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Mechanical feedback drives cell polarization, adhesion and migration

Besides frequently studied regulatory pathways for spatial assembly of molecular motor molecules and cell-cell/matrix adhesion proteins, cf. [1], mainly responsible for the functioning of cell migration and tissue formation are primary biophysical "actors" such as mass flow, traction force, tension and pressure. Their dynamics determine the processes of cell deformation and translocation as well as cell-cell cohesion.

As basis for a most simple mechanical model of single cell motility we use a two-phase "reactive, viscous and contractive fluid" continuum model, written as a hyperbolic-elliptic PDE system of Navier-Stokes type. This model is able to reproduce the observed chaotic dynamics of actin/myosin cluster formation [2]. Then we combine it with a suitable system of diffusion-transport-reaction equations for free and bound myosin dimers and integrin adhesion sites [3].

Numerical simulations of two- and one-dimensional model variants reveal spontaneous and induced front-rear polarization and, subsequently, directional persistence of cell migration. Thereby we demonstrate, how these experimentally observed phenomena of cell motility can be traced back to an interaction of different biophysical and biochemical mechanisms such as cell edge protrusion, adhesion site maturation and force-induced integrin-bond disrupture.

References

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