BP 24: Physics of Cells II

Time: Thursday 10:15–13:00 Location: ZEU 250

BP 24.1 Thu 10:15 ZEU 250

Anomalous reaction kinetics in crowded fluids — Marcel Hellmann[1,2], Dieter W. Heermann[2], and •Matthias Weiss[1,3] — [1]Cellular Biophysics Group, German Cancer Research Center, D-69120 Heidelberg, Germany — [2]Institut für Theoretische Physik, Universität Heidelberg, D-69120 Heidelberg, Germany — [3]Experimental Physics I, University of Bayreuth, D-95440 Bayreuth, Germany

Anomalous diffusion in crowded fluids, e.g. in the cytoplasm or on membranes of living cells, is a frequent phenomenon. The experimentally observed subdiffusive characteristics is most consistent with fractional Brownian motion, i.e. the motion of particles in a viscoelastic medium. Here, we show that biochemical reactions, e.g. (multiple) phosphorylation events, are massively influenced by the reactants' (sub)diffusion characteristics. In virtually all studied cases an anomalous kinetics was observed, i.e. a time-dependent rate coefficient emerged along with a segregation of reactants. As a consequence, multiple phosphorylation events, e.g. in intracellular signaling cascades, may occur with a higher probability as compared to reactions in purely viscous (water-like) environments that are fueled by a normal diffusion.

BP 24.2 Thu 10:30 ZEU 250

Thermal Measurements in Single Cells — •Simone Herth[1], Miriam Giesguth[2], Günter Reiss[1], and Karl-Josef Dietz[2] — [1]Fakultät für Physik, Universität Bielefeld — [2]Fakultät für Biologie, Universität Bielefeld

Thermocouples based on the Seebeck effect are commonly used as thermal sensors for a wide range of applications. Since the voltage measured at the reference points only depends on the temperature difference between the overlap of the two metals and the reference points and not on the size of the system, thermo couples can also be nanostructured on chip or even onto a glass capillary.

Ni and NiCr (Seebeck coefficient = 40 μV/K) was placed on the opposite sites of a glass capillary, which can be manipulated with a micromanipulator system. In this way, it is possible to place the capillary in a plant leaf and to measure the temperature increase during illumination. Due to the fine control of the micromanipulator, the microcapillary can also be inserted into a single cell, like a trichome of *Arabidopsis thaliana.*

BP 24.3 Thu 10:45 ZEU 250

High resolution imaging of the surface of single bacterial cells — •Dominik Greif, Daniel Wesner, Jan Regtmeier, and Dario Anselmetti — Experimental Biophysics & Applied Nanoscience, Bielefeld University, Universitaetsstr. 25, 33615 Bielefeld, Germany

Native surface structures of living bacteria are difficult to analyse by imaging with traditional scanning electron microscopy (SEM) because of possible artefacts that stem from the often necessary sample preparation procedures.

We systematically investigated the origin of surface morphology observed on *Sinorhizobium meliloti* bacterial cells by comparing results of the complementary techniques atomic force microscopy (AFM) and SEM. Those were applied from living bacteria in physiological environment to fixed bacteria in high vacuum. Stepwise, we applied different sample modifications (fixation, drying, metal coating, etc.) and characterized observed surface patterns. A detailed analysis revealed that the surface structure that is dominated by wrinkled protrusions in SEM images were not generated de novo but evolved from native structures on the surface of living bacteria [1]. In addition we evaluated the influence of osmotic stress to the surface morphology of living cells and also the contribution of exopolysaccharide and lipopolysaccharide (LPS) by imaging two mutant strains of the bacterium under native conditions [1]. Lastly, we could demonstrate that AFM images of living bacteria in culture medium allowed identification of surface features of the size of single proteins emphasizing the usefulness of AFM for high resolution cell imaging. [1] D. Greif et al., Ultramicroscopy 110 (2010) 1290-6

BP 24.4 Thu 11:00 ZEU 250

Fluoreszenz Messungen an Einzelzellen des Modelorganismus für die Photosynthese *Chlamydomonas reinhardtii* — •Andreas Garz[1], Michael Sandman[2], Heiko Lokstein[2], Martin Steup[2] und Ralf Menzel[1] — [1]Institut für Physik und Astronomie, Photonik — [2]Institut für Biochemie und Biologie, Pflanzenphysiologie, Universität Potsdam, Karl-Liebknecht-Str. 24/25, 14476 Potsdam

Die der Photosynthese zugrunde liegenden Mechanismen weisen nach wie vor viele ungeklärte Fragen auf. Innerhalb des interdisziplinären Forschungsverbundes GoFORSYS sollen die im Labor gewonnen Daten den bedeutendsten biochemischen Vorgang der Erde am Computer nachbilden.

In einem Teilprojekt untersuchen wir im Speziellen die regulierenden Mechanismen der Photosynthese, insbesondere deren Schutzmechanismen. Mittels des Prinzips der Puls-Amplituden-Modulation (PAM)-Fluorimetrie an einzelnen Zellen der Grünalge *Chlamydomonas reinhardtii* werden für diese das photochemische und nicht-photochemische Quenchen untersucht. Vorgestellt werden Fluoreszenzmessungen an einzelnen Zellen und die daraus abgeleitete photosynthetische Aktivität in Abhängigkeit des Zellentwicklungsstadiums und gezielt veränderter Umweltbedingungen.

BP 24.5 Thu 11:15 ZEU 250

Mechanics of Spindle Alignment in Saccharomyces cerevisiae — •Stephan Baumgärtner, Hannes Weisse, and Iva Tolic-Nørrelykke — Max-Planck-Institute for Cell Biology and Genetics, Dresden

Asymmetric cell devisions are an important process for cell differentiation in higher organisms. To study such divisons, the asymmetric dividing fungus Saccharomyces cerevisiae is an excellent model. It is essential for finishing cytokinesis to orient the mitotic spindle along the mother-bud axis for proper chromosome segregation. In an early pathway (PW), the older of the two spindle pole bodies (oSPB) is moved towards the mother-bud neck by astral microtubules (aMT). During a late PW, the aMTs grow inside the bud and get captured by the dynein anchor Num1 located in the bud cell cortex. Dynein translocates the oSPB through the neck by pulling on the aMTs.

Fast live cell imaging, quantitative image analysis and mathematical modeling is applied. Wild-type (WT) cells and cells lacking the early PW nearly all finished translocation of the spindle within 30 minutes from the onset of mitosis (spindle L $\geq 2\mu m$), only 80% of the cells lacking the late PW were able to do so. The spindle movement often shows pulling events (PE), i.e. rapid jumps of the spindle. In WT cells, these PE more often occur after the oSPB entered the bud. Cells lacking the late PW show much less PE and cells without the early PW show hardly any PE before the spindle entering. Thus, the efficiency of the delivery of the oSPB to the daughter cell depends mainly on the late PW, whereas the early PW is required to orient the spindle.

15 min. break

BP 24.6 Thu 11:45 ZEU 250

Using novel microscopy methods to correlate pluripotent stem cell state with subcellular structure — •Kevin Chalut, Markus Hoepfler, Andrew Ekpenyong, and Jochen Guck — Cavendish Laboratory, University of Cambridge, Cambridge, UK

The function of pluripotent stem cells (PSCs) is to commit to all types of tissue cells needed for an organism while self-renewing and maintaining their pluripotency until all lineages are established. PSC state - pluripotent, pre-committed, or committed - has primarily been probed by investigating biochemical properties, but the mystery of how biological diversity is established while maintaining pluripotency remains unsolved. In an effort to solve this mystery, we probed PSC state by evaluating their physical properties. These physical properties include their internal structure, particularly changes in chromatin structure. To visualise the relationship between chromatin structure and PSC state, we used a fluorescent label for heterochromatin proteins, and then imaged using confocal microscopy and STED. Furthermore, we used digital holographic microscopy, a live-cell and label-free technique, to visualise chromatin structure and correlate it with PSC state. We saw in all techniques that, prior to differentiation, the chromatin structure opens up considerably, diffusing throughout the nucleus. This opening up of chromatin correlates with greater transcriptional accessibility. These structural changes are a physical phenotype that we can use to deduce PSC state, and they can also be used as a biomarker for pluripotency and differentiation.

BP 24.7 Thu 12:00 ZEU 250

Anomalous diffusion of intracellular lipid granules — •Christine Selhuber-Unkel[1,2], Pernille Yde[2], Jae-Hyung Jeon[3], Vincent Tejedor[3], Kirstine Berg-Sorensen[4], Ralf Metzler[3], and Lene B. Oddershede[2] — [1]University of Kiel, Institute for Materials Science — [2]University of Copenhagen, Niels-Bohr-Institute — [3]Technical University Munich, Physik-Department — [4]Technical University of Denmark, Department of Physics, Kgs. Lyngby

The intracellular motion of cellular compartments plays an essential role for directed and undirected intracellular transport processes. We used live cell imaging and optical tweezers to track single endogenous, intracellular particles with high temporal and spatial resolution in order to investigate the diffusion properties of the granules in the different phases of the cell cycle. We found that the majority of the lipid granules underwent subdiffusive motion during all stages of the cell cycle. Interestingly, our results indicate that the cytoplasm is more elastic during interphase than during cell division and that its elasticity is relatively constant during the stages of cell division. In interphase, a comparison of our data with complementary analytical results has shown evidence for anomalous diffusion and ageing. We demonstrate that in the millisecond regime the granules follow subdiffusive motion according to the laws of continuous time random walk theory. At longer times granule motion is consistent with fractional Brownian motion.

BP 24.8 Thu 12:15 ZEU 250

Physical description of centrosome assembly and disassembly — •David Zwicker[1], Markus Decker[2], Steffen Jaensch[2], Anthony A Hyman[2], and Frank Jülicher[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Max Planck Institute of Molecular Cell Biology and Genetics, Dresden, Germany

The size of many cell organelles is strongly correlated with cell size. Achieving this requires a robust mechanism for scaling subcellular structures. Here, we propose a theoretical description of the growth phase of the centrosome, an organelle involved in mitosis. We identify a possible mechanism by which the centrosome volume may be controlled. Not only can our theory explain the growth dynamics for all cell sizes down to the sixteen cell stage of the C. elegans embryo, but it does also account for data acquired in experiments with aberrant numbers of centrosomes or altered cell volumes. Additionally, the model can describe the dissolution phase occurring during cell division and centrosomes of unequal size observed in cells with disturbed centrioles.

BP 24.9 Thu 12:30 ZEU 250

Spatial organization of the cell cytoplasm: Protein gradients and liquid-liquid phase separation in the C. elegans embryo — •Chiu Fan Lee[1], Clifford P. Brangwynne[2], Zdeněk Petrášek[3], Jöbin Gharakhani[1], Anthony A. Hyman[2], and Frank Jülicher[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Max Planck Institute of Molecular Cell Biology and Genetics, Dresden, Germany — [3]Biotechnologisches Zentrum der TU Dresden, Dresden, Germany

During the asymmetric division of the one-cell stage embryo of the nematode C. elegans, germ line granules (P-granules) segregate and localize in the posterior half of the cell in order to be unequally distributed to the two daughter cells. Segregation occurs via a spatial gradient of supersaturation of P-granule components which nucleate in droplets on in the posterior side and dissolve in the anterior side. This supersaturation gradient is generated by a concentration gradient of the protein Mex-5. Using a combined experimental and theoretical approach, we show that the Mex-5 gradient is established by a modulation of the diffusivity of Mex-5 via reactions that occur at the cell cortex and within the cytoplasm. We propose that Mex-5 may control P-granule phase separation via its competitive RNA binding activity, by which the local Mex-5 concentration influences the saturation point of the phase transition that triggers P-granule formation.

BP 24.10 Thu 12:45 ZEU 250

Random cell movement promotes synchronization of the segmentation clock — •Koichiro Uriu[1,2], Yoshihiro Morishita[2,3], and Yoh Iwasa[2] — [1]Max Planck Institute of Molecular Cell Biology and Genetics, Dresden, Germany — [2]Kyushu University, Fukuoka, Japan — [3]PRESTO JST, Japan

In vertebrate somitogenesis, the expression of segmentation clock genes show oscillation, synchronized over neighboring cells. Both experimental and theoretical studies have shown that the synchronization between neighboring cells is achieved by intercellular interaction via Delta-Notch signaling. However, the following question emerges: during somitogenesis, active cell movement is observed in the posterior presomitic mesoderm. Can a synchronized state be stably sustained under random cell movement? In this talk, we show that synchronized oscillation can be sustained under random cell movement. We also find that after disturbed initial condition, the synchronization of cells is achieved much faster with random cell movement. We also show that the anisotropy in the direction of cell movement and the shapes of tissues affect synchronization of the segmentation clock.