University of Victoria | Graduate Studies

Notice of the Final Oral Examination for the Degree of Doctor of Philosophy

of

AMIRREZA F. GOLESTANEH

MSc (Universiti Putra Malaysia, 2009)
BSc (Shahrekord University, 2005)

"Modeling of Cell Deformation and Adhesion Mediated by Receptor-Ligand Interaction"

Department of Mechanical Engineering

Friday, July 31, 2015
12:30 P.M.
Engineering and Computer Science Building
Room 467

Supervisory Committee:
Dr. Ben Nadler, Department of Mechanical Engineering, University of Victoria (Supervisor)
Dr. Stephanie Willerth, Department of Mechanical Engineering, UVic (Member)
Dr. Reuven Gordon, Department of Electrical and Computer Engineering, UVic (Outside Member)

External Examiner:
Dr. Peter Schiavone, Department of Mechanical Engineering, University of Alberta

Chair of Oral Examination:
Dr. Wanda Boyer, Department of Educational Psychology and Leadership Studies, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

Cell adhesion to a substrate or another cell plays an important role in the activities of the cell, such as cell growth, cell migration and cell signaling and communication with extracellular environment or other cells. The adhesion of the cell to the extracellular matrix also plays a vital role in life, as it involves in healing process of a wound and formation of the blood clot inside a vessel. The spread of cancer metastasis tumors inside the body is mostly dependent on the mechanisms of the cell adhesion. The current work is devoted to studying deformation and adhesion of the cell membrane mediated by receptors and ligands in order to enhance the existing models. In fact phospholipid molecules as the constructive units of the cell membrane grant sufficient in-plane continuity and fluidity to the cell membrane that it can be acceptably modeled as a continuum fluid medium. Therefore a two dimensional isotropic continuum fluid model is proposed in here for cell under implementation of membrane theory. In accordance to lack of sufficient study on direct effect of presence of receptors on membrane dilation, the developed model engages the intensity of presence of receptors with membrane deformation and adhesion. This influence is considered through introduction of spontaneous areal dilation. Another innovation is introduced regarding conception of receptor-ligand bonds formation such that a nonlinear constitutive relation is developed for binding force based on charge-induced dipole interaction, which is physically admissible. This relation becomes also enriched by considering one-to-one shielding phenomenon. Diffusion of the receptors is formulated along the membrane under the influence of receptor-receptor and receptor-ligand interactions. Then the presented models in this work are implemented to an axisymmetric configuration of a cell to study the deformation and adhesion of its membrane. Another target of this work is to clarify the impacts of variety of material, binding and diffusion constitutive factors on membrane deformation and adhesion and to declare a rational comparison among them.