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Systems Biology of G-protein Sensing and Response during Cell Polarity

A basic property of cells is polarity; from this asymmetry complex structures and behaviors arise. Cell polarity can be directed from internal or external cues. A common type of external cue is a chemical signal; the cell senses a gradient of the chemical, reorganizes its internal components (polarization), and then moves (chemotaxis) or projects (chemotropism) toward the source. This process occurs through receptor-mediated signal transduction pathways, and many of the best-studied examples involve heterotrimeric G-protein and small G-protein (Cdc42) systems.

There are many challenges associated with this complex behavior. In particular the cell must amplify a shallow external gradient into a steep internal gradient of components that are tightly localized in an all-or-none fashion. In addition, the cell must track the direction of the gradient which may be shifting. These performance objectives can be conflicting leading to a tradeoff. Another important challenge is filtering the input noise in the gradient.

In this talk, I will describe our analysis of mathematical models of gradient-induced cell polarization in yeast. At the core is a two-stage system consisting of a heterotrimeric G-protein sensing module and a Cdc42 responding module. I will focus on how this arrangement balances the tradeoff between amplification and tracking, and acts as a filter that attenuates input noise.