

Department of Applied and Computational Mathematics and Statistics Colloquium



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Post-Turing tissue pattern formation: Insights from mathematical modelling

Cells and tissue are objects of the physical world, and therefore they obey the laws of physics and chemistry, notwithstanding the molecular complexity of biological systems. What are the mathematical principles that are at play in generating such complex entities from simple laws? Understanding the role of mechano-chemical interactions in cell processes, tissue development, regeneration and disease has become a rapidly expanding research field in the life sciences. To reveal the patterning potential of mechano-chemical interactions, we have developed two classes of mathematical models coupling dynamics of diffusing molecular signals with a model of tissue deformation. First, we derived a model based on energy minimization that leads to 4-th order partial differential equations of evolution of infinitely thin deforming tissue (pseudo-3D model) coupled with a surface reaction-diffusion equation. The second approach (full-3D model) consists of a continuous model of large tissue deformation coupled with a discrete description of spatial distribution of cells to account for active deformation of single cells. The models account for a range of mechano-chemical feedbacks, such as signaling-dependent strain, stress, or tissue compression. Numerical simulations show ability of the proposed mechanisms to generate development of various spatio-temporal structures. We compare the resulting patterns of tissue invagination and evagination to those encountered in developmental biology. We discuss analytical and numerical challenges of the proposed models and compare them to the classical Turing patterns as well as reaction-diffusion ODE models coupling diffusion-based cell-to-cell communication with intracellular signaling.

Thursday, February 28, 2019

4:15 PM – 5:15 PM

127 Hayes-Healy Center

Colloquium Tea 3:45 PM to 4:15 PM 101A Crowley Commons Room