WHAT'S GOING ON

GRK2062

NEWSLETTER #2 2016

in the Research Training Group Molecular Principles of Synthetic Biology

FOCUS ON RESEARCH

A In thermodynamic equilibrium, transitions between microscopic states are pairwise-balanced. B Non-equilibrium steady states can break detailed balance and exhibit flux loops. C Flux cycles (white arrows) indicate the net rate of transitions between configurations, as determined from a simulation of the fluctuations of two positions of a biopolymer (inset).

Prof. Dr. Chase Broedersz
AA I Area A Synthetic Cells and Switches

Non-equilibrium dynamics of living matter

What are the physical and chemical properties that distinguish living systems from inanimate matter? One key characteristic of all living systems is that they operate far from thermodynamic equilibrium. Nevertheless, many subcellular processes resemble those of thermal equilibrium, e.g. the apparent diffusive transport of proteins in the cytoplasm. Indeed, most cellular components exhibit vigorous fluctuations, including the jiggling of chromosomal loci, stress fluctuations of the actin cytoskeleton, or the erratic beating of a primary cilium. Such fluctuations can affect the function of these cellular components, such as the accuracy of mechanosensation of the primary cilium. However, if non-equilibrium active processes can give rise to fluctuations that look similar to thermal fluctuations, how can we tell the difference?

All equilibrium systems must satisfy the principle of *detailed balance*. Put simply, this means that if there is a process that allows a transition between two configurations of a system, then there should be a process that allows the reverse transition with an equal rate (Figures A, B). Living systems violate detailed balance and thermal equilibrium at the molecular scale through enzymatic processes that require a constant input of energy. However, the way in which detailed balance is violated in the dynamics of cellular components at larger scales remains poorly understood.

We have developed a non-invasive approach to identify non-equilibrium dynamics in living systems, based on the principle of detailed balance (Science, in press). Using this method, we are investigating non-equilibrium dynamics and the breaking of detailed balance for a range of cellular systems, including primary cilia, flagella, and cytoskeletal networks; the behavior we observe at this mesoscopic scale bears a striking resemblance to the cyclical enzymatic processes driving biological activity at the molecular scale (Figure C). This work will not only be of interest for applications to biology, but will also be of interest to the biophysics community, because it addresses the very basic question of how molecular-scale non-equilibrium processes are manifest in the system dynamics at larger scales.

GRK2062 PUBLICATION

Integrative Biology 2016

Chemical communication between bacteria and cell-free gene expression systems within linear chains of emulsion droplets

M. Schwarz-Schilling, L. Aufinger, A. Mückla and F. C. Simmel

Abstract

Position-dependent gene expression in gradients of morphogens is one of the key processes involved in cellular differentiation during development. Here, we study a simple artificial differentiation process, which is based on the diffusion of genetic inducers within one-dimensional arrangements of 50 μm large water-in-oil droplets. The droplets are filled with either bacteria or cell-free gene expression systems, both equipped with genetic constructs that produce inducers or respond to them via expression of a fluorescent protein. We quantitatively study the coupled diffusion-gene expression process and demonstrate that gene expression can be made position-dependent both within bacteria-containing and cell-free droplets. By generating diffusing quorum sensing signals in situ, we also establish communication between artificial cell-free sender cells and bacterial receivers, and vice versa.

http://dx.doi.org/10.1039/C5IB00301F

We are looking forward to highlight future GRK2062 publications in this section. Therefore we kindly ask you to inform the GRK2062 office in a timely manner about your accepted papers.

NEW MEMBERS

PhD-students

Marcel Damm, M.Sc. Biology, is supervised by Dario Leister since January 2016. Working title of his PhD thesis: "Introduction of a functional plant photosystem I in a prokaryote".

Daniel Gast, M.Sc. Chemistry, started his PhD study in October 2015. Supervised by Anja Hoffmann-Röder he is working on "Synthesis of glycoconjugates for applications as potential Ear-P inhibitors and antibacterial vaccines".

Andreas Reichert, M.Sc. Molecular Biotechnology, started his PhD study in November 2011. Supervised by Arne Skerra he is focusing on "Design and engineering of orthogonal translation components for synthetic biology". Andreas has taken on responsibility for the joint LMU/TU-iGEM Team 2016.

Mona Dotzler, M.Sc. Biology, started her PhD study in February 2016. Supervised by Kai Papenfort she is focusing on "Synthetic small RNA regulators for tailored gene expression in bacteria".

FAREWELLS

Arthur Guljamow will join in April 2016 the research group of *Prof.* Elke Dittmann at University of Potsdam focusing on *secondary metabolites of cyanobacteria*. Arthur was working as postdoc in the Leister lab for two years. We wish him all the best! Research Group

EVENTS

Retreat 2016

We are looking forward to our first Retreat which will take place in the Benediktine abbey of Frauenwörth on the Fraueninsel (The Women's Island) in Lake Chiemsee. The Retreat is scheduled from April 7th to April 9th, 2016.

Arrival

We will start by bus on April 7th at 9:00 am at the LMU Biocenter in Martinsried (bus stop "LMU Martinsried"), our next stop to pick up people will be at *Munchen Ostbahnhof* at 9:30 am (vis-à-vis Burger King, *Friedenstr.* 17a). Abbey Frauenwörth will be reached by ferry at 11:30 am. After lunch scientific talks will start at 1 pm.

Program

For details of the program please visit the schedule of the Retreat 2016

Upcoming Transferable Skills Courses

Scientific Writing, Science Craft
This course will run on the 26th and 27th of July 2016 in room D00.013 at LMU Biocenter. For a full description please click here.

JOURNAL CLUB

Nature Reviews Microbiology 14, February 2016, p.135–149

Review
Synthetic biology to access and expand nature's chemical diversity

Michael J. Smanski et al.

Abstract

Bacterial genomes encode the biosynthetic potential to produce hundreds of thousands of complex molecules with diverse applications, from medicine to agriculture and materials. Accessing these natural products promises to reinvigorate drug discovery pipelines and provide novel routes to synthesize complex chemicals. The pathways leading to the production of these molecules often comprise dozens of genes spanning large areas of the genome and are controlled by complex regulatory networks with some of the most interesting molecules being produced by non-model organisms. In this Review, we discuss how advances in synthetic biology — including novel DNA construction technologies, the use of genetic parts for the precise control of expression and for synthetic regulatory circuits — and multiplexed genome engineering can be used to optimize the design and synthesis of pathways that produce natural products.

Full text: http://dx.doi.org/10.1038/nrmicro.2015.24

MISCELLANEOUS

The **European Association of Students and Post-docs in Synthetic Biology (EUSynBioS)** was founded as a student-led initiative in late 2014. Their goal is to shape and foster a community of young researchers active the young scientific discipline of synthetic biology within Europe by means of providing an integrative central resource for interaction and professional development. http://www.eusynbios.org/

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