Modeling Cell Shape and Biological Transport

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The ability of cells to exert forces and move about in their environment is essential to the survival of single-celled and multicellular organisms. Cell movement requires the coordination a number of sub-processes involving biochemical signaling and mechanical force generation. How such coordination can occur is a major area of study. In this talk I will discuss two lines of research that address different aspects of cell motion and biological transport.

In the first part, I will discuss a model and numerical simulation method to study how cell membranes change shape in response to forces that arise from the cell cortex. The cell cortex is a thin layer of cytoskeletal material that lies beneath the cell membrane in many cells. While models of biological membranes have existed for some time, the cell cortex is much more complicated, and detailed models do not yet exist. Thus, as a first step toward understanding the effect of the cell cortex, I will discuss how forces that mimic those generated by the cell cortex affect cell shape, leading to biologically realistic results.

In the second part, I will discuss how cell-level behaviors impact tissue and organ-scale properties through the use of multi-state continuous-time random walk models. These models can be posed in a general framework that includes details such as spatially heterogeneous binding, stochastic internal state changes, and various modes of spatial transport. Macro-scale equations with coefficients that depend on the local details are then obtained to describe transport on a tissue or organ-scale. Both lines of research have extensions that will be discussed throughout the talk.