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Active Soft Matter Model for Simulations of Cellular Mechanotransduction and Cell motility

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Recently, experimental studies have revealed that the mechanical properties of extracellular matrix has significant influence on the differentiation of stem cells or the fate of stem cells. To explain such mechanobiology phenomenon has been one of the current focuses of stem cell research as well as mechanobiology research.

Since 2007, we have developed an active soft matter cell model and related computational methods to simulate cellular mechanotransduction and cell motility. In this presentation, we shall discuss an active soft matter modeling and simulations of cellular mechano-transduction, in particular, we shall discuss cell spreading and locomotion over the soft elastic substrate. Our work is focused on modeling and simulation of two main aspects of mechanotransduction: (1) How does the external mechanical stimuli change the molecular conformation of cytoskeleton filaments, and (2) How does the mechanotransduction affect the cell motility?

Considering the size of the stem cells, a few microns to ten microns, and their special characteristics, we have proposed a multiscale model of soft matter to simulate stem cells. A coarse-grained contact model is proposed that can describe the long-range Van der Waals force, steric force, and colloidal interactions in general. We have applied the contact model in conjunction with a soft matter cell model to study contact and adhesion of stem cells. By modeling the cell as an isotropic amphiphilic aggregate, it may be shown that under external stimulus the cell can change its microstructure, conformation, as well as configuration.

In this presentation, we shall present our latest results on numerical simulations of cell contact, adhesion, spreading, and motility.