AGjDPG 3: Biomechanics (joint focused session with BP)

This sessions discusses recent advances in our understanding of the mechanics of cellular systems with the concepts and methods from physics, both from the theoretical and from the experimental points of view. (Organizers Jochen Schneider for jDPG and Ulrich Schwarz for BP)

Time: Wednesday 15:00–16:45 Location: H6

Invited Talk AGjDPG 3.1 Wed 15:00 H6

Active Mechanical Processes in Cells and Tissues — •Frank Jülicher — Max Planck Institute for the Physics of Complex Systems, Nöthnitzerstrasse 38, 01187 Dresden

Living cells are extraordinarily dynamic and have the ability to generate movements and forces. This is particularly striking in the case of swimming microorganisms or the process of cell division. A key example for force generating processes in cells is the operation of molecular motors that interact with filaments of the cytoskeleton. In the cell, cytoskeletal networks form gel-like materials with unconventional active material properties that are the consequence of force generating processes. Active cellular processes have also interesting effects on larger scales. Tissues are collections of many cells which can also be considered as active media. Active processes in tissues result e.g. from cellular dynamics, cellular force generation and cell division. These processes introduce mechanical stresses and permit active rearrangements and flows in tissues. In recent years it has become increasingly clear that cells and tissues can also respond to mechanical conditions. Furthermore, there is evidence that mechanical feedbacks may be important in pattern formation processes by which complex organisms form in a developmental process from a single fertilized egg cell. Theoretical approaches are important to characterize the principles which govern the behaviors of active biomaterials and the formation of patterns. Furthermore, theoretical descriptions of cell dynamics and multicellular systems provide a key tool to understand complex dynamics observed in quantitative experiments in vitro and in vivo.

Invited Talk AGjDPG 3.2 Wed 15:30 H6

Cell mechanics: An experimental biophysicist's perspective — •Jochen Guck — Biotechnology Center, Technische Universität Dresden, Germany

The mechanical properties of cells are increasingly being investigated and it is well worth taking a closer look why. From a physics point of view, they prescribe the response to external forces and define the limits of a cell's interaction with its three-dimensional physical environment. Largely determined by the cytoskeleton, an internal polymer network regulated by intricate biochemical processes, cell mechanics also has an important biological component. The cytoskeleton is central to many biological functions, evolves during the normal differentiation of cells, and is characteristically altered in many diseases, including cancer. In this presentation I will review this link between physical description and biological function, describe some of the methods to measure cell mechanics and try to communicate the fascination of this topic from a personal point of view.

AGjDPG 3.3 Wed 16:00 H6

Flagellar synchronization independent of hydrodynamic interactions — •Benjamin Friedrich and Frank Jülicher — Max-Planck-Institute for the Physics of Complex Systems, Dresden, Germany

Inspired by the coordinated beating of the flagellar pair of the green algae *Chlamydomonas*, we study theoretically a simple, mirror-symmetric swimmer, which propels itself at low Reynolds number by a revolving motion of a pair of spheres [1]. We show that perfect synchronization between these two driven spheres can result from the motion of the swimmer, which feeds back on the two spheres by local hydrodynamic friction forces. Hydrodynamic interactions, though crucial for net propulsion, contribute little to synchronization for this free moving swimmer. The swimmer design for optimal synchronization reflects a trade-off between the swimmer's ability to move and the premise of broken symmetries required for synchronization. This simple swimmer exemplifies a novel paradigm for hydrodynamic synchronization that could explain flagellar synchronization in *Chlamydomonas*.

[1] B.M. Friedrich, F. Jülicher: Phys. Rev. Lett. **109**, 138102(2012).

AGjDPG 3.4 Wed 16:15 H6

The muscle's force-velocity relation derived from a basic principle — •Michael Günther[1,2,3], Daniel Haeufle[1,2], and Syn Schmitt[1,2] — [1]Universität Stuttgart, Institut für Sport- und Bewegungswissenschaft, Germany — [2]Stuttgart Research Centre for Simulation Technology (SimTech), Germany — [3]Friedrich-Schiller-Universität, Institut für Sportwissenschaft, Germany

In 1938, A.V. Hill extracted from heat and force measurements on frog muscles that the muscle's concentric force-velocity relation is a hyperbola. In 1957, A.F. Huxley published a model that could approximate the Hill relation from assuming eight microscopic parameters describing partly cross-bridge geometry and partly transition rates for cross-bridge attachment and detachment. Other Huxley-type models, using an increasing number of parameters, have been developed since then. In this presentation, we outline a very reduced set of assumptions that is sufficient to derive the Hill relation from the force equilibrium within a simple macroscopic arrangement of mechanical elements and very few further assumptions about the properties of these elements, all based on physiology. With just three elements, incorporating one force-dependent damper, just four mechanical parameters are needed to find a hyperbolic force-velocity relation. A most recent version of our model including a second damping element can even well explain the heat rate-velocity relation, assuming six parameters. From our model, it can be concluded that it might be erroneous to presume that using the isotonic condition guarantees a direct experimental determination of the properties of the active muscle part.

AGjDPG 3.5 Wed 16:30 H6

Dynamics of regenerating tissues under mechanical stress — •Claus Fütterer[1,2], Julia Fischer[1], Kao-Nung Lin[1], and Michael Krahe[1] — [1]Fakultät für Physik und Geowissenschaften, Institut für Experimentelle Physik I, Universität Leipzig, 04103 Leipzig, Germany — [2]ranslationszentrum für Regenerative Medizin (TRM), Universität Leipzig

Hydra vulgaris tissue fragments regenerate and provide an ideal system to study the relation of single cell mechanics to tissue mechanics. We studied tissue toroids with about 1500 cells and studied the overall force fluctuations as well as single cell behaviour. We also applied continuous stress as well as stress pulses to the tissue and investigated the active and passive relaxation and contraction dynamics. We relate the mechanical measurements to the alpha and beta actin structures which form well organized supra-cellular structures responsible for the orchestration of the regeneration process.