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A modular view of directed cell migration

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Chemotaxis, the directed migration of cells in response to external chemical gradients, involves the coordinated action of separable but interrelated processes: motility, gradient sensing, and polarization. We have previously argued that separate “modules” give rise to these processes individually. In this talk I will describe a computational model in which the different modules are implemented in terms of reaction-diffusion equations. The central module is an excitable network. This module links to an idling cytoskeletal oscillator. In the absence of chemical stimuli, the excitable network can generate the signals that give rise to random migration. The response to combinations of uniform stimuli and gradients is mediated by a local excitation, global inhibition (LEGI) module that biases the direction in which excitability is directed. A polarization module linked to the excitable network through the cytoskeleton allows unstimulated cells to move persistently and, for cells in gradients, to gradually acquire distinct sensitivity between front and back. Migration and the accompanying changes in cellular morphology are simulated using a mechanical model of the cell implemented in the level set framework.