BP 7: Cell Mechanics III

Time: Monday 14:00–16:30 Location: BPa

BP 7.1 Mon 14:00 BPa

Highly Reproducible Physiological Asymmetric Membrane with Freely Diffusing Embedded Proteins in a 3D Printed Microfluidic Setup — Paul Heo[1], Sathish Ramakrishnan[1,2], Jeff Coleman[2], James E. Rothman[2], •Jean Baptiste Fleury[3], and Frederic Pincet[1] — [1]Laboratoire de Physiqe Statistique ENS, Paris, France — [2]Department of Cell Biology Yale School of Medicine, New Haven, USA — [3]Department of Experimental Physics and Center for Biophysics, Saarland University Saarbruecken, Germany

Experimental setups to produce and to monitor model membranes have been successfully used for decades and brought invaluable insights into many areas of biology. However, they all have limitations that prevent the full in vitro mimicking and monitoring of most biological processes. Here, a suspended physiological bilayer-forming chip is designed from 3D-printing techniques. This chip can be simultaneously integrated to a confocal microscope and a path-clamp amplifier. The bilayer, formed by the zipping of two lipid leaflets, is free-standing, horizontal, stable, fluid, solvent-free, and flat with the 14 types of physiologically relevant lipids, and the bilayer formation process is highly reproducible. Furthermore, different proteins family can be added to the bilayer in controlled orientation and keep their native mobility and activity. These features allow in vitro recapitulation of membrane process close to physiological conditions, as shown in the following references: Small, 2019, 10.1002/smll.201900725 Advanced Materials, 2020, 10.1002/adma.202070389 PNAS, 2021 (in press)

BP 7.2 Mon 14:20 BPa

Tracking Electrostatically Driven Membrane Transfer between Lipid Vesicles and a Supported Lipid Bilayer on a QCM — •Justus Bednár[1,2], Anastasia Svetlova[1,2], Vanessa Maybeck[1], and Andreas Offenhäusser[1] — [1]Forschungszentrum Jülich, Institute of Biological Information Processing: Bioelectronics (IBI-3) — [2]Fakultät für Mathematik, Informatik und Naturwissenschaften RWTH Aachen

Lipid bilayer systems are used widely in medicine and biotechnology. Supported lipid bilayers (SLBs) for example, can be employed as a biomimetic platform for cell cultures or can be studied as a model system of the cell membrane itself. If SLB and lipid vesicles have opposite surface charges, their electrostatic interaction can be used to modify the lipid composition of the SLB. Studying the underlying process, the quartz crystal microbalance (QCM) stands out for its ability to precisely monitor the acoustic response of a macroscopic SLB and coupled objects with a sub-second time resolution. Unfortunately, standard models that relate the QCM signal response to physical properties of the sample do not apply in this case.

Here, a viscoelastic model for an ensemble of lipid vesicles, coupled to an SLB, is presented. Experimental results demonstrate the capability of this model to estimate relative concentrations of extracellular vesicles (EVs) in bulk solution. Furthermore, throughout numerous experiments of electrostatically driven membrane transfer between lipid vesicles and an SLB, a non-trivial time-dependence of vesicle-adsorption is observed.

Invited Talk BP 7.3 Mon 14:40 BPa

Towards the mechanical characterization of neuronal network formation — Paulina Wysmolek[2], Florian Huhnke[2], Katja Salbaum[1], Joachim Spatz[2], and •Friedhelm Serwane[1,2] — [1]LMU, Department of Physics, Munich — [2]Max Planck Institute for Medical Research, Heidelberg

In recent years, researchers have engineered multicellular 3D systems, organoids, which share the same cell types and tissue organization as their in vivo counterparts. Those in vitro models provide an opportunity to glimpse at how biology self-assembles neuronal networks and how nanoscale building blocks, such as cell-cell adhesion molecules, contribute to the formation of tissue shape, structure and function. In this talk I will present the current and future research of our newly established ERC-group. We will explore, how tissue mechanical properties affect the formation and function of retina organoids. For this, we build on our expertise in mechanics measurements (1,2) and retina organoid technology. Quantifying the mechanics of neuronal systems opens the door to neurodegenerative disease modeling as it will be performed by our group. In addition, it allows developing a biophysical understanding how neuronal networks are initially formed.

(1) Serwane et al., In vivo quantification of spatially-varying mechanical properties in developing tissues. Nature Methods, 2017

(2) Mongera et al., A fluid-to-solid jamming transition underlies vertebrate body axis elongation. Nature, 2018

BP 7.4 Mon 15:10 BPa

Lattice defects induce microtubule self-renewal — Laura Schaedel[1], Sarah Triclin[1], Denis Chrétien[2], Ariane Abrieu[3], Charlotte Aumeier[1], Jérémie Gaillard[1], Laurent Blanchoin[1,4], Manuel Théry[1,4], and •Karin John[5] — [1]Univ. Grenoble-Alpes, CEA, CNRS, INRA, Biosciences & Biotechnology Institute of Grenoble, Laboratoire de Physiologie Cellulaire & Végétale, CytoMorpho Lab, 38054 Grenoble, France — [2]Univ. Rennes, CNRS, IGDR (Institute of Genetics and Development of Rennes) - UMR 6290, F-35000 Rennes, France — [3]CRBM, CNRS, University of Montpellier, Montpellier, France — [4]Univ. Paris Diderot, INSERM, CEA, Hôpital Saint Louis, Institut Universitaire d'Hematologie, UMRS1160, CytoMorpho Lab, 75010 Paris, France — [5]Univ. Grenoble-Alpes, CNRS, Laboratoire Interdisciplinaire de Physique, 38000 Grenoble, France

Microtubules are dynamic polymers, which grow and shrink at their extremities. Within the microtubule shaft, tubulin dimers adopt a highly ordered lattice structure, which is generally not considered to be dynamic. Here we report a new aspect of microtubule dynamics, whereby thermal forces are sufficient to remodel the lattice, despite its apparent stability. Our combined experimental data and numerical simulations on lattice dynamics and structure demonstrate that dimers can spontaneously leave and be incorporated into the lattice at structural defects. We propose a model mechanism, where the lattice dynamics is initiated via a passive breathing mechanism at dislocations, which are frequent in rapidly growing microtubules.

BP 7.5 Mon 15:30 BPa

Multiplication of gliding microtubules for biocomputational applications — •Cordula Reuther[1], Paula Santos Otte[1], Rahul Grover[1], Till Korten[1], Günther Woehlke[3], and Stefan Diez[1,2] — [1]B CUBE, TU Dresden, Dresden, Germany — [2]Cluster of Excellence Physics of Life, TU Dresden, 01062 Dresden, Germany — [3]Department of Physics, TU München, Garching, Germany

Recently, an approach to solve combinatorial problems was demonstrated by kinesin-1 driven microtubules exploring, as autonomous agents, physical networks of nanometer-sized channels [Nicolau et al., PNAS, 113(10), 2016]. The possibility to multiply the agents exponentially while traversing such networks is crucial for the scalability of these systems. We developed a method for the multiplication of microtubules gliding on surface-immobilized kinesin-1 and kinesin-14 molecules, respectively. Specifically, our method comprises two simultaneously proceeding processes: (1) elongation of microtubules by self-assembly of tubulin dimers and (2) cutting of microtubules by the severing enzyme spastin. The main challenge in doing so is to optimize both processes such that the average length of the filaments stays roughly constant over time while the number of filaments increases exponentially. Additionally, nucleation of new filaments ought to be avoided in order to prevent errors in the calculations performed by the microtubules. Thus, we first studied each of the two processes separately under various conditions before combining the optimized protocols to actually multiply microtubules. Finally, we aim to multiply microtubules in a physical network with channel structures.

40 min. Meet the Speaker