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Excitability in Dictyostelium development

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Discovering how populations of cells reliably develop into complex multi-cellular structures is a key challenge in modern developmental biology. This requires an understanding of how networks at the single-cell level, when combined with intercellular signaling and environmental cues, give rise to the collective behaviors observed in cellular populations. I will present work in collaboration with the Gregor lab, showing that the signal-relay response of starved cells of the amoebae Dictyostelium discoideum can be well modeled as an excitable system. This is in contrast to existing models of the network that postulate a feed-forward cascade. I then extend the signal-relay model to describe how spatial gradient sensing may be achieved via excitability. One potential advantage of relying on feedback for gradient sensing is in preventing "cheaters" that do not produce signals from taking over the population. I then combine these models of single-cell signaling and chemotaxis to perform large-scale agent-based simulations of aggregating populations. This allows direct study of how variations in single-cell dynamics modify population behavior. In order to further test this model, I use the results of a screen for mutant cell lines that exhibit altered collective patterns. Finally, I use an existing FRET movie database of starved cell populations at varying cell densities and dilution rates to study heterogeneity in repeated spatio-temporal activity patterns.