BP 20: Focus Biological Cells in Microfluidics I

Time: Tuesday 12:00–13:30 Location: BPc

BP 20.1 Tue 12:00 BPc

Numerical Investigation of Cell Deformation during Bioprinting — •Sebastian Johannes Müller and Stephan Gekle — Universität Bayreuth, Bayreuth, Deutschland

In 3D bioprinting, cells suspended in hydrogel are deposited through a fine nozzle, creating three dimensional biological tissues. Due to the high viscosity of the hydrogel, the cells experience hydrodynamic stresses that deform or damage the cells and can ultimately affect the viability and functionality of the cells in the printed construct.

Using numerical methods, we quantify these deformations in dependency of the flow parameters and cell elasticity. We consider shear thinning fluid rheology and validate our Lattice Boltzmann flow calculations with microfluidic flow experiments of typical hydrogel materials. Our hyperelastic cell, modeled as purely elastic continuum with neo-Hookean force calculations, is validated with experimental data for cells obtained via AFM indentation measurements.

By coupling our cell model with the fluid simulations, we investigate the cell deformation in typical flow scenarios, like capillary and shear flow. As essential part of the printing process, we further simulate the cell flowing through the transition from the printer nozzle into the free hydrogel strand, where additional radial flow components stretch the cell at short time scale.

BP 20.2 Tue 12:20 BPc

Microfluidic platforms to study forces on model cells — •Tom Robinson — Max Planck Institute of Colloids and Interfaces, Potsdam, Germany

Biological cells in their natural environment experience a variety of external forces such as fluidic shear stresses, osmotic pressures, and mechanical loads. The response of cell membranes to such forces is of great interest and model systems such as giant unilamellar vesicles (GUVs) offer the chance to investigate individual components without interference from cellular complexity (Robinson, Adv Biosyst., 2019). However, being able to handle and apply forces to these delicate objects in a controllable manner is non-trivial. Therefore, we present several microfluidic platforms to create, capture, analyse, and apply forces to GUVs. First, we present platforms for surfactant-free GUV production (Yandrapalli, et al. bioRxiv, 2020) as well as their high-capacity capture and isolation (Yandrapalli & Robinson, Lab Chip, 2019; Yandrapalli, et al. Micromachines, 2020). Lipid rafts are thought to play an important role in the spatial organization of membrane proteins. Therefore, GUVs with membrane domains are used as models to explore their behaviour in response to external forces. We use valve-based systems to apply precise fluidic shear stresses vesicles (Sturzenegger, et al. Soft Matter, 2016) and a device with an integrated micro-stamp to mechanically compress GUVs to study the effects that deformation has on lipid rafts (Robinson & Dittrich, ChemBioChem 2019). Microfluidic valves are also used to apply precise osmotic changes to measure membrane permeability to water (Bhatia et al. Soft Matter, 2020).

BP 20.3 Tue 12:40 BPc

High Throughput Microfluidic Characterization of Erythrocyte Shapes and Mechanical Variability — •Felix Reichel[1,2], Johannes Mauer[3], Ahsan Nawaz[1], Gerhard Gompper[3], Jochen Guck[1], and Dmitry Fedosov[3] — [1]Max Planck Institute for the Science of Light and Max-Planck-Zentrum für Physik und Medizin, Erlangen — [2]Biotechnology Center, Center for Molecular and Cellular Bioengineering, Technische Universität Dresden, Dresden — [3]Theoretical Soft Matter and Biophysics, Institute of Complex Systems and Institute for Advanced Simulation, Forschungszentrum Jülich, Jülich

The circulation of red blood cells (RBCs) in microchannels is important in microvascular blood flow and biomedical applications such as blood analysis in microfluidics. Current understanding of the complexity of RBC shapes and dynamical changes in microchannels is mainly formed by a number of simulation studies, but there are few systematic experimental investigations. Here, we present a first systematical mapping of experimental RBC shapes and dynamics for a wide range of flow rates and channel sizes. Results are compared with simulations and show good agreement. A key difference to simulations is that in experiments there is no single well-defined RBC state for fixed flow conditions, but rather a distribution of states. This result can be attributed to the inherent variability in RBC mechanical properties, which is confirmed by a model that takes the variation in RBC shear elasticity into account. These results make a significant step toward a quantitative connection between RBC behavior in microfluidic devices and their mechanical properties.

30 min. Meet the Speaker