Life Sciences
Newsletter 11

Soft Matters
October 2010

Special Issue on the FRIAS Natural Sciences Junior Groups

Jörn Dengjel

Spatio-temporal protein dynamics

The research focus of our group is the description of spatio-temporal protein dynamics in diverse biological settings with the help of quantitative, mass spectrometry (MS) -based proteomics. Proteomics is the large-scale study of proteins, their function, regulation, and structure. We are working on inherited skin disorders as well as on signaling events and cellular degradation pathways such as autophagy, a basic cellular recycling mechanism involved in numerous diseases e.g. cancer and neurodegenerative diseases. In all projects MS-based proteomics play a major role. Since October 2009 we have an Orbitrap XL mass spectrometer running non-stop and producing large-scale datasets which have to be evaluated and interpreted by bioinformatics means. We have streamlined experimental procedures and established standard operation protocols assuring the generation of

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From left to right: Sven Eiselein, Jörn Dengjel, Victoria Küttner, Adrian Sprenger, Mostafa Zarei, Fabian Metzger, Christine Gretzmeier, Andrea Zimmermann.

high-quality quantitative data.
The successful launch of our proteomics research group to date is reflected in the publication of two articles and two book chapters in 2010.
In addition, we have received research grants from the Freiburg Excellence Cluster biosss, the DFG, and the BMBF complementing our FRIAS funding. The foundation for successful work in the future has been laid and we are looking forward to gaining new insights into protein function and regulation.

Hauke Busch

Cellular control and communication

How do cells communicate and react? What influences their responses in the presence of tumor cells or when they age?
To answer these questions we study how cells in the skin communicate with each other, how skin cancer forms its microenvironment and how neuron-like cells develop.
Our group started early in 2009 to set up a cell culture laboratory at the Center of Biosystems Analysis (ZBSA), in which we conduct experiments with cells human skin and skin cancer. In climate chambers we observe under the microscope cellular behavior under different stimuli and conditions.
To obtain a holistic view of the dynamic response of the cells, we use DNA microarrays and quantitative PCR to simultaneously measure the expression of all the roughly 21000 genes in each cell. In this way we obtain information on which signaling parts in the cells are switched on and off and at what time. Finding and controlling cues that induce or modify cellular decisions like migration, division and differentiation is difficult, because cell regulation always involves thousands of genes and proteins present.
Therefore, biologists, chemists and medical doctors work side by side together with physicists and bio-engineers to produce, quantify and translate massive amounts of data into a comprehensive and comprehensible picture

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Special Issue on the FRIAS Natural Sciences Junior Groups

Francesco Rao

Dynamics of complex systems in biophysics

Since May 2010, Francesco Rao is a Junior Fellow at the FRIAS School of Soft Matter Research. By November his group will be fully installed at FRIAS and be composed of two PhD students, Stefano Mostarda (Italy) and Roman Shevchuk (Ukraine), as well as one PostDoc, Diego Prada Gracia (Spain).
A joint collaboration between Francesco Rao and Peter Hamm, professor at the Institute for Physics and Chemistry at the University of Zurich, allowed the development of a new theoretical framework based on complex networks and molecular simulations. Originally developed to understand the structure of the World-Wide-Web and social interactions, complex networks have now led to the uncovering of the inhomogeneous structure of water.
Life is made possible by the abundant presence of water on our planet. But what is special about water compared to other liquids? More than 100 years ago, Wilhelm Conrad Röntgen published his paper "Über die Konstitution des flüssigen Wassers", on the basis of which a discussion was launched whether at room temperature local ice structures can exist in water at the same time as the liquid form. Atomic studies show that this liquid is composed of a large number of co-existing structures, including crystal-like structures as in ice even at room temperature.

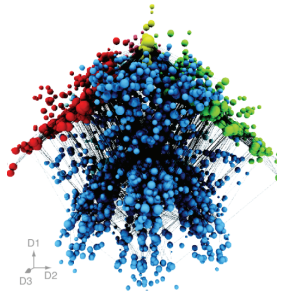

Figure: Conformation space network of water at ambient conditions

This scenario is radically different with respect to other liquids that look homogeneous at all scales. This observation is perhaps a key element in unravelling the hidden connection between water and life.
These results have recently been published in the Journal of Physical Chemistry (DOI:10.1021/jp1060792).

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Aurelio Mateo-Alonso

Development of molecular machines and heteroacenes for electronic applications

It has been a year and a half since Aurelio Mateo-Alonso (Koke) joined the FRIAS School of Soft Matter. The lab being fully operative, the whole group, consisting of the four PhD students Sunil Choudhary (India), Niksa Kulisic (Croatia), Sandeep More (India) and Francesco Scarel (Italy), is now fully immersed in developing new and exciting chemistry. In this period eight papers, three book chapters and two grants have materialised and the group is hoping that this success will continue.

Major contributions from the group's priority research topics including molecular machines and dye synthesis have been published.
Among these, a paper in *Nature Chemistry* and a paper in the 2011 Emerging Investigators Issue of *Chemical Communications* highlight some of the group's recent achievements.

Stefan Schiller

Combining macromolecular chemistry with synthetic biology

The group of Junior Fellow Stefan M. Schiller was successful with two proposals in the new International Research Training Group (IRTG) program "Soft Matter Science: Concepts for the Design of Functional Materials".

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The group received funding for two further PhD students who will join the group, post-doc Matthias Huber, the PhD students Cordula Hege and Andreas Schreiber and Andrea Bohnert (technical assistant). The first project focuses on supramolecular biomimetic systems based on new glycolipid conjugates which will be synthesized in Freiburg and biophysically characterized and applied together with Prof. Carlo Marques (Strasbourg) and Prof. Wolfgang Meier (Basel). Chunyan Yao will start working on this project October 15th. The second project focuses on the application of new protein based biomacromolecules (elastine like proteins and fibronectine) functionalized with *in vivo* incorporated unnatural amino acids.

From left: Cordula Hege, Lisa Boch, Evelyn Ronge, Stefan M. Schiller, Andreas Schreiber, Andrea Bohnert, Matthias Huber, Andreas Kürner

The new biomolecular conjugates are utilized to form mechanoresponsive sensor materials in a joint project with Prof. Pierre Schaaf (Strasbourg).

Florian Mintert

Coherent many-body quantum dynamics

In September 2010 physicist Florian Mintert joined the School of Soft Matter Research and started a Junior research group with Federico Levi (Italy) as PhD student and Scott Sanders (USA) as PostDoc. Florian's background lies in static and dynamic properties of coherence in many-body quantum systems.

In his PhD project with Andreas Buchleitner at the Max Planck Institute for the Physics of Complex Systems in Dresden he devised efficient means to estimate the entanglement of mixed many-body quantum states and employed these tools to investigate the entanglement dynamics in open quantum systems.

Having received his degree in 2004 from the Ludwig-Maximilians University in Munich he went to Rio de Janeiro for a half-year PostDoc followed by a longer stay with Eric J. Heller in Cambridge MA, where he worked on semi-classical wave-packet simulations of decoherence and matter-wave scattering from interacting many-body systems.

On his return to Europe he joined Andreas Buchleitner in Freiburg and started to use tools from entanglement theory to unravel the interference mechanisms that govern the excitation transport in disordered networks.

At FRIAS his group will investigate such transport processes using tools from optimal control theory.

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EVENTS TO COME

Every Monday
Joint Seminar
FRIAS seminar room at 11:15 h

Every Tuesday
Quantum Efficiency Seminar
FRIAS seminar room at 14:15 h

STAUDINGER LECTURE

November 23, 2010 at 16:15 h
Aula, KG I, Freiburg
Nobel Laureate **Anthony Leggett**,
Physics, University of Illinois at Urbana-Champaign
"Why can't time run backwards?"

of the complex orchestration of signalling pathways.

Model development and simulation are performed both at the University of Freiburg's Black Forest Grid as well as on our own 210 Core Supercomputer cluster in the basement of the ZBSA.

In the course of the last two years our group has grown to 11 people - comprising Master and PhD students, PostDocs and support staff. For this, we have secured further funds from various BMBF sponsored projects that study wound healing in the skin or investigate the metastasis formation in lung cancer. Recently, our research focus has shifted towards the important field of aging. We are co-coordinating the consortium 'Stromal Aging', that explores in collaboration with medical doctors and biologists from Heidelberg and Dusseldorf the changes in skin between young and old people. Furthermore, we will start new projects on kidney aging early next year.

As a member of a young researcher consortium, including Jörn Dengjel and six further groups from Freiburg, we will receive funding for two scientists thereby joining forces in experiments and theory to study the causes and effects of aged kidney cells *in vitro*. Having established an interdisciplinary systems biology group, we are now in the steady state of productivity with three papers having been published this year and several more in the review process. In the coming years we aim to move ahead in exploring the possibilities of combining cell biology with the general principles of systems theory.

Tom Michoel

Mathematical modeling of disease-perturbed networks using genome-scale data

After a PhD and postdoctoral work in mathematical physics, Tom joined the bioinformatics lab of Prof. Yves Van de Peer at VIB and Ghent University. He was responsible for a team of scientists working on computational problems in systems biology, in particular developing algorithms for reconstructing regulatory networks from gene expression and large-scale molecular interaction data.

Since September 2010 Tom Michoel is a Junior Fellow at the School of Life Sciences – LifeNet. His group at FRIAS, at the moment supported by the two PhD students David Vardanjan (Latvia) and Gustavo Hime (Brazil), will build on this work and investigate how disease and other processes critically affect normal network structures and how the dynamics of perturbed networks explains biological functioning at a system level.

He looks forward to being part of the systems biology research community of the University of Freiburg and to fruitful collaborations with both experimental and theoretical research groups.

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EVENTS TO COME

November 8, 2010
Joint Seminar with Regina Samaga: *"Interaction Graphs and Logical Networks as Modeling Frameworks for Signal Transduction Networks"*
FRIAS seminar room at 11:15 h

November 10-11, 2010
FRIAS-LifeNet Conference on *"Interdisciplinary Systems Biology Approaches"*
By invitation only.

STAUDINGER LECTURE

December 16, 2010 at 16:15 h
Chemistry Lecture Hall,
Albertstr. 21, Freiburg
Nobel Laureate **Robert Huber**,
Max Planck Institute of Biochemistry, Martinsried
"Intracellular Proteolysis: Mechanisms, Structures, and Application"