BP 15: Cell Mechanics I

Time: Tuesday 11:45–13:00 Location: H44

Invited Talk BP 15.1 Tue 11:45 H44

Does Oncology Need Physics of Cancer? — •Josef Käs — Peter Debye Institute for Soft Matter Physics, Leipzig University, Linnéstr 5, 04103 Leipzig

Cancer is a complex disease that accounts for nearly one in six deaths worldwide. More than 90 percent of deaths are due to metastasis * the process by which cancer cells spread from the primary tumor and seed a secondary tumor in a distant tissue. Despite advances in cancer treatment, metastatic recurrences remain a significant challenge. Understanding metastasis is crucial for a reliable predictive diagnosis needed for personalized oncology and to develop therapies that inhibit cancer spreading. The metastatic cascade routes in a mechanical problem for tumor cells on their way through the human body squeezing through dense tissues. Two clinical trials with more than 2000 breast cancer patients in each study prove that the onset of cancer cell motility can be explained as an unjamming transition and local cancer spreading of cancer cell clusters embedded in ECM must be described as active nematic droplets in a nematic phase. The gained physical parameters can be used a prognostic tumor marker for metastatic risk that improves breast cancer diagnosis by 26 percent. Beyond diagnostics the mechanical modulation of cancer cells by adipocytes points us towards migrastatic therapies to suppress metastasis.

BP 15.2 Tue 12:15 H44

Prostate cancer associated fibroblasts have distinct morpho-mechanical features that predict patient outcome — Antje Garside[1], Angela Jacobi[1], Shivakumar Keerthikumar[2,3], Michelle Richards[2], Birunthi Niranjan[2], Gail Risbridger[2,3], Mitchell Lawrence[2,3], and •Anna Taubenberger[1] — [1]BIOTEC, TUD, Dresden, Germany. — [2]Monash University, Victoria, Australia — [3]Peter MacCallum Cancer Centre, Melbourne, Australia.

Prostate cancer is among the most commonly diagnosed types of cancer. A key role in tumor progression has been attributed to the tumor stroma including its cellular components such as cancer associated fibroblasts (CAFs). Here we present a comprehensive study where we quantitatively assessed the morpho-mechanical properties of patient-derived prostatic CAFs and matched normal prostatic fibroblasts from a cohort of 35 patients, through combination of cell morphometric analysis and high-throughput mechanical probing of single cells by real-time deformability cytometry. CAFs comprised distinct morpho-mechanical features compared to their normal counterparts, including nuclear size and shape, cytoskeletal arrangement, cellular volumes and elastic properties. A combined score of these mechanical and morphological parameters distinguished patients with shorter and longer time to clinical relapse. Morpho-mechanical changes across patients were correlated with transcriptomic alterations in cellular components and pathways. In summary, our results suggest that high-throughput assessments of the biophysical properties of CAFs can serve as a complementary tool to predict patient outcome.

BP 15.3 Tue 12:30 H44

Viscoelasticity of Cancer Cells: New Insights from Magnetic Rotational Spectroscopy — •Jean-François Berret — Université Paris Cité, CNRS, Matière et systèmes complexes, 75013 Paris, France

Cell mechanical properties are linked to tumor progression and can serve as diagnostic biomarkers. Over the past two decades, numerous studies have shown that cancer cells are softer than healthy cells. While the viscoelastic nature of cells is well known, most studies focus on elasticity, with limited attention to viscosity. To address this, we developed Magnetic Rotational Spectroscopy (MRS), an active technique using non-toxic magnetic wires embedded in the cytoplasm and tracked via optical microscopy under a rotating magnetic field. This allows simultaneous measurement of viscosity η and elastic modulus G. MRS studies on 15 human and animal cell lines, both healthy and cancerous, uncovered a new finding: intracellular viscosity increases with wire size following a quadratic η(L)-relationship. Furthermore, in breast epithelial cells, only viscosity, not elasticity, could differentiate cells with low and high metastatic potential. A meta-analysis of literature on cell viscosity, covering whole-cell and intracellular data finally reveals that cancer cells have viscosities about 50% lower than healthy cells, suggesting that cancer cells are not only softer but also more fluid, offering potential for selective diagnostic tools in cell biomechanics. [1] A.M. Markl et al., Cancer Heterog. Plast., (2024). [2] J.-F. Berret, Nat. Commun. 7, 10134 (2016). [3] M. Dessard et al., Nanoscale Adv. 6, 1727 (2024).

BP 15.4 Tue 12:45 H44

Living Cells Feel the Surface Tension of Soft Solids — •Johannes Rheinlaender, Hendrik von Eysmondt, and Tilman E. Schäffer — Institute of Applied Physics, University Tübingen, Germany

For about 20 years it has been known that living cells actively respond to the stiffness of their microenvironment - most obviously - by a change in cell spreading area but also other properties such as stiffness, nucleus shape, and gene expression, denoted as mechanosensing. These effects are commonly investigated using hydrogels with a bulk Young's modulus in the kPa range, where cells respond to substrate stiffnesses typically between 1 and 100 kPa. On other soft materials such as elastomers, cell behavior has been shown to be different and weaker, plateauing below about 10 kPa, but the reason remained a matter of debate. On the microscale, surface properties such as surface tension are of increasing relevance, but probing interfaces with micro-indentation techniques such as atomic force microscopy is challenging due to adhesion effects. We therefore use scanning ion conductance microscopy (SICM), a unique scanning probe method benefiting from its non-contact measurement principle, to probe the surface tension of soft solids showing that elastomers exhibit surface tensions of about 10 mN/m, relatively independent of their bulk Young's modulus and surface treatment. Hence, cells mostly "feel" the bulk properties of elastomers for Young's moduli above about 10 kPa, but below mostly the surface tension, demonstrating that the substrate's surface tension is an important yet underestimated aspect in mechanobiology.