Physics Colloquium

Michigan Technological University

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Room 139 Fisher Hall

From Individuals Cells to Colonies — Emergent Behaviors in Biological Systems

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Abstract: Cells are intrinsically stochastic creatures. Not only do individual cells behave randomly during growth, migration and chemoresponse, but also they differ from each other even if the cells are derived from the same source. Despite this variability, multicellular organisms are capable of performing highly regulated, coordinated activities which are crucial to maintain the normal functionality of complex life systems. A crucial step to understand these two apparently conflicting facts is the emergent behavior coming out of cell-cell interactions.

In this talk, I will present two salient examples of such collective behaviors observed with mammalian cells. In the first example, we studied the spatial-temporal dynamics of fibroblast cells collectively responding to ATP molecules. By using calcium imaging on the single cell level in microfluidic devices, we characterized the correlations within the cell populations and identified the importance of pacemaker cells. We also found two channels of cell-cell signaling: gap junctions and diffusing molecules induced different collective responses. Unifying these observations yields a novel picture of collective chemosensing and also points to interesting theoretical questions in network theory. In the second example, we studied in vitro models of collective cancer invasion driven by two different forces. First in a microfabricated landscape of micropillars, cells migrate to the top of the pillars because of the need for more spaces. On the other hand, due to cell-cell interactions, invasion can be suppressed. These two competing factors resulted in distinct invasion profiles for metastatic and non-metastatic prostate cancer cells and interesting social behaviors between the two cell species. In another model, we studied breast cancer cells' invasion into extracellular matrix (ECM) driven by nutrition gradient, closely mimicking the physiological conditions. This ongoing project focuses on the cell migrations and the elastic stresses built up in the ECM. We would like to understand how long range mechanical interactions affect the observed rich dynamics of the invasion front in the three-dimensional configurations.

In the final part of the talk, I will summarize by pointing to my future research directions: the physics of cell communication and the physics of cancer.

Bio: Dr. Bo Sun got his college degree in physics from Tsinghua University, China. In 2006, he started his Ph.D research with Prof. David Grier at New York University on holographic optical manipulations and holographic imaging and graduated in 2010. He then joined Prof. Howard Stone 's group at Princeton University as a postdoc associate co-advised by Prof. Robert Austin in the physics department of Princeton University studying the emergent behaviors in mammalian cell systems.

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