BP 7: Posters: Cell adhesion, mechanics and migration

Time: Monday 17:30–19:30 Location: P3

BP 7.1 Mon 17:30 P3

Mechanical Response of MDCK II Cells to Porous Substrates — •Matthias Büchsenschütz-Göbeler[1], Jan Rother[3], Andreas Janshoff[3], Walter Arnold[1,2], and Konrad Samwer[1] — [1]I. Physikalisches Institut, Universität Göttingen — [2]Department of Material Science and Materials Technology, Saarland University — [3]Institut für Physikalische Chemie, Universität Göttingen

A large number of cellular processes, such as proliferation, differentiation and motility involve adhesion and mechanical adaption of living cells to surfaces. Usually, cells are part of whole cellular networks and connected by an extracellular matrix (ECM). Thereby, elasticity, chemical composition and topography of the ECM affect cell motility and viscoelasticity by changing signal transduction pathways that in turn influence organization of cytoskeleton. The viscoelastic response of living MDCK II cells and adhesion to porous surface elasticity has been investigated by conventional nanoindentation and by a microrheological approach using a modified atomic force microscope. The structure of the cytoskeleton has been monitored by scanning electron microscopy and total internal reflection microscopy. The results show that cells grown on porous substrates are generally softer than cells grown on smooth substrates. With increasing pore size the stiffness of the cells decreases until a certain threshold size is reached. For larger pore sizes the stiffness is increasing again. In addition to this mechanical behavior a correlation with the cytoskeletal structures of the cells is observed.

Financial support by the DFG SFB 937 is thankfully acknowledged.

BP 7.2 Mon 17:30 P3

Xenopus spindle size is set by the microtubule mass balance in an active liquid crystal — •Johannes Baumgart[1], Simone B. Reber[2], Anthony A. Hyman[2], and Frank Julicher[1] — [1]Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Str. 38, 01187 Dresden, Germany — [2]Max Planck Institute of Molecular Cell Biology and Genetics, Pfotenhauer Str. 108, 01307 Dresden, Germany

The spindle apparatus consists mainly of microtubules and associated proteins. Correct spindle length is essential to reliably segregate chromosomes. Although we have extensive knowledge of microtubule dynamics, we still lack an understanding of how their collective properties give rise to a spindle with a defined size. We describe the spindle as an active liquid crystal because the individual rod-like microtubules turnover fast and are short compared to the overall spindle length. Furthermore, they slide and align by the activity of specific motors and crosslinkers. This allows us to determine spindle size by using mass balance of dynamic microtubules considering a constant spindle mass density. Spindle size then results from the balance of localized nucleation mediated by chromatin and global disassembly of microtubules.

This model implies a linear relationship between spindle length and microtubule growth velocity. This is indeed observed experimentally (Reber et al., Nat Cell Biol, 2013, 15, 1116–1122). In experiments, *Xenopus laevis* egg extract was used, which rules out size control due to external constrains and component limitations.

BP 7.3 Mon 17:30 P3

A Novel Method for Traction Force Microscopy and first Applications — •Benedikt Sabass[1,2] and Ulrich S. Schwarz[2] — [1]Princeton University — [2]University of Heidelberg

We present a new and simple method to measure three-dimensional forces exerted by cells on flat elastic substrates. Traction force microscopy is a well-established technique for two-dimensional mapping of forces. However, the reconstruction of three-dimensional surface forces has been hampered by the difficulty to obtain reliable measurements of the vertical deformation of the substrate. The new method avoids this problem and only requires a standard experimental setup with a confocal microscope. We explain the mathematical background of our approach and describe the experiment. Advantages and disadvantages of the method are exemplified with simulated data. Finally, we discuss measurements that demonstrate the presence of weak out-of-plane forces in the case of adhering fibroblasts.

BP 7.4 Mon 17:30 P3

Mechanical and spectroscopic analysis of single erythrocytes using whole human blood samples — •Michael Göllner, Adriana Toma, and Thomas Pfohl — Department of Chemistry, University of Basel, Switzerland

Containing a wealth of information, human blood is the most used sample for diagnostic purposes. Microfluidics, with its unique advantages in performing analytical functions, has been increasingly used for whole blood and cell-based analysis. Single-cell studies using optical tweezers involve complex and expensive instrumentation to manipulate erythrocytes, which might be detrimental for easy application in medical diagnostics. Moreover, optical trapping shows photodamage causing difficulties with long-term and step-by-step analysis under reversible reaction control.

We developed a microfluidic setup in combination with optical and confocal Raman microscopy for single-cell assays starting with whole blood samples, which permits diffusion-controlled variation of the external environment without the need of optical tweezers for immobilizing the erythrocytes. Mechanical as well as spectroscopic properties like membrane elasticity, shape deformations and the full oxygenation cycle of individual erythrocytes under different osmolarities are investigated.

BP 7.5 Mon 17:30 P3

Stress fibre organisation dynamics in adult stem cells — •Carina Wollnik[1], Kwang-Rae Kim[2], Ina Schachtschneider[2], Carsten Gottschlich[2], Stephan Huckemann[2], and Florian Rehfeldt[1] — [1]Third Institute of Physics - Biophysics, Georg-August-University, Göttingen, Germany — [2]Institute for Mathematical Stochastics, Georg-August-University, Göttingen, Germany

Human mesenchymal stem cells (hMSCs) from bone marrow differentiate into other cell types like nerve, bone, and muscle cells. Here mechanical cues can be as important as biochemical ones as demonstrated by Engler et al. [1]. They showed substrate stiffness guides hMSCs towards different lineages in the absence of additional biochemical stimuli. Stress fibres composed of actin filaments, binding- and crosslinking-proteins and myosin motor-proteins, generate and transmit forces within the cell and to the ECM. Blocked motor-proteins stop the cell differentiation process, so stress fibre activity seems crucial. Though the differentiation process takes up to weeks, early characteristic stress fibre reorganisation can be detected within the first 24 hours and used as an early morphological marker[2]. In our experiments we use live-cell imaging of RFP-Lifeact transfected hMSCs and trace the stress fibres with sophisticated filament tracking algorithms [3], which enable us to investigate the dynamics of stress fibre formation in early stages after seeding that leads to a non-monotonic dependence of stress fibre polarization on the Young's modulus of the underlying substrate. [1]Engler et. al., 2006 [2]Zemel and F. Rehfeldt et al., 2010 [3]Gottschlich et al., 2009

BP 7.6 Mon 17:30 P3

T-cell response to ligand presentation in the form of nano-dot arrays — •Fuwei Pi[1], Pierre Dillard[1,2], Anne Charrier[1], Laurent Limozin[2], and Kheya Sengupta[1] — [1]Aix-Marseille Université, CNRS, CINaM UMR 7325, Marseille, 13288, France — [2]Laboratoire Adhésion & Inflammation, Aix-Marseille Université / Inserm U1067 / CNRS UMR7333, Marseille, 13288, France

We developed a simple cost-effective benchtop protocol to functionalize glass or polydimethylsiloxane elastomers with an array of nanometric protein dots for cell adhesion studies [1]. The diameter of the dot was varied down to about 80 nm. The adhesion of T-lymphocytes (Jurkat) on substrates patterned with the ligand anti-CD3 was studied using a variety of imaging techniques. The adhesion area was quantified using reflection interference contrast microscopy (RICM). Total internal reflection fluorescence (TIRF) microscopy was used to explore the possible colocalization of T-cell receptor microclusters and the activating anti-CD3 dots. The impact on the structure of the actin cytoskeleton was imaged with TIRF and confocal microscopy. We report modulation of the cell surface topography, and actin organization.

[1] F. Pi, P. Dillard, L. Limozin, A. Charrier, K. Sengupta; NanoLett. 13 7 3372-3378 (2013).

BP 7.7 Mon 17:30 P3

Regulation of Hematopoietic Stem Cell Adhesion by Nanometric Presentation of Niche Ligand Candidates — •Alexandra Burk[1,2], Cornelia Monzel[2], Hiroshi Yoshikawa[3], Anthony Ho[4], and Motomu Tanaka[1,2,5] — [1]Institute for Toxicology and Genetics, Karlsruhe Institute of Technology, Karlsruhe, Germany — [2]Physical Chemistry of Biosystems, Institute of Physical Chemistry, Heidelberg University, Heidelberg, Germany — [3]Department of Chemistry, Saitama University, Saitama, Japan — [4]Clinic for Internal Medicine V, Heidelberg University, Heidelberg, Germany — [5]Institute for Integrated Cell-Material Sciences (WPI iCeMS), Kyoto University, Kyoto, Japan

A major challenge in understanding the mobilization/immobilization mechanisms of hematopoietic stem cells (HSC) is to characterize the complex interplays of HSC-niche interactions in bone marrow such as the receptor/ligand pairs N-cad/N-cad and CXCR4/SDF1α. To quantify these interactions, we designed well defined niche models consisting of planar lipid membranes on solid substrates displaying recombinant N-cadherin and human SDF-1α at defined intermolecular distances (5 nm to 100 nm). For contact- and label-free imaging of HSC, micro-interferometry (RICM) and phase contrast imaging was applied. To evaluate the strength of cell adhesion, we developed a new technique utilizing pressure waves induced by a picosecond laser pulse for non-invasive HSC detachment. Moreover, time-lapse analysis of cellular motion resulted in characteristic mean square displacements and modes of motion depending on the underlying substrate.

BP 7.8 Mon 17:30 P3

Cell mechanics and innate immunity link up during infections — •Andrew Ekpenyong[1,3], Si Ming Man[2], Sarra Achouri[1], Gilbert Ng[1,3], Kate Hughes[2], Panagiotis Tourlomousis[2], John Wright[2], Pietro Cicuta[1], Clare Bryant[2], and Jochen Guck[1,3] — [1]Cavendish Lab., Dept. of Physics, Univ. of Cambridge, UK — [2]Dept. of Vet. Medicine, Univ. of Cambridge, UK — [3]Biotech. Center, Technische Universität Dresden, Germany.

Infections, in which pathogens invade and colonize host cells, constitute some of the most serious diseases faced by humans. Host cells use immune system proteins and other molecules to fight viral and bacterial invaders. The mechanisms by which these proteins enable cells to survive infections remain unclear. Moreover, during infections, some immune system proteins are known to alter the cytoskeleton, the structure that largely determines cellular mechanical properties. We therefore used an optical stretcher to measure the mechanical properties of primary immune cells (macrophages) during bacterial infection. We found that macrophages become stiffer upon infection. Remarkably, macrophages lacking the proteins, Caspase 1 and NLRC4, lost the stiffening response to infection. This *in vitro* result correlates with our *in vivo* data whereby mice lacking Caspase 1 and NLRC4 have more lesions, implying increased bacterial spread. Thus, the immune-protein-dependent increase in cell stiffness in response to bacterial infection seems to have a functional role in the system level fight against pathogens. We will discuss how this functional link between cell mechanics and innate immunity reduces the spread of infection.

BP 7.9 Mon 17:30 P3

Correlation analysis of the role of TRPC6 channels in the regulation of CXCR2-mediated chemotaxis of murine neutrophils — •Peter Dieterich[1], Otto Lindemann[2], and Albrecht Schwab[2] — [1]Institut für Physiologie, TU Dresden — [2]Institut für Physiologie II, Westfälische Wilhelms-Universität Münster

Cellular motility and the ability of cells to sense and react to changes of their environment are of fundamental importance for efficient immune response. Chemoattractants trigger receptor initiated signaling cascades including the activation of plasma membrane Ca^{2+} channels of the transient receptor potential channel family (TRPC). Here we disentangle the influence of TRPC6 channels on cell migration paths of murine neutrophils during chemotaxis caused by spatially increasing concentrations of keratinocyte-derived cytokine KC. Wildtype neutrophils show directed motion and diffusion. Blocking of the KC-receptor CXCR2 with a specific inhibitor reduces directed motion to $\sim 25\%$ compared to wildtype cells and simplifies velocity autocorrelations to an exponential decay. Knock-out of TRPC6 channels results in reduced directed motion to $\sim 20\%$. However, stronger temporal autocorrelations of the migration process are conserved. In addition, data are assessed with a generalized Langevin equation, allowing to separate the migration pattern into motor and navigation system and to quantify intrinsic correlation more precisely.

BP 7.10 Mon 17:30 P3

Two barriers or not? Dynamic force spectrosopy on the integrin $\alpha 7\beta 1$ invasin complex — Kristian Boye[1], •Agnieszka Ligezowska[2], Johannes A. Eble[3], Bernd Hoffmann[2], Beate Klösgen[1], and Rudolf Merkel[2] — [1]MEMPHYS Center for Biomembrane Physics, University of Southern Denmark, DK-5230 Odense M, Denmark — [2]Institute of Complex Systems 7: Biomechanics, Forschungszentrum Jülich, D-52425 Jülich, Germany — [3]Center for Molecular Medicine, Frankfurt University, D-60590 Frankfurt am Main, Germany

Dynamic force spectroscopy was applied to test the force driven dissociation of the specific bond between integrin $\alpha 7\beta 1$ and the bacterial protein invasin. Using biomembrane force probe, the single bonds were exposed to 14 different loading rates ranging from 18pN/s to 5.3nN/s. Plotting median yield forces, ranging from 8pN to 72pN, against the logarithm of the corresponding force loading rate revealed two linear regimes seemingly representing two energy barriers. Thermal fluctuations of the ultra-soft force transducer and the environment set a natural detection limit of the technique. The lowest rupture forces were unavoidably obscured by thermal fluctuations that might have led to an artificial shift towards higher forces. An in-depth data analysis including the detection limits showed that the second linear regime might be entirely due to the force shift effect. It is not necessarily rooted in the physical properties of the bond system. The bond dissociation could be well described by traverse over a single barrier [1].

[1] K. Boye et al., Biophys J. 105, 1-10 (2013)

BP 7.11 Mon 17:30 P3

Diffusion heterogeneities in cells during Mitosis — •Nisha Pawar and Matthias Weiss — Experimental Physics-I University of Bayreuth, Bayreuth, Germany

The Cytoplasm of the eukaryotic cell is highly complex and dynamic in nature. In addition, it is highly structured on many length scales. There are random motions within crowded and heterogeneous cytoplasm via protein complexes and organelles. Therefore diffusion behavior in cytoplasm can be expected to show spatial variations and a dependence on the cell cycle. The formation of mitotic spindle during the metaphase is expected to add another layer of complexity to the diffusion behavior of protein in the cytoplasm. We have probed the diffusion behavior of protein in cytoplasm during interphase and metaphase by Fluorescence Correlation Spectroscopy (FCS). Our results indicate that protein mobility not only heterogeneous in each of these states but also apparent mobility pattern depends on the cell cycle.

BP 7.12 Mon 17:30 P3

Distinct response of adherent cells to substrate elasticity and ligand affinity — •Christina Müller and Tilo Pompe — Institute of Biochemistry, Universität Leipzig, Germany

Cell fate decisions are triggered by physicochemical cues from the microenvironment. The mechanical properties of tissue, like stiffness or viscosity, can severely influence cells in their signaling, a process commonly referred to as 'mechanotransduction'. In this context we want to elucidate the impact of substrate stiffness and molecular friction of non-covalently attached adhesion ligands on early cell adhesion. We monitored human endothelial cells (HUVEC) on tailored polyacrylamide hydrogel layers with a graded stiffness in the range of 1 kPa to 10 kPa and a maleic acid copolymer coating. Coatings of different hydrophobicity provide a graded affinity for non-covalently attached fibronectin ligands. We used time-resolved Traction Force Microscopy to monitor the force generation of cells respective to substrate stiffness and ligand affinity during the first two hours of cell adhesion. For characterization of the cell response we determined the maximum traction stress Tmax,net contractile moment Mnet and strain energy U. We found differences in the temporal regulation of the local forces at the adhesion sites and the global contractility of adherent cells. While ligand affinity limits the slope and maximum value of cell traction stress, the total cell contractility is affected by substrate stiffness. In parallel, we investigate intracellular signaling processes to correlate the force generation to the biochemical key players in the cell's response to mechanical substrate parameters.

BP 7.13 Mon 17:30 P3

Influence of direct laser written three-dimensional topographies on osteoblast-like cells — •Judith K. Hohmann[1] and Georg von Freymann[1,2] — [1]Physics Department and Research Center OPTIMAS, University of Kaiserslautern — [2]Fraunhofer Institute

for Physical Measurement Techniques IPM, Department of Materials Characterization and Testing, Kaiserslautern

Biological cells react to various signals of their environment. While biochemical pathways have been investigated for decades, the influence of physical characteristics of the cellular environment has only been studied in the very recent past. Especially information on the interaction with three-dimensional structures is barely available, since common chemical and/or physical surface treatments (e.g. acid-etching, sand blasting) lead to randomly shaped surface topographies.

Our well-defined three-dimensional templates are fabricated by direct laser writing and coated with titanium dioxide via atomic layer deposition. This allows us to provide biocompatible substrates with nearly arbitrary micro structures.

We report on how geometric parameters influence viability parameters of osteoblast-like cells. We observe a significantly higher proliferation on particular topographies compared to unstructured surfaces. Additionally, an influence of structural parameters on the morphology and focal adhesion contacts of osteoblast-like cells is obtained and differentiation is verified via alkaline phosphatase staining. Our results might lead to novel dental implant surfaces which promote osseointegration.

BP 7.14 Mon 17:30 P3

Temperature induced sudden loss of cell nuclei integrity — •Enrico Warmt, Tobias Kiessling, Roland Stange, Anatol Fritsch, Mareike Zink, and Josef Käs — Universität Leipzig, Experimentelle Physik I, Germany

The DNA double helix, is one of the most stable proteins in a cell. However, despite the high temperature stability of DNA itself, we have found a sudden loss of cell nuclei integrity at relative moderate temperatures ranging from 45 to 55 degree Celsius. Suspended cells hold in an optical double beam trap were heated under controlled conditions and nuclear shape was monitored. At specific critical temperatures an irreversible sudden shape transition of the nuclei was observed. These temperature induced transitions differ in character of shape change for different cell lines. The high connectivity of the nuclei to the cytosol becomes visible when the initial shape transition of the nucleus propagates toward the plasma membrane.

BP 7.15 Mon 17:30 P3

Cell Shape and Forces on Micropatterned Substrates Predicted by a Cellular Potts Model — •Philipp J. Albert and Ulrich S. Schwarz — Institute of Theoretical Physics, University of Heidelberg

Micropatterned substrates are increasingly used to decrease the variability inherent to cell experiments and to quantitatively study the relation between cell shape and function. When combined with traction force microscopy on soft elastic substrates, micropatterns can be used to evaluate the average relation between cell shape and forces, independent of the exact organization of the adhesion contacts and the cytoskeleton in an individual experiment. However, a conceptually transparent and easy-to-implement modeling framework for this situation is still missing. Here we show that a two-dimensional cellular Potts model (CPM) can predict cell shape and forces on micropatterned substrates in good agreement with experimental results if the energy function of previous formulations of the CPM is modified to account for adhesive energies and local contour reinforcement by peripheral bundles. While these additional elements are required to describe shape and forces during periods of strong contraction, the CPM-part describes more dynamic situation, such as spreading over a pattern. Together, these elements result in a flexible and efficient framework to predict cell shape and forces on arbitrary adhesive geometries.

BP 7.16 Mon 17:30 P3

A Geometrical Model for Malaria Parasite Migration in Structured Environments — •Anna Battista[1], Janina Hellmann[2], Friedrich Frischknecht[2], and Ulrich Schwarz[1] — [1]ITP and Bioquant, Heidelberg University, Heidelberg, Germany — [2]Department of Infectious Diseases, University Clinics Heidelberg, Heidelberg, Germany

Plasmodium sporozoites are the form of the malaria parasite that is injected into the skin of the host during a mosquito bite. They migrate rapidly through the dermis searching for a blood capillary to penetrate. Sporozoites have a curved shape and this is essential for their migration patterns: they describe circles on a flat substrate, roughly helical trajectories in an unstructured 3D environment, and irregular trajectories with circular elements in the skin [1,2,3]. Experiments with micro-fabricated pillar arrays [1] have shown that obstacles can deflect sporozoite trajectories into complex motility patterns, suggesting that the irregular trajectories in the skin result mainly from physical interactions with the environment. We propose a model that combines the prominent geometrical features of the parasite with a detailed interaction scheme upon collision with obstacles. The model is able to reproduce trajectories in homogeneous pillar arrays as well as to predict curvature-dependent selection of pillars in heterogeneous arrays. This cannot be explained via a pure hard-core interaction, but requires a favourable contact with a pillar. References [1] S. Muenter, Cell Host & Microbe 6, 551-562 (2009). [2] R. Amino, Nature Medicine 12, 220-224 (2006). [3] J.K. Hellmann, Plos Pathogens 7, e1002080 (2011).

BP 7.17 Mon 17:30 P3

Ultra-soft PDMS elastomers for cell mechanic investigation — •Viktor Heinrichs, Sabine Dieluweit, Jörg Stellbrink, Rudolf Merkel, and Dieter Richter — Forschungszentrum Jülich GmbH

The elasticity of cell environment (e.g. extra cellular matrix) plays an important role in cell morphology and protein expression. Every tissue in the organism owns a specific elasticity; the cerebral tissue is the softest one and has an elasticity (Young's modulus) below 1 kPa. Therefore, an elastic and biocompatible model substrate with well-defined and adjustable properties for cell mechanic investigation is required. Cross-linked polydimethylsiloxane (PDMS) is frequently used because PDMS is nontoxic, easy to handle and commercially available, although an elasticity of 1 kPa is difficult to achieve. The preparation of the PDMS substrates is carried out by hydrosilylation reaction with well-defined polymers and crosslinking agent in the presence of platinum catalyst. The stiffness of PDMS networks can be varied by polymer chain length, reaction time of hydrosylilation and stoichiometrie. Quantification of mechanical properties was carried out by strained controlled rheometer (ARES-G2, TA Instruments). Using ultra-low frequency measurements (down to 10^{-5} s^{-1}) its Young's modulus was clearly formed to be 1.8 kPa. Using this approach, we created new well defined PDMS elastomers to simulate the cell environment and in particular for research of cerebral tissue. [1] N. Hersch, B. Wolters, G. Dreissen, R. Springer, N. Kirchgeßner, R. Merkel, B. Hoffmann, *Biol. Open* **2013,** *2, 251-361.*

BP 7.18 Mon 17:30 P3

Spiral actin-polymerization waves can generate amoeboidal cell crawling — •Alexander Dreher[1], Igor Aranson[2], and Karsten Kruse[1] — [1]Theoretische Physik, Universität des Saarlandes, Postfach 151150, 66041 Saarbrücken, Germany — [2]Argonne National Laboratory, Materials Science Division, 9700 South Cass Avenue, Argonne, USA

Amoeboidal cell crawling on solid substrates is characterized by protrusions that apparently randomly appear along the cell periphery and drive the cell forward. It is well-established that the protrusions result from local polymerization of the actin cytoskeleton. However, it is currently unknown how the formation of protrusions is triggered and whether the appearance of subsequent protrusions is coordinated. Recently, spontaneous formation of polymerization waves was observed in the actin cytoskeleton, which have been proposed to orchestrate the cytoskeletal dynamics during cell crawling. Here we study the impact of cytoskeletal polymerization waves on cell migration using a phase-field approach. In addition to directionally moving states, we found states reminiscent of the amoeboidal cell crawling. In this framework, new protrusions are seen to emerge from a nucleation process generating spiral actin waves in the cell interior. Nucleation of new spirals does not require noise, but occurs in a state that is apparently displaying spatio-temporal chaos.

BP 7.19 Mon 17:30 P3

Preparation of *in vitro* extracted, covalently crosslinked cell membrane. — •Patrick Paul[1], Ulla Nolte[1], Tobias Paust[1], Reinhard Fässler[2], and Kay E. Gottschalk[1] — [1]Institute of Experimental Physics, Ulm University, Ulm, Germany — [2]Department of Molecular Medicine, Max Planck Institute of Biochemistry, Martinsried, Germany

The interaction of proteins with the intracellular side of cell membranes is important for a variety of cellular functions. We are mainly interested in cell adhesion and migration and therefore, in the interaction in between integrins, proteins of the integrin complex and f-actin. To study this interaction, we extract the cell membrane with the unroof-

ing technique [1] and covalently crosslink substrate with cell membrane *in vitro* to stabilize the system. The cell membranes of adherent cells are prepared in such way, that the intracellular side is exposed.
Furthermore, we verify our sample preparation with the help of atomic force microscopy, fluorescence light microscopy and scanning electron microscopy.

Reference:
[1] John Heuser, The Production of 'Cell Cortices' for Light and Electron Microscopy, 2000, Munksgaard International Publishers, 545-552

BP 7.20 Mon 17:30 P3

Growth Dynamics of Cellular Clusters on Elastic Substrates — •Philipp Linke[1], Carina Wollnik[1], Sara Kaliman[2], Damir Vurnek[2], Ana-Sunčana Smith[2], and Florian Rehfeldt[1] — [1]3rd Institute of Physics - Biophysics, Georg-August-University, Göttingen, Germany — [2]Institute for Theoretical Physics and Cluster of Excellence: Engineering of Advanced Materials, University Erlangen-Nürnberg, Germany

Cellular motility is an important factor in many processes like wound healing, tissue formation, and immune reactions. Cells adhere to their environment using focal adhesions and react to the stiffness of their surroundings. To study the response of a distinct cell type to different stiffness we use collagen-I coated polyacrylamide (PA) gels with well-controlled stiffness to mimic different environments.

MDCK II cells have proven to be very useful as model system for endothelial morphogenesis. When growing on a flat surface, these cells usually form a cluster monolayer after a short time. We found recently that soft matrices mimicking the native mechanical conditions of kidney also lead to three dimensional structures. The formation dynamics of these structures is controlled by cellular contractility and the balance of cell-cell and cell-matrix contacts. We use Lifeact-RFP to visualize actin filaments in living cells to elucidate the growth dynamics of clusters of MDCK II cells. We are using the open source software Micro Manager in combination with a motorized xy-stage and a heating and CO2 incubation system to do parallel live cell microscopy of several clusters in physiological conditions.

BP 7.21 Mon 17:30 P3

Mechanical Properties of the Nucleus probed by Atomic Force Microscopy (AFM) — •Susanne Karsch and Florian Rehfeldt — 3rd Institute of Physics - Biophysics, Georg-August University, Göttingen, Germany

The nucleus, especially the nuclear envelope, consisting of two lipid bilayer membranes and a protein network made up by lamins, creates a specific microenvironment for the genome. Due to multiple connections with the cellular cytoskeleton, the nucleus is also mechanically interacting with the intra- and extra-cellular environment and plays a role in the mechano-sensing machinery. Experiments showed that the nucleus is several times stiffer than the cytoplasmic region, but the fundamental mechanical properties determining shape and structure are still poorly understood. Elucidating these properties is of high importance as it may impact gene expression and could be related to certain diseases. Biochemical modifications of cytoskeletal components can give hints how the nucleus interacts with the surrounding and subsequently varies its shape and mechanics. We measure mechanical properties of nuclei in cells and isolated nuclei by AFM to dissect contributions of the cytoskeleton. These measurements are complemented by confocal and fluorescent imaging to analyze and correlate the structure with mechanical properties.

BP 7.22 Mon 17:30 P3

Resolution Limits and Regularization in Traction Force Microscopy — •Jérôme R. D. Soiné[1,2], Christoph A. Brand[1,2], and Ulrich S. Schwarz[1,2] — [1]Institute for Theoretical Physics, Heidelberg University, Heidelberg, Germany — [2]Bioquant, Heidelberg University, Heidelberg, Germany

Regularization is a standard technique to achieve unique solutions for inverse problems that are ill-posed. One such problem is reconstructing cellular traction fields of adherent cells on planar elastic substrates, a method known as traction force microscopy (TFM). Regularization is based on the idea of suppressing noise effects. However, in TFM the choice of the regularization term and of the regularization strength may affect reconstruction results such as the spatial distribution of traction hot spots, traction magnitudes and feature sizes. We have conducted a systematic investigation of the effects of using different regularization schemes in TFM. In contrast to unconstrained TFM, we constrained cellular force transmission to specific locations identified from fluorescence microscopy data for proteins localizing to focal adhesions. We then correlated the properties of these focal adhesions with the traction forces reconstructed by different methods. This enabled us to give a systematic overview on how regularization influences the reconstruction of cellular traction fields and to provide theoretical tools to adjust regularization for various experimental environments. We also compare our results to model-based traction force microscopy (MB-TFM), a method in which biophysical models are used to further suppress the effect of noise and to extract more information.

BP 7.23 Mon 17:30 P3

Migration behavior of human mesenchymal stem cells on biomimetic elastic substrates — •Daniel Meyer and Florian Rehfeldt — 3rd Institute of Physics - Biophysics, Georg-August University, Göttingen, Germany

Cell motility and migration processes are vital during biological development but also homeostasis. They are essential in tissue regeneration, morphogenesis, but also in pathological mechanisms like tumor metastasis. While migration due to biochemical gradients (e.g. chemotaxis) is very well studied, the influence of other parameters of the microenvironment such as topography and stiffness are less understood.

Nowadays, it is a widely appreciated fact that the mechanical properties of the matrix are significant factors for cellular processes. Here, we use polyacrylamide (PA) substrates with well-controlled Young*s moduli E and distinct biochemical composition of ECM ligands to mimic in vivo microenvironments and analyze the migration behavior of human mesenchymal stem cells (hMSC) by life cell microscopy.

BP 7.24 Mon 17:30 P3

Tailoring the surface potential using Au nanoparticles and Au films deposition for bioelectronic applications — •Kyrylo Greben, Pinggui Li, Dirk Mayer, and Roger Woerdenweber — Peter Gruenberg Institute-8, Forschungszentrum Juelich, Juelich, Deutschland

Generally the growth of films (inorganic as well as organic) on a substrate depends strongly on the properties of the carrier. This also holds for the case of bioelectronic applications, where biological material is immobilized on an inorganic electronic, e.g. a semiconductor device. Therefore it is essential to be able to characterize the interface and the surface (structural, chemical but also electronic properties) of the carrier (substrate or electronic) under conditions that are identical or at least comparable to the conditions used during deposition or immobilization.

In this work we use the streaming current technique to analyze the surface properties of bio-compatible planar silicon and borosilicate glass substrates with different percentage of surface coverage (0 to 100%) of Au. The Au deposition is achieved either by immobilization of different concentration of Au nanoparticles or standard evaporation techniques. The isoelectric point changes from pH 3.1 for Si to pH 3.76 for the completely covered substrate in a nonlinear way. Reference measurement and the data obtained for the completely covered surfaces are in good agreement with the literature and measurements on inert materials like polypropylene (IEP at pH 4) and platinum (IEP at pH 3.82).

BP 7.25 Mon 17:30 P3

From cytoskeletal dynamics to collective cell migration - a Monte Carlo study — •Florian Martin, Claus Metzner, Janina Lange, and Ben Fabry — Biophysics Group, University of Erlangen

The growth of flat cell colonies on planar substrates is a spatial and temporal multi-scale process. Macroscopically and on long time scales, experiments show an almost deterministic increase of the colony radius and an outward streaming motion of individual cells. On mesoscopic time scales, cells change their shape within the monolayer and divide. Cell dynamics at shorter time scales is dominated by local cytoskeletal remodelling events, generating fluctuating traction forces that act on focal adhesions and are transmitted through cell-cell contacts. We present a bottom-up simulation of colony growth in which each cell is represented by a set of focal adhesions, attached to a dynamic stress fiber network that creates long-time correlated force fluctuations. The ongoing turn over of focal adhesions eventually leads to shape changes and migration of individual cells. As the proliferating and spreading cells are competing for adhesion sites on the substrate, a radial streaming motion emerges on a macroscopic scale. Also in agreement with measurements, the mean squared displacement of cytoskeletal markers shows a gradual transition from sub- to superdiffusive behaviour.

BP 7.26 Mon 17:30 P3

Dynamics of Cellular Force Generation — •Mari Gorelashvili[1], Philipp Paulitschke[2], Eva Weig[3], and Doris Heinrich[1,4] — [1]Fraunhofer Institute for Silicate Research ISC, Neunerplatz 2, 97082 Würzburg, Germany — [2]Ludwig-Maximilians University Munich, Geschwister-Scholl-Platz 1, 80539 Munich, Germany — [3]University of Konstanz, Universitätsstraße 10, 78464 Konstanz, Germany — [4]Leiden University, LION, Leiden Institute of Physics, Niels Bohrweg 2, 2333 CA Leiden,The Netherlands

Force generation is one of the basic mechanisms involved in cell-environment interaction. Different biochemical as well as biophysical properties of cellular force exertion have been revealed during the last decade. Nevertheless, simultaneous investigation of these mechanisms during cell migration in 3D environments is less studied. Here, we present a novel method for the investigation of force generation by living cells during the mirgation in quasi 3D environments. The method combines highly precise cellular force measurement and quantitative analysis of cytoskeleton dynamics. Well-defined flexible nanowire arrays serve as force sensors. During cell migration in-between these nanowires cytoskeleton structures and force sensors are imaged simultaneously by spinning disc confocal microscopy. Advanced quantitative analysis algorithms enable determining the force and investigation of underlying cytoskeleton dynamics with high spatial and temporal resolution.

BP 7.27 Mon 17:30 P3

Cell type specific mechano-sensitivity on elastic hydrogels — •Galina Kudryasheva[1], Florian Rehfeldt[1], and Assaf Zemel[2] — [1]3rd Institute of Physics - Biophysics, Georg-August-University, Göttingen, Germany — [2]Faculty of Dental Medicine, Hebrew University, Jerusalem, Israel

It is now widely accepted that the mechanical properties of cellular micro-environments are as important in the regulation and function of cellular processes as biochemical ones. Especially striking is the mechanically guided differentiation of mesenchymal stem cells (hMSCs) on elastic hydrogels. While the complex differentiation mechanisms take several days up to weeks to fully develop, the structure and dynamics of the acto-myosin fibers can be used as an early morphological marker and modelled using classical mechanics with an active spring model. Using fluorescence microscopy we analyze the cytoskeletal structure of cells cultured on elastic poly-acrylamide (PA) substrates with different Young's moduli E in the physiological range. Quantifying the stress fiber organization by an order parameter S gives insight into the mechano-sensing process and determines the mechanical susceptibility as well as an intrinsic pre-stress of the cell. We use this approach to analyze the mechanical cell-matrix interactions of hMSCS during their mechano-differentiation process and compare them with already committed cell types to gain more insight in the integration of mechanical signals to transcriptional changes.

BP 7.28 Mon 17:30 P3

Migration, Force Generation and Mechanocsensing of Cells in Collagen Gels — •Julian Steinwachs[1], Claus Metzner[1], Stefan Münster[1], Katarina Aifantis[2], Kai Skodzek[1], and Ben Fabry[1] — [1]Lehrstuhl für Physikalisch Medizinische Technik - Friedrich Alexander Universität Erlangen-Nürnberg — [2]Department of Civil Engineering and Engineering Mechanics - University of Arizona

Collagen gels are frequently used to study cell migration in a 3-D environment. Mechanical properties of collagen gels are governed by non-affine deformation of the fibrils, such as buckling and tautening, resulting at the macroscopic scale in strain stiffening under shear and a strong lateral contraction under stretch. It is currently unknown how these macroscopic properties play out at the scale of a migrating cell, and how this depends on cell geometry. We develop a non-linear elastic material model for collagen gels based on observations from confocal microscopy that fibrils can evade mechanical stress using their internal degrees of freedom. The tautening of fibrils results in a strong material stiffening against expanding forces. By this mechanism, even a soft collagen gel can sterically constrain a migrating cell. We compute cell traction forces from collagen fiber displacements during the migration of carcinoma cells through dilute and dense collagen gels. We find that cells exert highly localized forces that lead to long-ranging collagen displacements and little material stiffening. At the same time, the average traction force magnitude increases for denser collagen gels. This observation may explain why cells can migrate more efficiently in stiffer gels, despite their narrower pore diameter.

BP 7.29 Mon 17:30 P3

Fabrication of patterned neuronal networks on multi electrode arrays — •Norman Shepheard[1], Stefan Niehörster[1], Matthias Schürmann[2], Savio Fabretti[1], Barbara Kaltschmidt[2], Christian Kaltschmidt[2], and Andy Thomas[1,3] — [1]Fakultät für Physik, Universität Bielefeld — [2]Fakultät für Biologie, Universität Bielefeld — [3]Fachbereich Physik, Johannes Gutenberg Universität Mainz

The geometry of neuronal networks seems to be one of the key features to understand the brain functions. Difficulties to examine these networks are caused by the large amount of connections between neurons. A first step is analyzing networks with reduced complexity, for example in vitro neuronal networks with two or three connected neurons. We fabricated patterned adhesion films for neurons on commercial multi electrode arrays (MEAs). The adhesion film consist of three layers on top of the MEA surface which is made from silicon nitride. These layers are (3-aminopropyl)triethoxysilane (APTES), glutaraldehyde and as top layer poly-L-lysin (PLL) which is covalent bound [1]. Patterning is done by using the UV-lithographic 'lift-off' technique [1]. There are several demands to the geometry of the pattern, like the size of the grid, which has to match the distance between two neurons and which has to fit to the electrodes given by commercial MEAs. We successfully coated the pattern with neurons which is the final test. The aim of the overall project is to compare the behavior of small in vitro neuronal networks and artificial networks build up of memristors.

[1] Yong Hee Kim et al.; J Neurosci Methods. 2011; 202(1):38-44

BP 7.30 Mon 17:30 P3

Observing lateral waves on cells of controlled morphology — •Julia Strübig, Erik Bernitt, and Hans-Günther Döbereiner — Institut für Biophysik, Universität Bremen, Germany

Much of the current research on cell motility focusses on the wave-like organization of actin and its effectors. In spreading fibroblasts, laterally moving waves can be observed directly before the cell changes from an isotropic to a polarized state. In order to achieve reproducible conditions we force cells into well-defined morphologies using micro-contact printing of spherical fibronectin substrates. Using phase contrast microscopy we observe cells exhibiting persistent wave propagation around their circumference. We find different types of these lateral waves of which excitation mechanisms and consequences are widely unknown. Our system allows us to study wave phenomena on cells in a controlled and reproducible manner.

BP 7.31 Mon 17:30 P3

A real time drug-assay on individual motile cells — •Axel Hochstetter[1], Eric Stellamanns[2], Sravanti Uppaluri[2], Niko Heddergott[3], Markus Engstler[3], and Thomas Pfohl[1,2] — [1]Departement Chemie, Universität Basel, Basel, Switzerland — [2]Max-Planck-Institut für Dynamik und Selbstorganisation, Göttingen, Germany — [3]Biozentrum, Universität Würzburg, Würzburg, Germany

The protozoan flagellates Trypanosoma are not only causative agents of the sleeping sickness and the Chagas' disease, but they are also a model system for cell motility. These unicellular parasites live in bodily fluids of their hosts, preferentially in the blood stream. Especially blood capillary vessels are a world of microscopic dimensions - a world at low Reynolds numbers - where our macroscopic strategies of self-propulsion just do not work. To counter this, Trypanosomes show off their fascinating and complex patterns of motility.

In order to analyse these patterns, we present a straightforward microfluidic device in which diffusion controlled concentration changes can easily be induced together with a versatile method to measure their impact on living and motile eukaryotic cells. By combining microfluidics with optical tweezers and the motile protozoan flagellate Trypanosoma brucei brucei we can directly assess how drugs and other chemicals influence cells and their motility.

Our results show that our assay can be used for a quick and easy test of the effect of almost any water-soluble drug on motile cells, even for protozoa which are normally difficult to permanently observe.

BP 7.32 Mon 17:30 P3

Stochastic Resonance as underlying mechanism of growth cone chemotaxis — •Wolfram Pönisch, Melanie Knorr, and Josef Käs — Universität Leipzig, Fakultät für Physik und Geowissenschaften, Institut für Experimentelle Physik I, Physik der weichen Materie, Leipzig, Deutschland

Axon guidance is the manipulation of the growth direction of a pro-

truding growth cone, the fan-like shaped tip of a neurons axon. Previous research postulated an important role of stochastic resonance, the amplification of a signal by noise, during axon turning.

In order to get reliable data from experiments it is necessary to create stable and reproducible chemical gradients. In this project two different setups were examined critically: the Ibidi μ-Slide Chemotaxis chip and the classical micropipette assays. None of them were able to create gradients with the required quality for the examination of stochastic resonance.

Additionally an earlier developed numerical model was applied to simulate the edge fluctuations of the growth cone considering different concentration gradients. This model predicts the existence of an optimal noise level for the membrane fluctuations in order to induce turning of the in silico growth cone in a chemoattractant gradient.

BP 7.33 Mon 17:30 P3

Orientational order and motility in active droplets — •Diana Khoromskaia and Gareth Alexander — Centre for Complexity Science, University of Warwick, Coventry, UK

Spatially confined active matter exhibits fascinating collective behaviour, for instance internally generated flows in, and macroscopic self-propelled motion of active fluid droplets. Both seem to be associated with a particular long-range orientational order of the active particles in the droplet. Our aim is to understand which type of orientational order enables the transmission of local activity onto large scales and leads to directed movement of the drop. We consider a three dimensional drop of active matter that has a fixed, flat shape and is located on a plane surface. We impose different orientational fields with topological defects and calculate the resulting flow fields inside the drop analytically by solving the Stokes equation, which contains an active stress. For certain cases we show that an asymmetry in the imposed orientation field is inherited by the flow and enables motility in the case of appropriate boundary conditions at the contact surface.

One example of an active droplet is a cell extract, that is a solution of active cytoskeletal compartments confined by the cell membrane. Thus, understanding the interplay of orientational order and directed macroscopic movement could reveal new insights into the basic mechanisms of cell motility.

BP 7.34 Mon 17:30 P3

The influence of substrate stiffness on integrin mediated cell properties — •Maja Gulic[1], Thomas Kerst[1], Reinhard Fässler[2], and Kay-E. Gottschalk[1] — [1]Institute for Experimental Physics, Ulm, Germany — [2]Max Planck Institute of Biochemistry, Martinsried, Germany

Mechanical cues influence very basic cell properties like proliferation, cell shape or cell migration. Important components of the cell adhesion and migration machinery are the integrins, the actin cytoskeleton and messenger proteins. The analysis of the exact contribution of the individual components of this machinery to cellular properties is hampered by its complexity. Therefore, we reduced the complexity and examined mouse fibroblasts expressing only the fibronectin-binding integrins avb3 or a5b1 or a combination of the two.

To analyze the effect of integrin expression on cellular force generation, we used cell traction force microscopy. We fabricated polydimethylsiloxane (PDMS) micropost arrays via photolithography. We designed microposts with different height and diameter to vary the spring constant. Measuring the deflection of a micropost during adhesion of a cell made it possible to calculate the cellular force. We show differences between the cell types on the same array type as well as for the same cell type on different micropost forms. In addition we manipulated components of the force generation apparatus as well as the extracellular matrix with resulting differences in the cellular forces.

BP 7.35 Mon 17:30 P3

Probing the potential landscape of a bacterial protein chain motor used for self-propulsion — •Julian Roth, Matthias Koch, and Alexander Rohrbach — Lab for Bio- and Nano-Photonics, University of Freiburg, Georges-Koehler- Allee 102, 79110 Freiburg, Germany

The locomotion of swimming bacteria is normally related to rotary motors as e.g. flagella motors. This study concentrates on the helical bacterium Spiroplasma melliferum, a plant pathogen which lacks a stiff cell wall in contrast to most other bacteria. It is able to deform itself intensively, a property that is used for propulsion by generating a pair of kinks propagating down the length of the cell body - thus representing a linear motor. Kinks are generated by a cytoskeletal ribbon made of the unique protein Fibril, whose subunits can change their length through conformational changes. However, the functional principle and the mechanics of the Fibril ribbon have not yet been completely understood. In order to advance the understanding of contraction and relaxation of the Fibril ribbon our experiments are supported by a model, which we developed to describe the switching of the subunits of this ribbon according to Kramers rate theory. To test the validity of the model, we fix the ends of the cell by attaching optically trapped beads and probe its response to different external forces and environmental conditions as e.g. the addition of drugs. Additionally, we use the recently developed object-adapted optical trapping and shape-tracking technique [1] to image and analyze the complex cell movement. [1] Koch, M. & A. Rohrbach (2012). Nature Photonics 6(10): 680-686

BP 7.36 Mon 17:30 P3

Theory on active stress of a cortical cytoskeletal network — •Tetsuya Hiraiwa — Department of Physics, Freie Universität Berlin, 14195 Berlin, Germany

Active mechanics of a cortical cytoskeleton, which is a network consisting of actin filaments, myosin motor filaments and passive crosslinker proteins located underneath the cell membrane, plays crucial roles in dynamic cellular behaviors, such as cytokinesis and cell migration. In both a living cell and a reconstituted system, a cortical cytoskeleton behaves as active contractile gel. To understand mechanical property of such an active cortical cytoskeletal gel, we have theoretically studied on their active stress from a microscopic point of view. In this poster, we present an essential mechanical model of a cortical cytoskeletal network, and share with you our results on its spontaneously yielded active stress. In particular, since a cortical cytoskeleton in a living cell shows hydrodynamic characteristics, we consider the non-rigid network, in which there are few amount of crosslinkers and/or the crosslinkers can undergo turnover. We found that this system shows the crossover between the extensile and contractile states in terms of stress at a finite amount of passive crosslinkers, and hence would like to emphasize the significance of passive crosslinker proteins for the present mechanism of active contractility.

BP 7.37 Mon 17:30 P3

Modeling cytoskeletal polarization during confinement-induced persistent amoeboid motion — •Oliver Nagel[1], Can Guven[2], Matthias Theves[1], Meghan Driscoll[2], Wolfgang Losert[2], and Carsten Beta[1] — [1]Institute of Physics and Astronomy, University of Potsdam, Germany — [2]Department of Physics, University of Maryland, MD, USA

We studied the quasi one-dimensional motion of Dictyostelium discoideum amoebae inside narrow microfluidic channels with a cross section of 10 x 20 micrometer. Most of the cells performed a quasi one-dimensional random walk under these conditions. However a subpopulation of cells showed a completely different type of motion. They persistently moved in one direction for a long time without reversing or stopping. We performed laser scanning confocal imaging of a transfected Dictyostelium cell line that expressed myosin II-GFP together with LimE-mRFP, a marker for filamentous actin. Our experiments showed, that the polarized structure of the cell cortex was different from those of polarized cells in the absence of confinement. To systematically analyze the dynamics of local protrusions and retractions of the membrane, we used a custom made software tool for cell shape analysis. Taking into account the observed distributions of actin and myosin II in the cell cortex, we developed a model, based on the biased excitable network model by Iglesias and Devreotes [1] to describe this behavior. Ref.: 1. P. Iglesias and P. Devreotes, Current Opinion in Cell Biology, 24 (2012), 245*253 <doi:10.1016/j.ceb.2011.11.009>.

BP 7.38 Mon 17:30 P3

Controlling adhesion of *Acanthamoeba castellanii* by substrate stiffness — •Sören Björn Gutekunst and Christine Selhuber-Unkel — Institute for Materials Science, Christian-Albrechts-University Kiel, Germany

Acanthamoebae are found worldwide and are most commonly present in water reservoirs such as lakes and swimming pools, but even in soil and dust. Some acanthamoeba species are human pathogenic and can cause severe infections, such as acanthamoeba keratitis, which is caused by *Acanthamoeba castellanii.* Acanthamoeba keratitis is an infection of the human eye that is mainly caused by insufficient contact lens care. If Acanthamoeba castellanii trophozoites adhere to a soft contact lens material, they are easily transferred to the eye. In order to investigate the influence of substrate stiffness on the adhesion of

Acanthamoeba castellanii, we produced polyacrylamide substrates of different elasticity and quantified the motility, number and spreading area of adherent amoeba as a function of substrate stiffness. Our data indicate that Acanthamoeba castellanii adhesion is promoted on soft substrates, suggesting the presence of a mechanosensing mechanism.

BP 7.39 Mon 17:30 P3

Microrheology study of integrin dependent mechanical properties of fibroblasts under shear stress — •Fenneke KleinJan[1], Yoojin Lee[1], Reinhard Fässler[2], and Kay Gottschalk[1] — [1]Ulm University, Institute of Experimental Physics, Ulm, Germany — [2]Max-Planck Institute of Biochemistry, Department of Molecular Medicine, Martinsried, Germany

Physical forces are increasingly recognized as an important biological signal. The protein family of integrins are a key element in force sensing, functioning as a bidirectional force signalling protein. They link the cytoskeleton and the extracellular matrix, giving the cells the opportunity to respond to force by adapting the cytoskeletal filaments. However, how the different integrins cooperatively modulate the force response of the cytoskeleton is not understood.

To study the crosstalk between integrin avb3 and a5b1 we use mouse embryonic fibroblasts that express only the single integrin or a combination of both. We focused on the local mechanical properties of isolated cytoskeletal filaments using microrheology, studying both fibroblasts under static conditions and under influence of shear stress. Preliminary results show that the avb3 integrin is responsible for reinforcing the network. Cells expressing avb3 and avb3a5b1 integrins have a similar elastic modulus under static conditions and this modulus shows a comparable decrease when cells are exposed to shear stress.

BP 7.40 Mon 17:30 P3

Cell adhesion under lateral confinement — •Andreas Müller and Tilo Pompe — Universität Leipzig, Institute of Biochemistry, Johannisallee 21-23, 04109 Leipzig, Germany

The process of structuring of multicellular organisms into tissues and organs relies on the collective organization of cells into compartments. In this context, geometry plays a fundamental role in guiding cell adhesion and cellular behavior, in close relation to biochemical and biophysical characteristics of the extracellular matrix.

In order to better understand the impact of geometry on individual cells, we micropattern hydrogel substrates with adhesion ligands arranged in stripes. Cells grown on these micropatterns show distinct cytoskeletal morphologies, i.e. a bimodal distribution of actin stress fiber spacing depending on stripe width. As underlying regulating cues we hypothesize changes in interfacial energies of cells or intracellular forces. We use traction force microscopy and immunofluorescence staining to identify mechanical, biochemical and structural parameters relevant for cell adhesion under geometrical confinement. Biophysical and biochemical perturbations are used to distinguish regulating elements of intracellular signaling. Substrate stiffness, ligand affinity as well as intracellular force activation were modulated to test a broad range of possible mechanisms.

Next to stripe width, substrate stiffness could be shown to be an important parameter for actin fiber assembly and force generation on micropatterned substrates. With these studies we aim to demonstrate the relevance of geometry for cellular mechanical homeostasis.

BP 7.41 Mon 17:30 P3

Alteration of rolling adhesion in aged monocytes — •Samira Khalaji[1], Kay-E Gottschalk[1], Lisa Zondler[2], Veselin Grozdanov[2], and Karin Danzer[2] — [1]Institut für experimentelle Physik, 89081 Ulm, Germany — [2]Institut für Neurologie , 89081 Ulm, Germany

Cells alter adhesion to the cells or extracellular matrix during tissue remodeling, morphogenesis, and other responses to the environmental signals. Adhesion of blood monocytes was measured by setting up flow experiments using unidirectional laminar flow and low shear stress (0.59-1 dyn/cm2). Cells were isolated from young adult (20-40 years) and older adult (+40 years) donors and cultured 24 hours with/without Lipopolysaccharide (LPS) before running the flow experiments. Number of rolling and firmly adhesive cells to the substrate during the time point of 7-10 minutes was quantified using live cell imaging, plotted and compared in respect to the age.

BP 7.42 Mon 17:30 P3

Analytical analysis of cell deformation by hydrodynamic forces in microfluidic flow channels — •Alexander Mietke[1], Elisabeth Fischer-Friedrich[2], Salvatore Girardo[1], Philipp Rosendahl[1], Stefan Golfier[1], Oliver Otto[1], and Jochen Guck[1] — [1]Biotechnology Center, TU Dresden, Tatzberg 47/49, 01307 Dresden, Germany — [2]Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Strasse 38, 01187 Dresden, Germany

The mechanical response of cells or tissue to external loadings has gained significant interest during the last decades. A thorough theoretical understanding of the hydrodynamic forces acting on micron-sized objects is an essential prerequisite to probe and determine their mechanical properties. Here we present an analytic formalism to calculate the stresses and ensuing deformations of a spherical viscoelastic object being flowed through a microfluidic channel. Instead of performing full numerical simulations, we describe how a few simplifying assumptions can lead to a comprehensive analytical understanding of the system. This includes the different hydrodynamic stress components and the resulting deformations of the object. Our theory gives direct information about the scaling of shape measures depending on the experimental conditions and the mechanical properties of the object. Computations to determine and visualise flow fields and object deformations can be performed within a second. Finally, we demonstrate that our model is in agreement with experimental data. This analysis forms an important stepping stone for the further development of emerging high-throughput microfluidic cell mechanical phenotyping approaches.

BP 7.43 Mon 17:30 P3

Competition for space during bacterial colonisation of a surface — •Diarmuid Lloyd and Rosalind Allen — SUPA, School of Physics and Astronomy, University of Edinburgh, Edinburgh, UK

In the natural environment, bacterial populations often form densely packed self-assembled structures in cavities or on surfaces. Understanding how cells compete for space in these communities is essential if we are to translate our understanding of population dynamics and evolution in well-mixed communities to these real-life situations.

We have used fluorescence microscopy to study the competition for space between thousands of bacterial cells as they colonize a two-dimensional agarose surface. For each individual progenitor cell, we quantify the likelihood that their descendants will out-perform their neighbours for local space, under a range of environmental conditions, and how this affected the patterns of genetic segregation within the resulting surface community.

We find that for low-density populations cells which start growing earlier tend to out-compete their neighbours regardless of geometry. In contrast, for high-density populations, neighbour geometry may become significant.

BP 7.44 Mon 17:30 P3

Volume and morphological changes in single erythrocytes at high hydrostatic pressure — •Alfons Schulte[1], Sang Hoon Park[1], Silki Arora[1], Alesia Antoine[1], and Debopam Chakrabarti[2] — [1]Physics Department and College of Optics and Photonics, University of Central Florida, Orlando, FL 32816-2385, USA — [2]Burnett School of Biomedical Sciences, University of Central Florida, Orlando, USA

High pressure can change the cell morphology and membrane fluidity. We combine microscopy and spectroscopic probes to study pressure effects at the single cell level. In individual red blood cells large, reversible volume changes are observed over the pressure range from 0.1 to 200 MPa. In erythrocytes infected with the malaria parasite Plasmodium falciparum we observe clear differences in the deformability and between the compression and decompression curves. A possible mechanism for the reversible volume change may involve transport of water through the phospholipid membrane.

BP 7.45 Mon 17:30 P3

Mechanical properties of human neutrophils in sepsis — •Maik Herbig[1], Andrew Ekpenyong[1], Leon Menschner[2], Nicole Töpfner[2], Li Wenlong[1], Reinhard Berner[2], and Jochen Guck[1,3] — [1]Biotechnology Center, Technische Universität Dresden, 01307 Dresden, Germany — [2]University Hospital Carl Gustav Carus, 01304 Dresden, Germany — [3]Cavendish Laboratory, Dept. of Physics, Univ. of Cambridge, CB3 0HE, UK

Recent studies have suggested the use of cell mechanical properties as a diagnostic marker for cancer. Similar use in infectious diseases has received considerably less attention. Using an optical stretcher we have measured the mechanical properties of neutrophils during infection by

various sepsis-inducing bacteria. Tractable alterations in cell mechanics due to pathogens could engender its use as a diagnostic marker for sepsis. Furthermore, our work may offer new insights into the complex interactions between immune cells and pathogens.

BP 7.46 Mon 17:30 P3

Shape fluctuations and osmotic pressure in rounded fibroblasts — •Samaneh Rezvani and Christoph Schmidt — Drittes Physikalisches Institut - Biophysik, Georg-August-Universität Göttingen, Germany

The structure of the cytoskeleton is complex and controls a broad variety of dynamical behaviors.Oscillatory dynamics observed in certain cell types, most prominently in muscle cells such as, insect flight muscle cells which have evolved to generate rhythmic and rapid contractile forces.

Fibroblasts are the most common cells of connective tissue in animals and play an important role, for example, in wound healing. Shape studies of non-adhering rounded fibroblast cells showed a slow oscillatory behavior that can last many hours at a constant frequency.

Here, we further investigate periodic oscillations of 3T3 fibroblast cells in order to establish the driving forces. Using confocal microscopy, we follow the oscillation frequencies under controlled osmotic conditions in 3D.

BP 7.47 Mon 17:30 P3

Non-Equilibrium Cell Mechanics Probed with a Feedback-Controlled Dual Optical Trap — •Florian Schlosser, Florian Rehfeldt, and Christoph F. Schmidt — Drittes Physikalisches Institut - Biophysik, Georg-August Universität Göttingen, Göttingen

Cellular processes not only respond to biochemical, but also to mechanical stimuli. Cells sense the mechanical properties of their surroundings and can adapt to the mechanical properties of their micro-environment. Acto-myosin structures are key players in the generation of contractile forces that cells use to probe the outside world.

We study the contributions of acto-myosin fibers to the force produced by a cell. We attach fibronectin-coated beads to opposite sides of suspended 3T3 fibroblast cells and analyze the correlated motions of the two beads. Using a combination of active and passive microrheology, we could identify the non-equilibrium fluctuations and simultaneously probe the viscoelastic properties of the cell. With a feedback-controlled force clamp we were able to measure the cellular response to a constant external force.

Here, we present data on contractile forces and elastic properties of the cell. Biochemical perturbation experiments demonstrate the key role of myosin motors for contractile force generation. Using the optical trap in force-feedback mode (e.g. force clamp) allowed us to analyze the cellular fluctuations at different levels of pre-stress. Combination with confocal scanning microscopy allows us to directly image the fluorescently tagged actin distribution during the trapping experiments and correlate structure and function.

BP 7.48 Mon 17:30 P3

Force-induced nuclear shape changes in suspended cells — •Chii Jou Chan[1,2] and Jochen Guck[1,2] — [1]Cavendish Laboratory, Department of Physics, University of Cambridge, UK — [2]Biotechnology Center, TU Dresden, Dresden, Germany

While studies in the past on nuclear mechanotransduction have focused mostly on adherent cells attached to rigid substrates, we study how physical stress propagates and regulates nuclear shape changes for cells in suspended state using an optical stretcher. Intriguingly, we observed distinctly different nuclear response for both naturally suspended and adherent cells, when the cells were subjected to external mechanical stress. Specifically, the cell nucleus of a naturally suspended cell undergoes compression in response to membrane stretch while the cell nucleus for a naturally adherent cell experiences positive deformation, which correlates well with membrane stretch. Our studies suggest that while the vimentin intermediate filaments may play a dominant role in transmitting intracellular forces to cell nuclei of naturally suspended cells, the LINC complex found in many of the naturally adherent cells appear to regulate nuclear shape changes in response to whole cell deformation. Our findings shed new light on the different mechanical pathways from the force-responsive cytoskeleton to the nucleus which may lead to downstream cellular signaling events as the cells adapt to changes in the physical environment.