Simulation of the spreading of a cell on a substrate surface

by Miss Sun Lu

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Abstract

The adhesion of cells to the extra cellular matrix (ECM) is presently under heated discussion. This process is essential to many physiological and pathological processes. The mechanics and dynamics of cell adhesion and spreading are strongly dependent on receptor-ligand interactions between cells and ECM. The concerted deformations of the cell membrane, membrane-attached proteins, cytoskeleton, ligand type, and the concentration and stiffness of the ECM are believed to affect cell adhesion and spreading. Besides the large amount of experimental studies performed to investigate the process of cell spreading, significant theoretical and modeling effort has been made to understand the energetic, kinetics, and dynamics of cell adhesion and spreading. A thermodynamic framework for cell adhesion mediated by receptor-ligand binding was established in the pioneering work of Bell(1978). However, cell adhesion is a non-equilibrium process and can be better understood in terms of a nucleation and growth process. Several kinetic models have been proposed to describe the binding of ligands to cell surfaces. In this presentation, a continuum model was introduced for the adhesion of vesicles to substrate surfaces. In the model, the cell membrane was assumed to be a closed shell with hyperelasticity. The vesicle cavity is filled with a liquid of fixed volume. The receptors on the membrane are mobile and initially uniformly distributed while the ligands on the substrate surface are fixed and also uniformly distributed. The formation of localized regions of tight binding between receptors and ligands, results in cell adhesion to the substrate surface. And adhesive model was introduced to describe the adhesive interaction between the receptors and the ligands. The growth of the adhesion area occurs via recruiting receptors from the non-adhered region through diffusion. Finite-element methods are used to solve the governing equations for the deformation of the cell and the receptor diffusion on the membrane surface. Effects of the membrane stiffness, the cohesive parameters and the receptor density on the adhesion kinetics of the vesicle were studied.

Miss Sun Lu received her Bachelor’s Degree in Materials Science Department from Fudan University in 2006. Under the guidance of A/P Zhang Yongwei in Department of Materials Science and Engineering, NUS, she’s now doing her postgraduate project on the modeling and simulation of the mechanics of cell deformation.

Dr Xue Jun Min Host

All are Welcome!