Barcelona, Barcelona, Spain
9:15	**Synthetic Biology for Human Health Applications** **Timothy Lu**, Massachusetts Institute of Technology, Cambridge, USA
9:45	**Evolutionary Design Principles for Synthetic Biology** **Orkun Soyer**, University of Warwick, Coventry, UK
10:15	**The Wrong Use of Hill Functions for Synthetic Biology Designs: Lessons from Enzymology** **Carlos Rodriguez-Caso**, Universitat Pompeu Fabra, Barcelona, Spain
10:45	**Coffee Break**
11:15	**Cybergenetics: Synthetic Circuits and Systems for the Precise Control of Living Cells** **Mustafa Khammash**, ETH Zürich, Switzerland
11:45	**Design of Bimolecular Feedback Control Systems** **Declan Bates**, University of Warwick, Coventry, UK
12:15	**Design, Construction & Function of Genomically Recoded Organisms** **Farren Isaacs**, Yale University, New Haven, USA
12:45	**Open Debate**
13:15	**Lunch**
14:30	**SESSION 4: FROM THE BENCH TO SOCIETY** Chairs: **Christopher Coenen**, Karlsruhe Institute of Technology, Karlsruhe, Germany and **Lauren Swiney**, University of Warwick, Coventry, UK
14:30	**From Standard Biological Parts To Artificial Life? A Sociological Perspective** **Jane Calvert**, University of Edinburgh, UK
15:00	**The Glycomic Code: How the Complex Metabolic Network of Polysaccharides in Plant Cells Generates a Code that Supports Life on Earth** **Marcos Silveira Buckeridge**, University of Sao Paulo, Brazil
15:30	**Do you Believe in Standards?** **Manuel Porcar**, University of Valencia, Spain
16:00	**Coffee break**
16:30	**Lessons from History: Promises and Realities of the Artificial Synthesis of Life** **Juli Peretó**, University of Valencia, Spain
17:00	**Synthetic Biology – of Fundamental Concepts and First Applications** **Sven Panke**, ETH Zürich, Switzerland
17:30	**Open Debate**
18:00	**Closing Remarks**

SCIENTIFIC COMMITTEE

Jordi Garcia-Ojalvo, Director of the Dynamical Systems Biology laboratory, Department of Experimental and Health Sciences, **Universitat Pompeu Fabra**, Barcelona, Spain

Jordi Garcia-Ojalvo obtained his PhD in statistical physics at the University of Barcelona in 1995. He did postdoctoral work at the Georgia Institute of Technology in Atlanta in 1996, working on laser dynamics, and at the Humboldt University of Berlin in 1998 as an Alexander von Humboldt Fellow, studying noise effects in excitable media. He was IGERT Visiting Professor at Cornell University in Ithaca, New York, in 2003, at which time he began working in the field of systems biology. In 2008 he became Full Professor at the Universitat Politecnica de Catalunya, where he had been teaching applied physics since 1991. He is Visiting Research Associate in Biology at the California Institute of Technology since 2006, and joined the Universitat Pompeu Fabra in October 2012.

Ricard Solé, ICREA Research Professor, Head of the Complex Systems Lab, **Universitat Pompeu Fabra**, Barcelona, Spain

Ricard Solé is ICREA research professor (the Catalan Institute for research and Advanced Studies) currently working at the Universitat Pompeu Fabra, where he is the head of the Complex Systems Lab located at the PRBB. He teaches undergraduate courses on Biomathematics, principles of biological design and cell-tissue engineering. He completed degrees in both Physics and Biology at the University of Barcelona and received my PhD in Physics at the Polytechnic University of Catalonia. He is also External Professor of the Santa Fe Institute (New Mexico, USA). He has received a European Research Council Advanced Grant (ERC 2012) and support from the Fundación Botin. His main goal is exploring the evolutionary origins of complexity in both natural and synthetic/artificial systems. A key aspect of this research is considering the nature and universality of the so called Major Evolutionary Transitions and to what extent we can replicate them (or not) using synthetic approaches, including artificial life approaches, synthetic biology experiments and evolved neural networks.

Francesc Posas, Cell Signaling Research Group, Department of Experimental and Health Sciences, **Universitat Pompeu Fabra**, Barcelona, Spain

Francesc Posas is Full Professor of Biochemistry and Molecular Biology at the Department of Experimental and Health Sciences of the Universitat Pompeu Fabra (UPF). After obtaining his doctorate in Biochemistry and Molecular Biology at the Universitat Autònoma de Barcelona (1995), he made his postdoctoral stay at Harvard University (Boston, USA). From 1999 leads the Cell Signaling Research Group (http://www.upf.edu/cellsignaling). Dr. Posas received the award to Young Investigators from the Catalan Government (2001), EMBO Young Investigator Program (2000), EURYI to young investigators from the EU (ESF) (2004), EMBO member (2006), awarded with an ICREA Academia Researcher for University Professors. Recently he has been awarded, together with Dr. Ricard Solé (UPF), an ERC Advanced Grant with a project based on biological computation.

John McCarthy, Professor of Molecular Systems Biology, Director, **Warwick Integrative Synthetic Biology centre** (WISB), School of Life Sciences, **University of Warwick**, Coventry, UK

John McCarthy studied Biochemistry in Oxford and began his research career studying the biochemistry and biophysics of electron transport–dependent ATP synthesis. In subsequent years in Germany he switched to research on mechanisms underpinning the control and regulation of gene expression and became a Department Head in one of Germany's Federal Research Institutes. He also engaged with various challenges in biotechnology, collaborating with a large number of biotechnology and pharmaceutical companies. John moved to Manchester in 1996, where he was Head of the Department of Biomolecular Sciences at UMIST 1998-2000. He took on leadership of the Manchester Interdisciplinary Biocentre project in 1998, and was Director of this institute from 2004 until 2010, when he moved to become Head of Life Sciences at the University of Warwick. John was the recipient of a Wolfson-Royal Society Merit Award in 2002, and was awarded a BBSRC Professorial Fellowship in 2007. John is currently Director of the BBSRC/EPSRC-funded Warwick Integrative Synthetic Biology centre (WISB). He has organised many international scientific conferences and international postgraduate training courses, with an increasing focus on novel interdisciplinary research areas, and was one of the founding Editors of the RSC journal Integrative Biology. His current research interests include rate control and noise in the eukaryotic gene expression pathway, and a range of synthetic biology projects.

Ahmad Khalil, Innovation Career Development Assistant Professor, Dept. of Biomedical Engineering and Associate Director, Biological Design Center, **Boston University**, Boston, USA

Ahmad (Mo) Khalil is the Innovation Career Development Assistant Professor of Biomedical Engineering, and the Associate Director and Founding Core Member of the Biological Design Center at Boston University. He is also a Visiting Scholar at the Wyss Institute for Biologically Inspired Engineering at Harvard University. His research is broadly focused on understanding how cells use molecular networks to process information and make decisions. His lab employs multidisciplinary approaches, with emphasis on synthetic biology, to explore and engineer these complex cellular systems. He is recipient of the National Science Foundation CAREER Award, and has received numerous awards for achievements in life science innovation, including a Kern Faculty Fellowship, a Wallace H. Coulter Translational Award, and a Dean's Catalyst Award. He has also received awards for teaching excellence and was selected to attend the 2014 National Academy of Engineering Frontiers of Engineering Education. Mo was an HHMI Postdoctoral Fellow with Dr. James Collins at Boston University. He completed his Ph.D. with Dr. Angela Belcher at MIT, where he was awarded a Charles Stark Draper Laboratory Graduate Fellowship. He graduated Phi Beta Kappa from Stanford University with a B.S. in Mechanical Engineering and a minor in Chemistry.

INVITED SPEAKERS

Thursday, September, 17th, 2015

John McCarthy, Professor of Molecular Systems Biology, Director, **Warwick Integrative Synthetic Biology centre** (WISB), School of Life Sciences, **University of Warwick**, Coventry, UK

Chair of the SESSION 1: EXPANDING THE TOOLBOX

See his CV at the Scientific Committee Section

Ahmad Khalil, Innovation Career Development Assistant Professor, Dept. of Biomedical Engineering and Associate Director, Biological Design Center, **Boston University**, Boston, USA

See his CV at the Scientific Committee Section

Naturally-Inspired Engineering of Biological Systems

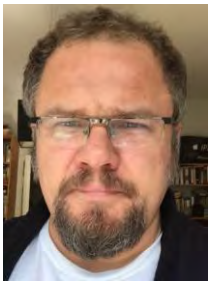
A universal feature of natural regulatory systems, from transcriptional to signaling, is the assembly of multi-component molecular complexes. Molecular assemblies play key roles within biological networks, serving as sophisticated information processing hubs and allowing increased programmability of network connections in time and space. I will describe our efforts to use synthetic biology to explore and engineer this ubiquitous form of cellular regulation using eukaryotic transcription as a model. Throughout, I will highlight new technologies we have been developing to subject (engineered) cells to complex environmental conditions and to study their response at high-resolution and over long experimental times. By developing a molecular programming language that looks more like the programming language evolution has built, we hope to provide a bottom-up paradigm for studying complex regulation and networks, and a more efficient, powerful, and naturally-inspired means of engineering new cellular functions.

Alfonso Jaramillo, Professor of Synthetic Biology, **University of Warwick**, Coventry, UK

Professor Alfonso Jaramillo holds a PhD in Particle Physics (1999) and a Habilitation in Biology (2007). After postdoctoral appointments with Prof. Wodak (ULB, Brussels) and Prof. Karplus (ULP, France and Harvard, USA), he started in 2003 as Assistant Professor at the Ecole Polytechnique (France), becoming tenured in 2005. There, he further developed computational synthetic biology. In 2009, after moving to Genopole (France) as CNRS-senior researcher, he started engineering novel RNA-based circuits in bacteria, allowing the reprogramming of living cells with a synthetic signal transduction system. In 2013, he opened a second lab at the University of Warwick (UK), where he holds the Chair of Synthetic Biology. He has been coordinating several Synthetic Biology international consortia and he is member of the editorial boards of ACS Synthetic Biology and the J. of Biol. Engineering. His lab is currently engineering RNA circuits and synthetic bacteriophages by combining computational design, genome engineering and directed evolution.

Synthetic RNA Wires in E. coli

The engineering of RNA devices able to detect nucleic acids would enable the detection of bacteria propagating high levels of antibiotic resistance or virulence, or bacteria involved in nosocomial or pandemic infections, major health problems. They could also be used to produce scalable synthetic regulatory circuits able to detect complex RNA levels of endogenous genes, which would have important applications in medicine. The development of RNA-based devices in living cells able to sense small-molecules could allow the post-transcriptional control of cellular phenotypes during fermentation, which would open the way to use synthetic strains in industrial biotechnology. The advance of our knowledge of RNA structure is allowing the engineering of multifunctional RNA molecules by using computational design techniques. These are limited by the lack of feedback from experimentation to modelling, particularly considering the time response at the single-cell level. More accurate biological modelling will not only facilitate the engineering of biology, but it will eventually lead to the quantitative prediction of phenotype from genotype. We developed a computational and experimental methodology facilitating the engineering of RNA-based signal transduction systems in living cells, which is used to generate genetically-encoded devices for the detection of specific small-molecules and nucleic acids. Our work provides a new strategy to engineer synthetic regulatory networks using RNA.



Mart Loog, Professor of Molecular Systems Biology, Institute of Technology, **University of Tartu**, Tartu, Estonia

Mart Loog is professor of molecular systems biology and head of a research group at the Institute of Technology, University of Tartu. Mart received PhD in medicinal biochemistry from Uppsala University, Sweden in 2002, followed by postdoctoral training at University of California, San Francisco. In 2006 Mart established his laboratory at the newly established Institute of Technology. He has received several international fellowships and awards including The Welcome Trust Senior International Fellowship and a startup research grant from European Molecular Biology Organization (EMBO) and Howard Hughes Medical Institute (HHMI). In 2012 he received Estonian National Science Prize in chemistry and molecular biology. In 2015 he was awarded the ERC Consolidator Grant and became a principal coordinator of a H2020 ERA Chair project SynBioTEC to establish the multidisciplinary Centre of Synthetic Biology. Mart's research directions include regulation of eukaryotic cell cycle, synthetic circuit design and systems biology of regulatory networks.

Multisite Phosphorylation Networks as Tunable Circuit Elements for Synthetic Biology Applications

Multisite phosphorylation of proteins is a powerful signal processing mechanism playing crucial roles in cell division and differentiation as well as in disease. We recently demonstrated a novel phenomenon of multisite phosphorylation in cell cycle regulation. We showed that cyclin-dependent kinase (CDK)-dependent multisite phosphorylation of a crucial substrate is performed semiprocessively in the N-to-C terminal direction along the disordered protein. The process is controlled by key parameters including the distance between phosphorylation sites, the distribution of serines and threonines in sites, and the position of docking motifs. According to our model, linear patterns of phosphorylation networks along the disordered protein segments determine the net phosphorylation rate of the protein. Additionally, by introducing diversional phosphorylation sites for multiple kinase inputs three-branched switches can be designed. Similar principles of sequential signal processing via multisite phosphorylation can be applied to synthetic circuit design. A toolbox of synthetic parts based on multisite phosphorylation would revolutionize the field because of the fast time scales and wide combinatorial possibilities.

Yizhi Cai, co-Director, Edinburgh Genome Foundry, **University of Edinburgh**, Edinburgh, UK

"Patrick" Yizhi Cai received a bachelor degree in Computer Science in China, a master degree in Bioinformatics from University of Edinburgh in the UK, and a PhD in Genetics, Bioinformatics and Computational Biology from Virginia Tech in the USA. Cai has his postdoctoral fellowship under Jef Boeke in the Johns Hopkins University School of Medicine. Cai serves as a senior scientific consultant to Beijing Genomics Institute, and is the first Autodesk Distinguished Scholar. Starting summer 2013, Cai starts his own research group at the University of Edinburgh with a prestigious Chancellor's Fellowship, and his lab focus on Computer Assisted Design for Synthetic Biology, NeoChromosome design and synthesis in the yeast, and DNA assembly automation. Dr. Cai found and directs Edinburgh Genome Foundry, a UK national facility for automated DNA synthesis and assembly.

Synthetic Genomics: from Genetic Parts to Genomes

The Synthetic Yeast genome project, or Sc2.0 (www.syntheticyeast.org), aims to design, construct, and replace the native 12Mb genome of Saccharomyces cerevisiae with a fully synthetic version. Sc2.0 chromosomes encode a myriad of designer changes. First, to improve genomic stability, destabilizing elements such as transposons and tRNA genes are removed from the synthetic genome. Second, synonymously recoded sequences called PCRtags permit encryption and tracking of the synthetic DNA. Finally, to enable downstream genetic flexibility, Sc2.0 encodes an inducible evolution system called SCRaMbLE (Synthetic Chromosome Rearrangement and Modification by LoxP-mediated Evolution) that can generate combinatorial genetic diversity on command. To date, ~10% of the genome has been synthesized and we have powered a semi-synthetic yeast entirely dependent on multiple synthetic chromosome arms designed to our specifications. Software and experimental infrastructure developed to facilitate Sc2.0 genome design and construction are applicable to new projects ranging from single gene/pathway design to synthesizing artificial chromosomes. Sc2.0 international partners include Imperial College London, Edinburgh University (UK); Tsinghua University, Tianjin University, BGI (China) and New York University. Sc2.0 has the potential to revolutionize the future of genome structure-function analysis.

Steen Rasmussen, Professor in Physics and Director at the **Center for Fundamental Living Technology**, University of Southern Denmark, and Research Professor at the **Santa Fe Institute**, New Mexico, USA

PhD in physics and postdoc at the Technical University of Denmark. Since 1988 at Los Alamos National Laboratory and the Santa Fe Institute New Mexico, USA. During his 20 years in the USA (1988-2007, Alien of Extraordinary Abilities) he contributed to a variety of interdisciplinary research projects ranging from artificial life and human genome to disaster mitigation and urban transportation. He eventually became the Scientific Team Leader of the Self-Organizing Systems (SOS) team in 2002. Over the last twelve years his main effort has been to construct minimal protocells bottom up from nonliving organic and inorganic components. To do that he has organized, sponsored and lead international research teams in the US, across Europe and in Denmark, where he returned in 2007. More recently he has also engaged as a science policy advisor and in exploring likely societal impacts of intelligent and living technologies.

How to Assemble Minimal Life Bottom Up?

A design strategy to achieve a minimal self-reproducing and evolving physicochemical system was outlined in Rasmussen et al. (2003, 2004). To reach this goal we have defined a chemical dependency between three component subsystems, a metabolism, an informational system and a container. In this arrangement, the replication of the information molecules depends on the formation of the container, while the production of new container- and information molecules depends on the work of the metabolism. Finally, the information molecules control the metabolic rate. We present our main results regarding the individual components as well as an integration of the three physicochemical systems, the metabolism, information system and the container (Ikari et al., 2015, Cape et al., 2012; Fellermann et al., 2011; DeClue et al., 2009, Rouchelau et al., 2007). Further, we discuss the main open questions we have regarding implementing a non-enzymatic replication of container attached conjugated DNA molecules. Finally, we outline the more general open issues about which kind of evolution we might expect for bottom up self-assembled protocells, ranging from simple optimization to open-ended evolution of functionalities (Tanaka et al., 2014, Bedau et al., 2003).

Mark Isalan, Reader in Gene Network Engineering, **Imperial College London**, London, UK

Mark Isalan heads the Gene Network Engineering group in the Dept. of Life Sciences at Imperial College London. He carried out a Ph.D. in engineering zinc fingers to bind new DNA sequences at the MRC LMB, in the University of Cambridge UK,1996-2000. This work was supervised by Prof. Sir Aaron Klug, OM, FRS, and continued postdoctorally from 2000-2002 at Gendaq Ltd, UK (now owned by Sangamo Biosciences, Richmond CA). The work ultimately contributed to the CompoZr zinc finger nucleases now available commercially from Sigma Aldrich. From 2002-2006 Dr. Isalan was awarded a Wellcome Trust International Research Fellowship to carry out research on engineering artificial gene networks in Prof. Luis Serrano's group at the EMBL Heidelberg, Germany. From 2006-2013 he was a group leader at the EMBL-CRG Systems Biology Unit in Barcelona, specialising in synthetic gene network engineering. He moved to Imperial College London in 2013 and continues to work in protein and gene network engineering, aiming to design biological systems that behave predictably and robustly

Engineering Synthetic Development: How many Ways can you Make a Stripe?

Synthetic biology is a promising tool to study the function and properties of gene regulatory networks. Gene circuits with predefined behaviors have been successfully built and modeled, but largely on a case-by-case basis. In this talk, I will present work where we go beyond individual networks and explore both computationally and synthetically the design space of possible dynamical mechanisms for 3-node stripe-forming networks. First, we computationally test every possible 3-node network for stripe formation in a morphogen gradient. We discover four different dynamical mechanisms to form a stripe and identify the minimal network of each group. Next, with the help of newly established engineering criteria we build these four networks synthetically and show that they indeed operate with four fundamental distinct mechanisms. Finally, this close match between theory and experiments allows us to infer and subsequently build a 2-node network that represents the archetype of the explored design space.

Jaume Bertranpetit, Professor of Biology at the **Pompeu Fabra University**, Barcelona, Spain

Chair of the SESSION 2: EXPANDING THE HORIZON

Group leader in the Evolutionary Biology and Complex Systems Program in this University. Promoter of the Institute for Evolutionary Biology, IBE (UPF-CSIC). Former Professor at the Barcelona University. His research field is in different aspects on the study of the human genome variation and diversity: human population genetics, molecular evolution, comparative genomics and the interaction between human evolutionary biology and other fields, including medicine, genetic of complex diseases, statistical genetics and others. Recent publications are mainly on the footprint of natural selection in the human genome and the emerging field of Evolutionary Systems Biology, with the relationship of molecular networks and adaptation in genome-wide perspective. He has published over 300 research papers, most of them since his major dedication to genome studies (since 1992). Member of the Institut d'Estudis Catalans and a number of international organizations. Director of ICREA (Institució Catalana de Recerca i Estudis Avançats).

Wendell Lim, Department of Cellular and Molecular Pharmacology, **University of California San Francisco**, San Francisco, CA, USA

Professor and Chair, Dept. of Cellular and Molecular Pharmacology. Investigator, Howard Hughes Medical Institute. Director, UCSF Center for Systems & Synthetic Biology. Deputy Director, NSF Synthetic Biology Engineering Research Center (A.B., Harvard University, Chemistry; Ph.D., Massachusetts Institute of Technology, Biochemistry & Biophysics, Postdoctoral Fellow; Yale University, Molecular Biophysics). Wendell Lim is interested in understanding how genetically encoded molecular programs can yield the remarkable regulatory behaviors observed in biological organisms, at multiple scales. They utilize a mechanistic understanding of molecules as a foundation to study how systems of interacting molecules assemble to yield cellular or organismal signaling behaviors – complex behaviors in both space and time. His lab is interested in both the fundamental principles governing these molecular programs, as well as the way such programs have evolved. They use synthetic biology as an approach to systematically understand the design principles of molecular networks, as well as an approach to engineer cells with useful designed behaviors, such as therapeutic immune cells that are custom programmed to recognize and treat cancer or other diseases.

Programming and Perturbing Cell Signaling Networks

They are interested in the design principles of cell signaling circuits that allow cells to sense their environment, to process this information, and to make complex response decisions. They are using synthetic biology approaches to systematically reconstitute signaling networks in order to better understand their design logic and fitness tradeoffs. They are also harnessing our increasing understanding to build cells with useful customized sensing-actuator functions, such as therapeutic immune cells that can recognize and treat cancer or other diseases.

Marie-Anne van Sluys, Professor at the **Biomass Systems and Synthetic Biology Center**, University of São Paulo, Brazil

Marie-Anne Van Sluys, Professor at the Botany Department of the University of São Paulo (USP), holds a BA in biological sciences (Rio de Janeiro State University, 1983) and a PhD in Biology (University of Paris-Sud 11, 1989). Dr Van Sluys heads the Genomes and Transposable Elements (GaTE) Laboratory/USP, is an Adjunct Member of the Life Sciences Advisory Committee at the São Paulo Research Foundation (FAPESP) and was the president of the Research Committee of the Biosciences Institute/USP (2006-2008). Dr Van Sluys work on Arabidopsis thaliana contributed to the concept that transposons are active in other plant systems and was the first to demonstrate that specific DNA methylation, targeted to the certain positions, was molecularly involved in the activation/inactivation cycling. Dr Van Sluys led one of the FAPESP groups that resulted in Nature 2000 publication of the first plant pathogen genome. As a consequence, she undertook the international leadership of the collaboration with USDA-ARS and was invited to join the Committee on California Agricultural Research Priorities – Pierce's Disease from the National Research Council (NRC USA) in 2003. Her work on genomics and transposable elements contributed to unravel the association of these moving units with genomic islands that define species and pathotypes in Xanthomonas. Dr. Van Sluys has authored more than 80 publications in the field of genetics, with an emphasis on the molecular biology of plants and bacteria. Today her research interests focus: genomics; DNA repair in plants; and transposable elements in bacteria and plants. Recently, she was one of the founders of the Bioenergy Research Program (BIOEN)/FAPESP with a broad spectra view where five research divisions are proposed: Biomass, Processes, Alcohol Chemistry, Engines and Impacts. Her leadership motivated 32 professionals to join her group at different stages of their career. These are now inserted in both private and public sectors.

Transposable Elements: Moving Genomic Islands Around

Munehiro Asally, Assistant Professor, Warwick Integrative Synthetic Biology Centre, School of Life Sciences, **University of Warwick**, Coventry, UK

The main focus of his research is the dynamics of bacterial community formation. Combining fluorescent time-lapse microscopy, quantitative analysis, molecular genetics and mathematical modelling, his group aims to understand and engineer biofilm formation, mainly using the gram-positive model bacterium Bacillus subtilis. His research group launched in September 2014 at the University of Warwick. Prior to the current position as an Assistant Professor at Warwick, he worked as a postdoctoral researcher in the laboratory of Gurol Suel at the University of California San Diego. He received his PhD from Osaka University in 2007.

A Solution to Conflicts in a Growing Biofilm

A community of cells often faces internal conflicts of cooperation and conflict. It remains largely unknown how a community of cells resolves the internal conflicts. Structured bacterial community, known as biofilm, is an ideal experimental platform to investigate such conflict and the population level solutions in a living system. Using the gram-positive bacterium Bacillus subtilis as a model system, we recently discovered a novel metabolic interaction within a biofilm, which in turn increased the fitness of the community under stress condition. The insights obtained in our work offer a novel strategy to control biofilms.

Ricard Solé, ICREA Research Professor, Head of the Complex Systems Lab, **Universitat Pompeu Fabra**, Barcelona, Spain

See his CV at the Scientific Committee Section

Synthetic Transitions

The evolution of life in our biosphere has been marked by several major innovations, including the origin of cells, multicellularity, language or even consciousness. With the rise of synthetic biology and advanced simulation modelling techniques, novel perspectives to these problems have led to a rather interesting scenario, where not only the major transitions can be studied or even reproduced, but even new ones might be potentially identified or even created.

Victor de Lorenzo, Professor of Research of the National Research Council (CSIC) at the Systems Biology Program of the **Centro Nacional de Biotecnología**, Madrid, Spain

Head of Laboratory of Environmental Molecular Microbiology at the National Center for Biotechnology. He specializes in Molecular Biology and Biotechnology of soil bacteria (particularly Pseudomonas putida) as agents for the decontamination of sites damaged by industrial waste. In 2001 this work received the National Award King James I for Environmental Protection. In June 2008 he received the GSK International Award of the American Society for Microbiology, and in October of the same year he was granted a Grand Prix of the French Academy of Sciences. He is a member of the EMBO (European Molecular Biology Organization) and the American Academy of Microbiology, and he has co-chaired the EC-US Working Group on Synthetic Biology. He has also Co-chaired the EC President's Science and Technology Council. He has published over 250 articles in scientific journals and specialized books, and he has served as advisor of numerous international panels. His current work maps at the interface of Synthetic Biology with Environmental Biotechnology.

Cyborg-ization of Soil Bacteria for Smart Degradation of Environmental Pollutants

Much of contemporary Synthetic Biology aims at re-programming entire microorganisms (rather than single genes) for enhancing existing functions and/or performing new-to-nature tasks. In the case of bacteria, key aspects to this end include the removal of undesired genomic segments, systems for production of directed mutants and allelic replacements, random mutant libraries to discover new functions, and means to stably implant larger genetic networks into the genome of specific hosts. Soil bacteria such as Pseudomonas putida are pre-endowed with the metabolic, physiological and stress-endurance traits that are demanded by current and future synthetic biology and biotechnological needs. Our current attempts to use these tools for modifying lifestyle from planktonic to surface-attached for the sake of engineering catalytic biofilms will be presented.

INVITED SPEAKERS

Friday, September, 18th, 2015

Marta Ibañes, Associate Professor of the Structure and Constituents of Matter Department, **University of Barcelona**, Barcelona, Spain

Chair of the SESSION 3: QUANTITATIVE APPROACHES

Graduated and Doctor in Physics by the University of Barcelona, she started her research in the field of Systems Biology in 2003 when she joined as a postdoctoral research associate, Fulbright fellow, the Salk Institute for Biological Studies in La Jolla (California, USA). She coordinated the initiation of the Master in Biophysics at the University of Barcelona (2006-2008) after joining this university as a Ramon y Cajal Researcher. Her research interests are in the self-organizing and emergent phenomena arising from nonlinear and stochastic dynamics of coupled elements, focused on developing organisms. She combines her expertise in modeling with collaborations with experimental groups.

Timothy Lu, Associate Professor, **MIT**, Cambridge, Massachusetts, USA

Timothy Lu, M.D., Ph.D. is an Associate Professor leading the Synthetic Biology Group in Research Laboratory of Electronics, Department of Electrical Engineering and Computer Science and the Department of Biological Engineering at MIT. He is a core member of the MIT Synthetic Biology Center and a co-founder of Sample6 Inc., Synlogic Inc, and Eligo Biosciences. Tim's research at MIT focuses on engineering computing and memory circuits in living cells, applying synthetic biology to tackle important medical and industrial problems, and building living biomaterials that integrate biotic and abiotic functionalities. He is a recipient of the NIH New Innovator Award, the Presidential Early Career Award for Scientists and Engineers, and the Ellison Medical Foundation New Scholar in Aging Award, among others.

Synthetic Biology for Human Health Applications

Synthetic biology is an emerging discipline for engineering biological systems. Exponential increases in our ability to read and write DNA are significantly accelerating our ability to reprogram biology for real-world applications. The ambitions of the field are to revolutionize the ways we study, diagnose, and treat a wide range of problems in biomedicine, environmental science, biotechnology, and other areas. Although synthetic biology is still at an early-stage of development that can be likened to the early days in the semiconductor industry just after the creation of the transistor, exciting academic and commercial applications are already being pursued. We have built foundational toolkits to make the engineering of biological systems more reliable, powerful, and rapid. In addition, we have invented technologies to tackle several real-world applications and have had the opportunity to translate these academic inventions into commercial ventures in diagnostics and therapeutics.

Orkun Soyer, Professor, **University of Warwick**, Coventry, UK

Soyer is currently leading an interdisciplinary research group in Systems and Synthetic Biology at the University of Warwick. He was born in 1975 in Istanbul and studied Chemistry at the Bogaziçi University. After receiving a PhD and at the University of Michigan, Ann Arbor, Soyer held a postdoctoral research position at the ETH, Zurich and independent group leader positions at Microsoft Research - University of Trento Computational Biology centre and University of Exeter. Soyer's research interest combine evolutionary biology with systems and synthetic approaches and employs both modeling and experimental tools. The ongoing research projects in his group focuses on understanding and engineering microbial communities, understanding metabolic basis of host-pathogen interactions, and modeling and engineering cellular signaling networks.

Evolutionary Design Principles for Synthetic Biology

The grounding rationale of synthetic biology is rooted in a strong desire to "engineer" biology through the use of engineering principles, however, it is not clear what these principles should cover in the context of biology. They are clearly expected to include those that are well-established in other engineering disciplines (e.g. computer-aided design, standardization, and modularity), but are also in need to expand to meet the challenges and potentials arising from the unique features of biological systems. Here, I will argue that any engineering attempts to biology should include an evolutionary perspective on design. The emergence of design in engineering and evolution display marking differences, with the evolutionary processes particularly prone to exploit inherent features and constraints of biological systems. In this talk, I will aim to demonstrate how evolutionary and engineering viewpoints could be combined to enrich designs in synthetic biology, and in turn, how evolutionarily motivated designs can provide insights onto biological function and evolutionary processes. The talk will be focused in two parts. On one hand, I will aim to illustrate how an evolutionary

viewpoint can provide insights on which of multiple functionally-equivalent designs might be most amenable to implement in a given biological system. On the other, I will explore how functions that are not easily implemented (or imagined) under simplistic engineering viewpoints, can be implemented through designs that are understood from an evolutionary standpoint. These two parts are set in the context of example studies of cellular signaling networks and microbial communities respectively.

Carlos Rodriguez-Caso, Postdoctoral Researcher at the Complex Systems lab at the **Universitat Pompeu Fabra** and part-time Lecturer in the Biomedical Engineering Degree, Barcelona, Spain

Postdoctoral researcher at the Complex Systems lab at the Universitat Pompeu Fabra and part-time lecturer in the biomedical engineering degree. With a background in Biology he combines theoretical, computational and experimental approximations to the study of the principles of biological organisation at molecular and cellular scale, from the perspective of systems and synthetic biology. His research spans different branches of Molecular Biology, Physics and Computation applied to the study of complex biological networks, hierarchical systems and systems dynamics.

The Wrong Use of Hill Functions for Synthetic Biology Designs: Lessons from Enzymology

Within the field of synthetic biology, a rational design of genetic parts should include a causal understanding of their input-output responses—the so-called transfer function—and how to tune them. However, a commonly adopted strategy is to fit data to Hill-shaped curves without considering the underlying molecular mechanisms. Here we provide a novel mathematical formalization that allows prediction of the global behavior of a synthetic device by considering the actual information from the involved biological parts. This is achieved by adopting an enzymology-like framework, where transfer functions are described in terms of their input affinity constant and maximal response. As a proof of concept, we characterize a set of Lux homoserine- lactone-inducible genetic devices with different levels of Lux receptor and signal molecule. Our model fits the experimental results and predicts the impact of the receptor's ribosome-binding site strength, as a tunable parameter that affects gene expression.

Mustafa Khammash, Professor of Control Theory and Systems Biology at ETH-Zurich, Department Head, Department of Biosysteme Science and Engineering (D-BSSE), **ETH-Zurich**, Switzerland

Mustafa Khammash is the Professor of Control Theory and Systems Biology at the Department of Biosystems Science and Engineering (D-BSSE) at ETH Zurich, and is currently serving as the head of the department. He received his PhD in control theory at Rice University, Houston in 1990. From 1990 till 2001, he was on the Engineering faculty of Iowa State University. In 2001 he joined the University of California at Santa Barbara (UCSB) where he served as the Director of the Center for Control, Dynamical systems, and Computations (CCDC) from 2006 till he joined ETH in 2011. Working at the interface of systems biology, synthetic biology, and control theory, Khammash develops novel computational methods for the modeling, simulation, analysis, and control of biological networks. In the area of systems biology, he utilizes these methods for reverse engineering biological complexity, with particular interest in understanding the role of dynamics, feedback, and randomness in endogenous biological circuits. In the area of synthetic biology, his research focuses on creating the mathematical foundation and necessary tools for the robust and precise control of living cells. Khammash is a Fellow of the IEEE, IFAC, and the Japan Society for the Promotion of Science (JSPS).

Cybergenetics: Synthetic Circuits and Systems for the Precise Control of Living Cells

Norbert Wiener's 1948 Cybernetics presented a vision unifying the study of control and communication in the animal and the machine. Predating the discovery of the structure of DNA and the ensuing molecular biology revolution, applications in the life sciences at the time were limited. More than 60 years later, the confluence of modern genetic manipulation techniques, powerful measurement technologies, and advanced analysis methods is enabling a new area of research in which systems and control notions are used for regulating cellular processes at the gene level. This presentation describes novel analytical and experimental work that demonstrates how de novo control systems implemented with stochastic components can be interfaced with living cells and used to precisely control their dynamic behavior.

Declan Bates, Professor of Bioengineering, School of Engineering, **University of Warwick**, Coventry, UK

Declan Bates was born in Clonmel, Co. Tipperary, Ireland in 1970 and educated at Powerstown National School and CBS High School, Clonmel. He received a B.Eng degree in Electronic Engineering and a Ph.D. degree in Robust Control Theory from the School of Electronic Engineering, Dublin City University, Ireland, in 1992 and 1996 respectively. On completing his PhD he joined the Control and Instrumentation Research Group led by Prof. Ian Postelthwaite in the Department of Engineering at Leicester University, where he worked as a post-doctoral research associate, lecturer, senior lecturer and professor. In 2010 he was appointed to a Chair in Biological Systems Engineering in the College of Engineering, Mathematics and Physical Sciences of the University of Exeter and in 2013 he moved to the University of Warwick as Professor of Bioengineering.His research is focussed on the modelling, analysis, design and control of complex biological systems. In 2006, he was awarded an EPSRC Discipline Hopping Research Fellowship to pursue research on the Control Engineering/Life Sciences Interface. He is a member of one of 5 project teams formed during a week-long "sandpit" on Synthetic Biology organised by EPSRC and the US National Science Foundation (NSF) in 2009, which were awarded over $9M in research funding – in 2013 his team were awarded further joint funding from EPSRC/NSF to continue their research collaboration. From 2007 to 2010, he was a member of BBSRC's Engineering and Biological Systems Research Committee, and subsequently a core member of BBSRC's Research Committee C on Technology and Methodological Development. From 2009 to 2014, he was a member, Co-Chair and subsequently Chair of the Research Grants Review Committee of the International Human Frontier Science Program.He is a member of EPSRC's Peer Review College, an associate editor of the journal IET Systems Biology, and a founding member of the EPSRC-funded Robust Synthetic Biology Network (RoSBNet). He is the co-author (with Carlo Cosentino) of Feedback Control in Systems Biology, published by Taylor & Francis. He has authored more than 125 peer reviewed research publications and obtained funding in excess of £8.5M from EPSRC, BBSRC, MRC, ESA and industry.

Design of Bimolecular Feedback Control Systems

A fundamental aim of Synthetic Biology is to achieve the capability to design and implement robust embedded biomolecular feedback control circuits. An appropriate modelling and design framework for tackling this problem is provided by Chemical Reaction Networks (CRNs), which represent a convenient and concise way to model chemical and biological processes and provide an effective tool for the analysis of the behaviour of these processes. Previous work within this framework has investigated the design and implementation of linear feedback controllers. Here, we extend this approach to allow the implementation of nonlinear controllers, based on Sliding Model Control Theory, whose strong performance and robustness characteristics have been widely recognised in more traditional control engineering application domains. We show how a signalling cycle with ultrasensitive response dynamics can provide a biomolecular implementation of a nonlinear quasi Sliding Mode Controller. Comparison of the performance of our nonlinear controller compared to that of a linear Proportional-Integral (PI) controller shows the potential for achieving significantly faster response dynamics without introducing overshoots in the transient response.

Farren Isaacs, assistant professor of Molecular, Cellular and Developmental Biology and Systems Biology, **Yale University**, New Haven, USA

Farren Isaacs is assistant professor of Molecular, Cellular and Developmental Biology and Systems Biology at Yale University. He received a B.S.E in Bioengineering from the University of Pennsylvania and Ph.D. in Biomedical Engineering-Bioinformatics at Boston University, where he pioneered the development of synthetic RNA molecules capable of probing and programming cellular function. As a research fellow in genetics at Harvard, he invented enabling technologies for genome engineering. His research is focused on finding ways to construct new genetic codes and reprogrammable cells that serve as factories for chemical, drug and biofuel production. He has been named a "rising young star of science" by Genome Technology Magazine, a Beckman Young Investigator by the Arnold and Mabel Beckman Foundation and recipient of a Young Professor award from DuPont.

Design, Construction & Function of Genomically Recoded Organisms

The conservation of the genetic code, with minor exceptions, enables exchange of gene function among species, viruses and across ecosystems. Fundamental changes to the genetic code could significantly enhance our understanding of the origins of the canonical code and reveal new subtleties of how genetic information is encoded and exchanged. Modifying the canonical genetic code could also lead to orthogonal biological systems with new properties. I will first present the development of genome engineering technologies – MAGE (multiplex automated genome engineering) and CAGE (conjugative assembly genome engineering) – that permit versatile genome modifications. Next, I will discuss the design and construction of a genomically recoded organism (GRO) using MAGE and CAGE. In the GRO, all known UAG stop codons in Escherichia coli MG1655 were replaced with synonymous UAA codons, which permitted the deletion of release factor 1 and reassignment of UAG translation function. This GRO exhibited improved properties for incorporation of nonstandard amino acids that expand the chemical diversity of proteins in vivo. The GRO also exhibited increased resistance to T7 bacteriophage, demonstrating that new genetic codes could enable increased viral resistance. Finally, I will describe the engineering of the GRO to depend on synthetic amino acids aimed at construction of safe GMOs unable to grow in the wild. This work increases the toolbox for genomic and cellular engineering with the goal of expanding the functional repertoire of organisms.

Christopher Coenen, Senior Researcher, Institute for Technology Assessment and Systems Analysis (KIT-ITAS), **Karlsruhe Institute of Technology** (KIT), Karlsruhe, Germany

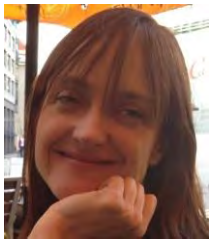
Co-chair of the SESSION 4: FROM THE BENCH TO SOCIETY

Senior researcher at the Karlsruhe Institute of Technology's Institute for Technology Assessment and Systems Analysis (KIT-ITAS). At ITAS since 2003. Before moving to Karlsruhe in 2009, based in Berlin at the Office of Technology Assessment at the German Parliament (TAB), which is run by KIT-ITAS. As team member or project leader, he has conducted more than 15 projects on behalf of such institutions as the German Parliament, the European Parliament and the European Commission. Currently, he is, amongst other things, in charge of the coordination of the EU-funded project SYNENERGENE on synthetic biology, a large-scale stakeholder and public dialogue and agenda-setting action plan with more than 20 partners from three continents, and the Editor in Chief of the journal NanoEthics (Springer). Among his main fields of interest are a wide variety of societal, political, philosophical, and cultural aspects of synthetic biology, nanotechnologies and neurotechnologies, and the 'human enhancement' topic.

Lauren Swiney, Postdoctoral Researcher, Institute of Cognitive and Evolutionary Anthropology, **University of Oxford** and Visiting Postdoctoral Researcher, Institute of Cognition and Culture, **Queen's University Belfast**, and Research Associate, Warwick Integrative Center for Synthetic Biology, Coventry, UK

Co-chair of the SESSION 4: FROM THE BENCH TO SOCIETY

Research Associate, Warwick Integrative Center for Synthetic Biology. Formerly Research Associate at Oxford University's Institute for Cognitive and Evolutionary Anthropology, and Visiting Researcher at the Institute of Cognition and Culture, Queen's University Belfast. She is a cognitive scientist whose interdisciplinary research spans the fields of psychology, anthropology and philosophy of mind, investigating how our thoughts and behavior are shaped both by our evolved cognitive architecture and by the world around us. Her most recent research investigates the role that cognitive biases play in shaping attitudes towards the emerging field of Synthetic Biology (SB), how these processes interact with cultural factors such as religious beliefs, and the implications of this for education and communications strategies. Her research has been supported by the US Air Force European Office of Aerospace Research and Development, and the Department of Employment and Learning, Northern Ireland.



Jane Calvert, Reader in Science, Technology and Innovation Studies at the **University of Edinburgh**, UK

Jane Calvert is a Reader in Science, Technology and Innovation Studies at the University of Edinburgh. She has a background in human sciences (Sussex), philosophy of science (London School of Economics), and science policy (Sussex). Her current research, funded by a European Research Council Consolidator grant, focuses on attempts to engineer living things in the emerging field of synthetic biology, which raises intriguing questions about design, evolution and 'life'. She is also interested the governance of emerging technologies, intellectual property and open source, and interdisciplinary collaborations of all sorts. She was a member of the Royal Academy of Engineering's Working Party on Synthetic Biology, the UK Synthetic Biology Roadmap Coordination Group, and the Nuffield Council on Bioethics Working Party on Emerging Biotechnologies. She is currently a member of the UK BBSRC's BioScience and Society Strategy Panel. She is a co-author of the book Synthetic Aesthetics: Investigating Synthetic Biology's Designs on Nature, published by MIT Press in 2014.

From Standard Biological Parts to Artificial Life? A Sociological Perspective

My talk is inspired by the conference title: from standard biological parts to artificial life. I will discuss why, as a sociologist of science, I became interested in standard biological parts. I will then demonstrate how my analysis is changing as synthetic biology is moving to more complex organisms and systems, such as eukaryotic systems. I will focus on the technical, social and conceptual issues that I find particularly salient in the synthetic yeast project, including its design principles, its emphasis on openness, and the attention it draws to the spatiality and temporality of living things. I will ask how more complex entities of this sort challenge the engineering aspirations of synthetic biology. I will end by reflecting on what these developments in synthetic biology tell us about 'life', and ask whether this word even makes sense in an engineering context.

Marcos Silveira Buckeridge, Associate Professor at the Department of Botany of the **University of São Paulo**, Sao Paulo, Brazil

Background in Biology (BSc in Biological Sciences, University of Guarulhos, MSc in Molecular Biology, Federal Univ. of São Paulo, PhD in Biochemistry, University of Stirling, Scotland). Actual Director of the National Institute of Science and Technology of Bioethanol (INCT do Bioetanol) and Executive Director of the Academy of Sciences of the State of São Paulo. He is a Review Editor for Trees: structure and function (Springer) and Communicating Editor for Bioenergy Research (Springer). He has been a member of the IPCC and an author of AR5, 2014. Buckeridge´s scientific approach is strongly based on a Systems Theory and tries to understand plant responses to the environment. The plant cell wall is a subsystem has been a particular focus used in Buckeridge´s lab. The work on cell walls includes deciphering how their structure-function relationship correlates with its metabolism within plant systems. One perspective of this approach is the possibility to engineer cell wall degradation within the plant for bioenergy purposes. Buckeridge´s group attempts to develop computational tools to help integrate plant systems (from transcriptional to physiological scales) and subsystems in order to view the plant functioning as a whole system. The perspective in this case is the understanding of the responses of plants to the climate change and increase in food production and quality.

The Glycomic Code: How the Complex Metabolic Network of Polysaccharides in Plant Cells Generates a Code that Supports Life on Earth

Plant cell walls are everywhere in our daily life. The clothing we use, the food we eat and the forests that keep our climate stable, all depends on the metabolic networks that generate a complex structure of macromolecules that surrounds all plant cells. As a result, a Glycomic Code emerges. The cell walls are the entities that afford the existence and maintenance of metabolism in plants, not only protecting plant cells against the attack of microorganisms, but also controlling cell-cell communication. Because cell walls consist of half of the weight of most plant cells, breaking the glycomic code is key to plant engineering. In this presentation, I will show how we are trying to decipher the Glycomic Code using the cell walls of grasses as a model system with the perspective of improving the production of renewable energy and new plant materials.

Manel Porcar, Researcher and lab leader (Biotechnology and Synthetic Biology), Cavanilles Institute, **University of Valencia**, Valencia, Spain

Manuel Porcar is an applied microbiologist and synthetic biologist. He is a biologist by training (University of Valencia) and he carried out a PhD on applied bacteriology in the Public University of Navarra, with several postdoctoral stays in Institut Pasteur (Paris, France). in 2004, he received a Ramón y Cajal fellowship to work with transgenic plants and associated insects in the University of Valencia, where he established the Biotechnology and Synthetic Biology group in the Cavanilles Institute. In the last seven years, he has been actively involved in the setting of conceptual and technical tools for Synthetic Biology, and he has been the main instructor of several award-winning teams attending the international Genetic Engineering Machine (IGEM) competition. My main research topics are bioprospection, laboratory adaptive evolution, standardization in biology and social perception of new technologies.

Do you Believe in Standards?

Standards are central in engineering. Synthetic biology, an engineering fresh view on time-consuming regular biotechnology, requires standards with which building complex biological systems. In my talk, I will discuss the concept of standard in biology, the parallelism and differences between biological systems and machines, the case of the Registry of biological parts and the iGEM competition, and, finally, the need of an integrated approach including evolution to define standards. In my view, biological systems are not biomachines mainly because the way they are structured is opposed to the way machines are designed. This, as well as the many reports highlighting the difficulties of standardization in biology, suggests a cautious approach to the very concept of standard in biology, as well as the need to flexibilize engineering assumptions when they are to be applied to living beings.

Juli Peretó, Tenured Professor, Department of Biochemistry and Molecular Biology, and researcher at the Evolutionary Genetics Unit, Cavanilles Institute for Biodiversity and Evolutionary Biology, **University of València**, Valencia, Spain

His research interests include the evolution of metabolism, the minimal genome concept, and the history of ideas on the natural origin and the artificial synthesis of life. He tries to teach metabolism with an evolutionary flavor to biologists, biochemists and biotechnologists. He has been coordinator of a consortium of eight European universities in the Erasmus Intensive Program course "Origin, Evolution and Future of the Biosphere". He was formerly Secretary and Vice-President of the International Society for the Study of the Origin of Life (ISSOL) and in 2014 was elected Fellow. His most recent book, coauthored with M. Porcar, is "Synthetic Biology: from iGEM to the artificial cell" (Springer, 2014).

Lessons from History: Promises and Realities of the Artificial Synthesis of Life.

Synthetic biology aims at the design and construction of biological devices and systems for useful purposes. Nevertheless, the combination of our still fragmentary biological knowledge and the messy nature of biological devices are major challenges for engineering life in a predictive manner. Yet, the desire to make life is not new. Materialist and evolutionist scientists over a century ago were convinced of the possibility and even the need to synthesize living beings to advance the knowledge on the nature and origin of life. In retrospect, that promises were premature, but journalists presented many advances in biology in the past century as an attempted synthesis of life. Nor is it new, therefore, the fine line which separates the scientific enthusiasm from hype.

Sven Panke, Associate Professor of Bioprocess Engineering, Department of Biosystems Science and Engineering, **ETH Zurich**, Basel, Switzerland

Sven Panke is a Professor of Bioprocess Engineering at the ETH Zurich. After his PhD, also at ETHZ, he worked for two years for the Dutch chemical company DSM (Geleen, The Netherlands). He returned to ETH in 2001 as an Assistant Professor, received tenure in 2007, and then moved to the newly founded ETHZ Department of Biosystems Science and Engineering in Basel. His main research topics include integrated reaction-separation systems, high-throughput screening, and synthetic biology. His work was awarded with the ETH Medal and the DSM Research Award.

Synthetic Biology – of Fundamental Concepts and First Applications

Synthetic biology is considered by many as an enabling technology of the 21st century which will allow us to drastically accelerate the arrival of novel biotechnological processes and products in modern society, and maybe even fundamentally change our ideas about what a biotechnological product is. On the other hand, synthetic biology is considered a field in which some of the most fundamental questions of the life sciences are addressed. I will try to navigate between these two extremes and sketch trajectories of how synthetic biology will likely affect our lives in the near future.

PRACTICAL INFORMATION

Debates Venue

CAIXAFORUM BARCELONA
Avinguda Francesc Ferrer i Guàrdia, 6-8
Barcelona, Spain
http://obrasocial.lacaixa.es

Scientific presentations and debates: AULA 1 (2nd Floor)
Coffee breaks and lunches: CAFETERIA (1st Floor)

CaixaForum Barcelona
Obra Social "la Caixa"

CaixaForum, the Social and Cultural Centre of "la Caixa" Out Reach Projects, is housed in one of Barcelona's chief Art-Nouveau building that stands as a unique example of Catalan Art-Nouveau industrial architecture of the early twentieth century. The building was designed by Josep Puig i Cadafalch and completed in 1911. It first operated as a spinning mill and textile factory but closed down just seven years after its opening. After that, it was pressed into service as a warehouse during the Barcelona World Fair of 1929, and in 1940 it was converted into stables and garages for the National Police Force. Awarded in 1912 with the City Council's prize for the best industrial building, it has been declared in 1976 Historical Artistic Monument. CaixaForum opened in 2002 and was designed as a space for dissemination and debate on culture and its many manifestations. With this aim, it offers a wide range of activities for all kind of public (exhibitions, familiar activities, concerts, poetry, literature, conferences, videoart, festivals, courses, new medias, etc.).

More info: http://obrasocial.lacaixa.es

Contact person during the event

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ADDITIONAL INFORMATION

Suggested Reading

"SynBio Politics - Bringing synthetic biology into debate"
V. Rerimassie and D. Stemerding, Rathenau Instituut, 2014, The Hague
http://www.rathenau.nl/uploads/tx_tferathenau/Report_SynBio_Politics_Rathenau_01.pdf

"Synthetic biology"
Secretariat of the Convention on Biological Diversity, 2015, Montreal
https://www.cbd.int/ts/cbd-ts-82-en.pdf

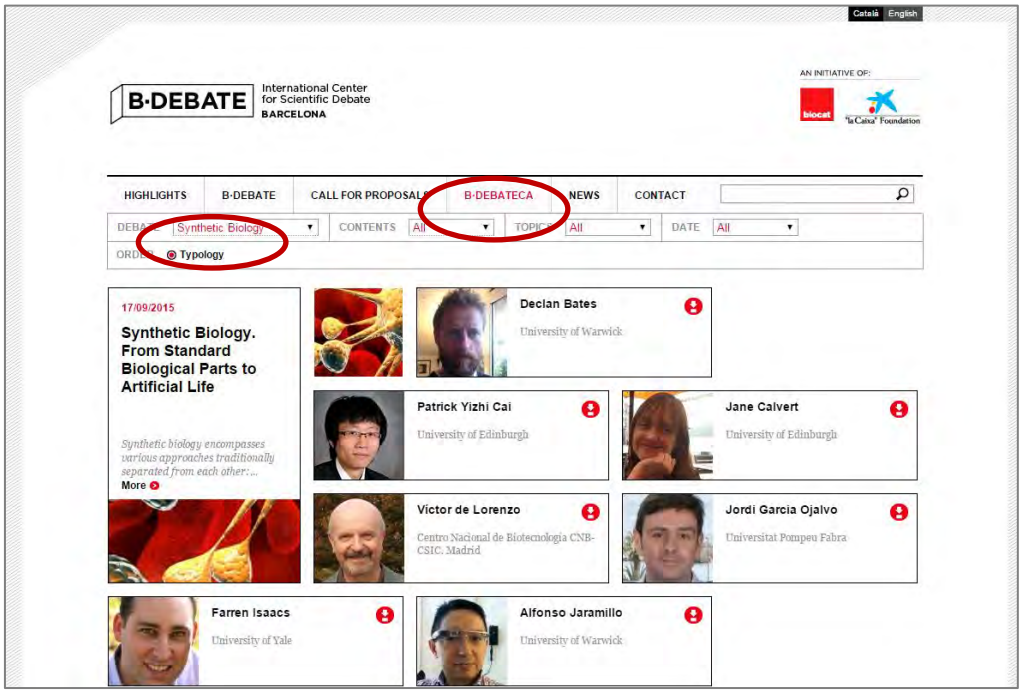
"Build life to understand it"
W.A. Lim and M.B. Elowitz, Nature vol. 648, pp. 889-890, 2010
http://www.nature.com/nature/journal/v468/n7326/full/468889a.html

B·Debateca

On the website of **B·Debate**, you will find all the information related with the celebration of the meeting that includes reports, conclusions, scientific documents, interviews with the experts, speaker's BIOs, presentations, videos, images, press documentation and other related materials.

We invite you to visit the section **B·Debateca** on www.bdebate.org!

Contents of the meeting "SYNTHETIC BIOLOGY. FROM STANDARD BIOLOGICAL PARTS TO ARTIFICIAL LIFE".



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B·Debate International Center for Scientific Debate Barcelona is a **Biocat** initiative with support from **"la Caixa" Foundation**. It drives first-rate international scientific debates, to foster dialogue, collaboration and open exchange of knowledge with prestigious national and international experts, to approach complex challenges of high social interest in life sciences. B·Debate sees debate as a powerful, effective way to generate knowledge and strives to help position Barcelona as a benchmark in generating knowledge and Catalonia as a country of scientific excellence.

B·Debate sees debate as a powerful, effective way to generate new knowledge. The debates are top-notch international scientific meetings featuring a selection of experts of renowned international prestige and scientists that work in Barcelona and Catalonia, moderated by scientific leaders. Since 2009 B·Debate has invited about 1200 recognized speakers and over 7.000 attendees. B·Debate seeks out answers to the challenges and needs of society in the field of life sciences, taking into account the complex, ever-changing conditions of this global world. The debates foster the integration of different disciplines of science and deal with such diverse topics as ageing, new therapeutic approaches to various diseases, innovative technology to improve knowledge of the human genome, food resources, new tools to integrate knowledge management, clinical genomics, neurosciences, climate change, and new energy sources, among others. The knowledge and results obtained through these events is spread throughout both the scientific community and general society through the various **B·Debate** channels and instruments.

More information: www.bdebate.org/en

The **Department of Experimental and Health Sciences** (DCEXS) of the **Universitat Pompeu Fabra** is a **Maria de Maeztu Excellence** Unit that combines research and teaching in the fields of molecular biology, biomedicine, and systems and synthetic biology. The DCEXS is integrated in the Barcelona Biomedical Research Park (PRBB), a leading biomedical research node in Southern Europe with more than 100 laboratories and researchers from more than 50 different countries, conducting cutting-edge research and transfer to society. DCEXS also actively trains future talent in research through undergraduate, postgraduate and doctorate studies in the fields of biology, biomedical engineering, bioinformatics, and medical sciences. It has research programmes on Cell and Molecular Biology, Molecular Medicine, Evolutionary Biology and Complex Systems, Biomedical Informatics, Genetics and Neurosciences, as well as Public Health and Education in Health Sciences.

More information: www.upf.edu/cexs

COLLABORATORS

The **Warwick Integrative Synthetic Biology centre** (WISB) of the **University of Warwick** delivers an integrated, internationally leading programme of research, innovation and training for synthetic biology. The centre's state-of-the-art technology platforms and infrastructure support WISB researchers to develop an ambitious programme of theoretical and applied research. In collaboration with international partners, WISB's four integrated research themes address specific, industrially relevant design challenges across multiple scales of biological organisation: genetic circuits, pathways, and multi-cellular systems. WISB is driving advances that translate into real-world benefits for today's society, and trains future generations of outstanding synthetic biology researchers. WISB is a BBSRC/EPSRC Synthetic Biology Research Centre (SBRC).

More information: www2.warwick.ac.uk/fac/cross_fac/wisb/

The **Biological Design Center** (Bio-D) of **Boston University** is a research center devoted to understanding how complex biological systems – from molecules to tissues – are designed, and in turn using these principles to engineer new biological systems to advance solutions in medicine, materials, energy, and the environment. Spanning synthetic biology, systems biology, cell and tissue assembly, and quantitative biology, a unifying theme of the research activities is a focus on forward engineering approaches as a way to understand complex biological systems, harness them as powerful technologies, and motivate an interdisciplinary and concept-focused teaching of biology.

More information: www.bu.edu

The **Biomass Systems and Synthetic Biology Center** is part of the São Paulo State Bioenergy Research Center. The mission of BSSB is to produce scientific knowledge and technologies for the production of sustainable energy sources using plants, microorganisms and their combinations. The convergence of Synthetic Biology and Systems Biology generates the knowledge of the parts and the diagram connections that allow the creation of new organisms. The research groups at the Center plan and develop projects in Genomics, Genetics, Cell Biology, Chemistry, Biochemistry, Physiology, and Modeling, which encourage the emergence of multidisciplinary collaborative research among the participating USP institutions. It is in this context that the USP SynBio Center places itself in the frontier of knowledge, focusing on research that can lead into new applications in bioenergy.

More information: bioenfapesp.org/bssb

VENUE:

CaixaForum Barcelona

Av. Francesc Ferrer i Guàrdia, 6-8
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