AKB 11 Cell Adhesion I

Time: Tuesday 12:00–13:00 Room: ZEU 260

AKB 11.1 Tue 12:00 ZEU 260

Cellular Unbinding Forces on Biofunctionalized Nanostructured Substrates — •Christine Selhuber[1], Nadine Walter[1], and Joachim P. Spatz[1,2] — [1]University of Heidelberg, Biophysical Chemistry, INF 253, D - 69120 Heidelberg — [2]Max-Planck-Institute for Metals Research, Heisenbergstrasse 3, D-70569 Stuttgart

The adhesion of cells to substrates is a highly complex biological process and a fundamental step for many cell activities. To explore integrin mediated adhesion we investigate cell adhesion as a function of defined ligand distances.

To generate ligand patterns, we apply a nanolithographical technique that is based on the self-assembly of diblock copolymers. The result is a pattern of hexagonally arranged gold dots, where the separation of the dots is controlled over a wide length scale. The gold dots are functionalized with an RGD peptide to create adhesive patches for cellular integrin receptors. Cell culture experiments have shown that a dot separation of more than 73 nm restricts cell adhesion, cell spreading and focal contact formation.

To quantify the regulation of cell adhesion by specific nanostructures, we study unbinding forces of cells both during initial and long-term adhesion. The unbinding forces are measured with magnetic tweezers and AFM, respectively. For both adhesion periods the experiments reveal a strong dependence of unbinding forces on ligand distance.

The results indicate that characterizing adhesion forces is a suitable method for probing cell adhesion properties as a function of substrate preparation.

AKB 11.2 Tue 12:15 ZEU 260

Impact of receptor-ligand distance on adhesion cluster stability — •Thorsten Erdmann and Ulrich S. Schwarz — Center for Modelling and Simulation in the Biosciences (BIOMS), Universität Heidelberg, Im Neuenheimer Feld 293, 69120 Heidelberg, Germany

Cells adhere to substrates through two-dimensional clusters of weak adhesion bonds, which open and close stochastically. In many common receptor-ligand systems, the ligands are tethered to the substrate via polymeric spacers. Binding of tethered ligands depends crucially on receptor-ligand distance because it requires stretching of the polymers. Experimentally, the distance-dependent interplay of rupture and rebinding in adhesion clusters can be studied *in vitro*, e.g. in the surface forces apparatus. We study this effect theoretically using a one-step master equation for the stochastic dynamics of parallel bonds. The force exerted by stretched tethers is balanced by the elastic stiffness of the force transducer. The force accelerates rupture of ligands but it is shared equally by all closed bonds. Formation of new bonds reduces the receptor-ligand distance and increases the probability for further binding. Receptor-ligand binding in adhesion clusters is thus a cooperative and self-reinforcing process. A bifurcation analysis of the deterministic differential equation for the average number of closed bonds reveals the existence of a bistable region in which bound and unbound clusters coexist. Stochastically, the system fluctuates continuously between these two macrostates.

AKB 11.3 Tue 12:30 ZEU 260

Theoretical and experimental studies of force induced growth of focal adhesions — •Achim Besser[1], Patrick Heil[2], Joachim P. Spatz[2], and Samuel A. Safran[3] — [1]Center for Modelling and Simulation in the Biosciences, University of Heidelberg, INF 293, 69120 Heidelberg, Germany — [2]Dept. Biophysical Chemistry, University of Heidelberg, INF 253, 69120 Heidelberg, Germany — [3]Dept. Materials and Interfaces, The Weizmann Institute of Science, 76100 Rehovot, Israel

Focal adhesions are μm-sized protein aggregates that connect the actin cytoskeleton to the extracellular matrix, a network of macro-molecules surrounding tissue cells. Experiments show that as the force acting through the actin cytoskeleton is increased, focal adhesions grow in size and in the direction of the force. We consider a model for the adsorption of adhesion proteins from the cytoplasm to the adhesion site and the resulting force-sensitive anisotropic growth. The theory couples the mechanical forces to the adsorption dynamics. We derive the velocity of both the front and back of the adhesion as a function of the applied force. In addition, our results show that the relative motion of the front and back of the adhesion is asymmetric and in different ranges of forces, the adhesion shrinks or grows in the direction of the force.

These force-induced shape adaptations of focal adhesions are visualized in our experiments by means of fluorescence microscopy. The application of a micro-mechanical device allows the exertion of forces in the nN regime on the cell and thereby controlled stimulation of adhesion growth. The obtained experimental data is in line with the qualitative predictions of our model.

AKB 11.4 Tue 12:45 ZEU 260

Experiment and Modelling of Pattern Development during Fibronectin Nanofibril Formation — •Tilo Pompe[1,2], Jörn Starruss[3], Manfred Bobeth[4], Wolfgang Pompe[4,2], and Carsten Werner[1,2] — [1]Leibniz Institute of Polymer Research Dresden, Hohe Str. 6, 01069 Dresden, Germany — [2]Max Bergmann Center of Biomaterials Dresden — [3]Institut für Lebensmittel- und Bioverfahrenstechnik, Technische Universität Dresden, 01062 Dresden, Germany — [4]Institut für Materialwissenschaft, Technische Universität Dresden, 01062 Dresden, Germany

Adherent endothelial cells reorganize fibronectin molecules in the extracellular space into an ordered fibrillar network with characteristic patterns on the microscale as well as on the nanoscale. Cell culture experiments on polymer substrates with a gradated physicochemistry yield a dependence of fibronectin fibril pattern on the modulated anchorage strength of fibronectin to the substrates. The distinct spacing of fibronectin fibrils observed on the nanometer scale by scanning force microscopy can be correlated to the force sensitivity of the adhesion apparatus of the cell and the inner structure of the actin stress fibres [1].

To support this idea a stochastic model has been developed to explain the nanoscale observation of paired nanofibrils as a result of diffusion-controlled aggregation and myosin-driven transport of fibronectin-integrin complexes. The evolving patterns of fibronectin clusters and fibrils can be summarized in a morphological diagram as a function of fibronectin-substrate and fibronectin-fibronectin interaction energies.

[1] Pompe T, Renner L, Werner C (2005) Biophys. J. 88:527-534.