# BP 7: Posters - Mechanics and Dynamics of 3D Tissues (Focus Session)

Time: Monday 17:30–19:30 Location: P3

BP 7.1 Mon 17:30 P3

**Contractile performance of cardiac tissues under synchronized mechanical and electrical stimulation** — •Delf Kah[1], Ingo Thievessen[1], Claire Amado[2], Julia Kraxner[1], Marina Spörrer[1], Sandra Wiedenmann[1], Wolfgang Goldmann[1], and Ben Fabry[1] — [1]Department of Physics, Biophysics Group, Friedrich-Alexander-University Erlangen-Nuremberg, D-91052, Erlangen, Germany — [2]Laboratoire de Physique de la Matière Condensée, URA 792 du CNRS, Collège de France, 75231 Paris Cedex 05, France

In vitro engineered cardiac tissue grafts are of growing interest either as substitutes for scarred myocardial tissue after infarction or chronic cardiomyopathies, or as a drug testing platform. To investigate how mechanical and electrical conditioning influences the maturation and contractility of engineered cardiac tissue, we developed a stretchable and electrically paceable bioreactor consisting of an array of 4x2 mm microwells with two elastic pillars that serve as force sensors. Cardiac cells mixed with monomeric collagen are added to the microwells and, after polymerization and compaction of the collagen matrix, form an aligned tissue that spans between the pillars. Mechanical stretching with a linear stepper motor, electrical pacing with carbon electrodes, and microscopic imaging of the tissue is synchronized by a microcontroller, allowing us to study isotonic, isometric or eccentric contractions for various pacing protocols. Maximum contractile forces and electrical field strength threshold increased with increasing isotonic load, or pillar stiffness, indicating a pronounced mechanical responsiveness of the cardiomyocytes during the tissue maturation process.

BP 7.2 Mon 17:30 P3

**Morphogenesis control using mechanical stress** — •Jason Khadka, Jean-Daniel Julien, and Karen Alim — Max Planck Institute for Dynamics and Self-Organization

A major question in developmental biology is to understand how reproducible shapes arise from the collective behaviour of individual cells. Can mechanical interaction of cells within a tissue counteract randomness? We address this question in the shoot tip of plants. It has been shown that cortical microtubules in plant cells respond to mechanical stresses within a tissue. Cortical microtubules pattern down cell wall mechanics and thus mechanical stresses feed back on the mechanics of cell wall and cell growth. Here, we study how this mechanical feedback counteracts randomness in cell growth and thus gives rise to robust shape formation in the shoot tip. We present a three dimensional vertex model of plant tissue growth. Evaluating this model at different mechanical feedback strengths we assess the role of mechanics for reproducible three-dimensional shape formation.

BP 7.3 Mon 17:30 P3

**Dynamics of fluid pumping through a thick epithelium** — •Niladri Sarkar[1], Jacques Prost[2,3], and Frank Jülicher[1] — [1]Max Planck Institute for the Physics of Complex Systems — [2]Institut Curie/CNRS — [3]MBI, National University of Singapore

We study the dynamics of a thick epithelial tissue which pumps an interstitial fluid. We consider a tissue with average cell polarity normal to the tissue layer. The cell pumps fluid against a pressure difference. Using a two-component hydrodynamic continuum theory, we study the dependence of tissue stress, cell velocity and fluid flow on the the external fluid pressure and the cell pumping activity. We find that the existence of steady states depend strongly on the external pressure difference, the pumping activity and the properties of the interface seperating the tissue from the surrounding fluid.

BP 7.4 Mon 17:30 P3

**Non-Linear Compliance of Elastic Layers to Indentation** — •Adrian Fessel and Hans-Günther Döbereiner — Universität Bremen, Bremen, Deutschland

We present a single-exponent scaling model for description of large, non-linear deformations in elastic layers, based on analytical analyses and approximations of asymptotic behavior for small and large indentation upon variation of layer thickness. For very thin layers, the scaling model arises as an extension of an analytically exact model for small indentation. In conjunction with data from finite element simulations, investigation with the model leads to the conclusion that when drafting experiments, it is essential to recognize that separation of non-linear material properties from effects of geometrical confinement is conveniently possible only with thin layers. Furthermore, partition of strain-energy into parts associated with specific asymptotic regimes motivates introducing a scalar which we define in analogy to Poisson's ratio but for the ratio of principal strains in the layer geometry. Numerically, we find quantitative agreement between the scalar and the exponent characterizing the scaling model in the case of a thick, linear-elastic layer, and qualitative agreement in the non-linear case. We conjecture this effect to be due to higher-order contributions of geometrical confinement present even in linear-elastic settings.

BP 7.5 Mon 17:30 P3

**Time-dependent tension drives collective cell migration in zebrafish** — •Bernhard Wallmeyer[1], Sarah Trinschek[2], Sargon Yigit[1], Uwe Thiele[2], and Timo Betz[1] — [1]Institute of Cell Biology, Center for Molecular Biology of Inflammation, Von-Esmarch-Str. 56, 48149 Münster, Germany — [2]Institute for Theoretical Physics, University of Münster, 48149 Münster, Germany

Collective cell migration is a fundamental process during embryogenesis and adult life. An in vivo model for collective cell migration is epiboly. Epiboly is an event occurring in early zebrafish development, where the cells that initially form a cluster at one pole of the spherical yolk, spread towards the other pole in a continuous movement to eventually fully cover the yolk. Inspired by the physics of wetting we determine the contact angle between the cells and the yolk during epiboly. Similar to the situation of a liquid drop on a surface there are three interfaces, namely, between cells-medium, yolk-cells and yolk-medium that carry mechanical tension. By assuming that the origin of interface tension lies in cell-cell adhesion we propose a time-dependent tension due to the dynamics of adhesive contacts. Using the classical physics of wetting this model accurately characterizes the contact angle measured in our experiments. We are thus able to describe the fundamental and complex developmental mechanism of morphogenesis onset by three main parameters – the static tension strength $\alpha$, the offset angle $\delta$ and the time scale $\lambda$.

BP 7.6 Mon 17:30 P3

**A new method for analyzing high-frequency microrheology data** — •Kengo Nishi[1], Maria Kilfoil[2], Fred MacKintosh[3], and Christoph Schmidt[1] — [1]Goettingen University, Goettingen, Germany — [2]University of Massachusetts Amherst, Massachusetts, USA — [3]Rice University, Houston, USA

Passive microrheology is an experimental technique used to measure the mechanical response of materials from the fluctuations of micron-sized beads embedded in the medium. In one common approach, one uses the fluctuation-dissipation theorem to obtain the imaginary part of the material response function from the power spectral density of bead displacement fluctuations, while the real part of the response function is calculated using a Kramers-Kronig integral. The high-frequency cut-off of this integral strongly affects the real part of the response function in the high frequency region. To moderate this high-frequency cut-off, we recently proposed a new analysis method for passive microrheology by using the fluctuation-dissipation theorem in time domain, i.e., Fourier transforming the time derivative of the mean squared displacement or the auto correlation function. To see the validity of this method, we conducted one- and two-particle microrheology experiments, and the systematic error analysis by synthetic data.

BP 7.7 Mon 17:30 P3

**Organs-on-a-chip: Microphysiological platforms as in vitro models of cardiac and adipose tissue** — •Oliver Schneider, Julia Rogal, Christopher Probst, and Peter Loskill — Department of Cell and Tissue Engineering, Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB, Stuttgart, Germany

Drug discovery and development to date relies on animal models, which are useful, but fail to resemble human physiology. The discovery of human induced pluripotent stem (iPS) cells has led to the emergence of drug screening using human disease-specific organ-models. One promising approach are microfluidic devices, simulating 3D tissue structure and function. Using microfabrication techniques we have developed two microphysiological platforms (MPSs) incorporating in vitro models of human cardiac and adipose tissue. Both MPSs con-

sist of three functional components: a tissue culture chamber mimicking organ-specific geometrical in vivo properties; 'vasculature-like' media channels enabling a precise delivery of compounds (nutrients, drugs); *endothelial-like* barriers protecting the tissues from shear forces while allowing diffusive transport. We developed and deployed a novel biocompatible membrane as barrier, matching the desired organ-specific properties by varying its porosity. Both organ-chips manage to create physiological micro-tissues that are viable and functional for multiple weeks. The developed chips are the first systems that combine human genetic background, physiologically relevant tissue structure and 'vasculature-like' perfusion. Both MPSs are extremely versatile and can be applied for drug toxicity screening and mechanistic research on tissue dynamics.