4u Controlling the Motion of Cells along Compliant Polymeric Substrates

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To perform various biological assays and tissue engineering studies, it is vital to control the dynamic behavior of in vitro cells. In particular, there is a critical need for ``smart'' surfaces that can effectively modulate the motion of the cells and thereby allow them to be readily sorted, isolated or encapsulated. To design such smart surfaces, one needs efficient computational models that capture not only the fluid-membrane interactions within the cell, but also the cell-substrate interactions. In this poster I present a newly developed hybrid approach that couples mesoscale models for hydrodynamics (lattice-Boltzmann) and micromechanics (lattice spring) to examine the fluid-driven motion of vesicles on compliant surfaces. The vesicles, modeled as fluid-filled elastic shells, represent a suitable model for biological cells, like leukocytes or red blood cells. What is unique to this work is that I consider explicitly how the substrate' compliance and topography affect the cells' movement along the surface. By focusing on compliant surfaces, I find that simple modifications of these substrates permit significant control over the motion of cells. In particular, systems are isolated that affect not only the cell's velocity, but also its specific ``gait'' or way of moving along the surface. In addition, surface patterns are uncovered that can drive the cells to stop or be sorted at specified locations along the interface. Thus, these findings can yield guidelines for controlling the in vitro trafficking of cells on elastic surfaces. Note that these fluid-filled shells can also serve as a model of polymeric microcapsules. Hence, these smart surfaces could also be utilized to direct targeted delivery of encapsulated ``payloads''. Such control over vesicle dynamics can facilitate the fabrication of arrays of mobile micro-reactors. In this context it would be interesting to model how interactions with the substrate can cause the outer shell to burst and thereby release its functional contents. In this poster I will also speculate about means to simulate rupture when microcapsules binds to and are distorted by the contact with the substrate. In addition, I will outline how to combine this with a recently developed model for introducing nanoscale particles into a multi-component fluid. This will allow me to model the release of encapsulated nanoparticles when the microcapsule bursts and, consequently, to capture not only the interactions between the enclosed and host fluids, but also the dynamic interactions between the released fluid and the targeted surface.