BP 18: Cell mechanics II

Time: Wednesday 15:00–17:15 Location: H10

BP 18.1 Wed 15:00 H10

Combined Traction Force and Scanning Probe Microscopy for Investigation of Active and Passive Cell Mechanics — •Johannes Rheinlaender, Nicolas Schierbaum, and Tilman E. Schäffer — Institute of Applied Physics, Eberhard Karls University Tübingen, Germany

Living cells are highly complex systems and their mechanics are governed by the cytoskeleton, which exhibits two outstanding characteristics: "passive" viscoelastic material properties and "active" contractile forces. Understanding their interplay is subject of current research, but there is no technique for the direct measurement of both viscoelastic material properties and contractile forces in parallel. We therefore for the first time directly combined traction force microscopy (TFM) and scanning probe microscopy (SPM), specifically, scanning ion conductance and atomic force microscopy (AFM). Using combined TFM and AFM, we directly measured the relation between viscoelastic material properties in terms of stiffness and fluidity and contractile forces in terms of the net contractile moment on the single-cell level. We found a strong correlation between each stiffness, fluidity, and net contractile moment, suggesting a common mechanism controlling all three parameters. Myosin II inhibition results in concurrent change of all three parameters to this correlation, confirming that the actomyosin machinery concurrently controls both viscoelastic material properties and contractile forces. Further experimental and theoretical work is required for a complete understanding of cell mechanics, but combined TFM and SPM is powerful tool for this purpose.

BP 18.2 Wed 15:15 H10

Investigating cancer cell behaviour during migration through a confining microenvironment — •Carlotta Ficorella — University of Leipzig, Linnéstraße 5, 04103 Leipzig, Germany

The extra-cellular microenvironment plays a fundamental role in tumour growth and progression, strongly affecting the migration strategies adopted by single cancer cells during metastatic invasion. Here we use a novel microfluidic device to investigate the ability of mesenchymal and epithelial breast tumour cells to migrate through quasi-three-dimensional narrowing microstructures upon chemoattractant stimulation.

Our results show that both epithelial and invasive cells are able to easily disassemble and rearrange their cytoskeleton, in order to achieve migration through the constriction openings. Metastatic mesenchymal cells, on the other hand, exhibit no invasive behaviour. We also demonstrate that migration of epithelial cells through a highly compressive environment can occur in absence of a chemoattractive stimulus, thus suggesting that they are just as prone to react to mechanical cues as invasive cells.

BP 18.3 Wed 15:30 H10

Spatial heterogenity of the mechanics of solid tumors — •Thomas Fuhs, Erik W. Morawetz, Frank Sauer, Steffen Grosser, and Josef A. Käs — Peter Debye Institut für Physik weicher Materie, Universität Leipzig, Deutschland

In solid tumors tissue that is stiffer than healthy tissue is formed by cells that are softer than healthy cells. We try to address this contradiction by spatially resolved investigation of the mechanics of solid tumors tissues. We are able to measure the elasticity of slices of solid tumors on the millimeter scale with micrometer spatial resolution by AFM. This avoids measuring only heavily selected regions or only single cells extracted from dissected tissue. At the same time we are able to precisely align our AFM data with immunohistological stains. We can correlate the spatial heterogeneity of the elasticity maps with the distribution of cytokeratin. We complete these measurements with elasticity data on the whole tissue scale obtained by magnetic resonance elastography and single cell data from optical stretcher measurements. Each set of measurements is performed with tissue and from the same tumor, minimizing the error through biological variance within a dataset. Through the combination of the measurements we are able to bridge the scales from single cells to tissue level, to see how the individual cells contribute to the whole.

BP 18.4 Wed 15:45 H10

Modeling of T-Cell polarization — •Ivan Hornak and Heiko Rieger — Saarland University, Center for Biophysics, Theoretical Physics Saarbrücken, Germany

Cytotoxic T lymphocytes (T) and natural killer (NK) cells are the main cytotoxic killer cells of the human body to eliminate pathogen-infected or tumorigenic cells (i.e. target cells). They form a tight contact, the immunological synapse (IS), with targets and release their lytic granules containing perforin/granzyme and cytokine containing vesicles. Once a NK or T cell has identified a target cell and established a contact zone one observes a re-polarization of the cell involving the rotation of the microtubule (MT) half-spindle and a movement of the centrosome or microtubule organizing center (MTOC) to a position that is just underneath the plasma membrane at the center of the IS. Concomitantly a massive relocation of organelles attached to MTs is observed, including the Golgi apparatus, lytic granules and mitochondria. Since the mechanism of this relocation is poorly understood we devised a theoretical model for the molecular motor driven motion of the MT half-spindle confined between plasma membrane and nucleus during T cell polarization. We analyze different scenarios currently discussed in the literature, including cortical sliding and capture shrinkage mechanism, and compare quantitative predictions about the spatio-temporal evolution of MTOC position and spindle morphology with experimental observations. We propose that our model opens a way to infer details of the molecular motor distribution from the experimentally observed features of the MT half-spindle dynamics.

BP 18.5 Wed 16:00 H10

Toward theoretical model for cell blebbing — Sebastian Hillringhaus, Gerhard Gompper, and •Dmitry A. Fedosov — Institute of Complex Systems, Forschungszentrum Jülich, Jülich, Germany

Cell blebbing corresponds to the dissociation of cell membrane from the inner cellular network as result of internal stresses. Therefore, it represents the instability of the connection between the membrane and actin cortex. We employ a coarse-grained cell model to study cell blebbing for a number of involved parameters, including membrane rigidity, cytoskeletal stress, and binding strength between the membrane and bulk cytoskeleton. Furthermore, theoretical model for the detachment of bound solid surfaces is extended in order to include the effect of deformable cellular structures on the blebbing process.

BP 18.6 Wed 16:15 H10

How the cytoskeleton and cell shape directs pollen tube outgrowth in Arabidopsis thaliana — Lucie Riglet[1], •Karin John[2], Frédérique Rozier[1], Thierry Gaude[1], Catherine Quilliet[2], and Isabelle Fobis-Loisy[1] — [1]RDP, ENS Lyon, France — [2]LIPhy, CNRS, U. Grenoble-Alpes, France

In the flowering plant Arabidopsis thaliana, the pollen tube that transports male gametes grows within the cell wall of the epidermal cells of the female reproductive organ, also named stigmatic papilla. In the katanin mutant (ktn), the shape of the papilla is slightly altered and cortical microtubules (CMT) are completely disorganized compared to the wild type. At the same time the directionality of pollen tube growth is disturbed. We show by Atomic Force Microscopy and measurements of pollen tube growth speed, that alterations in the CMT organization affect the mechanical properties of the stigmatic cell wall, which could be responsible for the disoriented pollen tube growth. We propose a simple model mechanism, where pollen outgrowth is directed by two basic principles: (i) minimizing locally the curvature of the pollen tube path on the papilla surface and (ii) mechanical anisotropy of the papilla wall stiffness.

Invited Talk BP 18.7 Wed 16:30 H10

Physics of epithelial folding — •Guillaume Salbreux — The Francis Crick Institute

The shape of a biological tissue is determined by mechanical stresses acting within the tissue cells. During embryonic morphogenesis, forces generated in the actomyosin cytoskeleton in the cells of epithelia result in cell deformation, cell rearrangements, and 3D bending of the epithelium. To understand tissue morphogenesis, force generation at the cellular scale must be related to flows and deformation occurring at the tissue scale. Here I will discuss how this relation can be captured by a 3D vertex model or by a continuum theory of active surfaces subjected to internal torques. Using this framework, I will discuss ep-

ithelial fold formation in the Drosophila wing disc and the formation of pancreatic cancerous tumours.

BP 18.8 Wed 17:00 H10

Mechanical Properties of Head and Neck Squamous Carcinoma Cells — •Hsiao-Ching Tsai[1], Julia Kristin[2], Jörg Schipper[2], and Mathias Getzlaff[1] — [1]Institute of Applied Physics, Heinrich-Heine-Universität Düsseldorf — [2]Hals-Nasen-Ohren-Klinikum Düsseldorf

Several studies have shown that many human diseases can be associated to the mechanical properties of living cells. Additionally, elastic properties of cancer cells may play a major role in malignant processes. Since cell stiffness is related to invasiveness, we suggest that the elasticity parameter is a useful parameter to distinguish between cancer and non-malignant cells. Atomic Force Microscopy (AFM) is a powerful technique to determine mechanical properties. However, the characterization of mechanical properties of cells or tissue with AFM is relatively costly, difficult and time-consuming. Moreover, the experimental result is hard to reproduce due to the aquatic environment. Therefore, the discrimination of elastic properties of Head and Neck Squamous Carcinoma Cells (HNSCC), one of the most severe tumor cells, is not determined yet. In this study, we culture both normal cells and cancerous human oral cells from different location of head-neck area and applied them with an indentation study of AFM. With this measurement, we can get not only the cell morphology, but also the elastic modulus using Hertz Contact Model.