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A Model of Fission-Yeast Cell Shape Driven by Membrane-Bound Growth Factors

Fission yeast serves as a model for how cellular polarization machinery is used to regulate cell growth. Many studies identify active Cdc42, found in a cap at the inner membrane of growing tips, as an important growth regulator, likely through control of exocyst tethering and the targeting of other polarity-enhancing structures. To investigate how these molecular processes might control shape, we propose a simple model based on the hypotheses that (i) the delivery and internalization rate of wall or membrane components limits cell expansion and (ii) a growth factor, such as Cdc42, signals for delivery of these components. We numerically simulate cell growth according to an axisymmetric, finite-element computational model of growth-factor-directed cell-wall remodeling under turgor pressure. We find relationships between signal profile and cell shape, and motivate future experiments on the link between cell signaling and shape.

Fission yeast is a model organism for cell shape in part because of the numerous identifiable shape mutants. Deletion of many Cdc42 regulators leads to defects in shape or polarized growth, such as cells of varying diameter, round cells, and branched cells. We consider the roles of auxiliary proteins, incorporate findings on length-dependent polarity change, compare model results to cell morphologies of mutants of Cdc42 regulators, and suggest possible mechanistic roles for these regulators. Finally, we describe a model that includes three simple interacting modules and can reproduce many known shape mutants using reasonable assumptions about the mechanistic roles of the regulating proteins.