Tackling cell deformation, division and migration by a combination of experiments and computational models

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In this talk, we review our recent results related to the observation and modeling of cell deformation, division and migration [1]. We first discuss our experiments demonstrating that water transport in and out of the cell is needed for the formation of blebs, commonly observed protrusions in the plasma membrane driven by cortex contraction. Simulations of a model of fluid-mediated membrane-cortex deformations show that a permeable membrane is necessary for bleb formation which is otherwise impaired [2]. Next, we discuss two mechanical models for individual and multiple cell divisions: i) A three dimensional model of motor-driven chromosome congression and bi-orientation during mitosis revealing that successful cell division requires control of the total number of microtubules [3]. ii) A model for the division of stem cells in a crypt that relates stem cell population dynamics to the effect of mechanical forces acting on the spindle. We observe that the mechanically induced strategy for development is sub-optimal and crucially depends on the stiffness of the spindle [4]. Finally, we discuss the observation of universal activity bursts in collective cell migration [5].

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