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Mechanics of actin-based motility

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The ability of cells to move is critical for organism evelopment, maintenance, and repair. Growth of actin filament networks drives a variety of cellular and intracellular motions and contributes to the mechanical rigidity of the cell's cytoskeleton. During motility, eukaryotic cells and intracellular pathogens are propelled by dendritic actin networks oriented in the direction of motion and characterized by a branched architecture. Nucleation-promoting factors activated near the cell membrane trigger the formation of nascent filaments from the side of existing filaments in the network. Here we use laser tracking and atomic force microscopy to test models of actin-based motility and actin network elasticity. A Brownian ratchet mechanism has been proposed to couple actin polymerization to cellular movements, whereby thermal motions are rectified by the addition of actin monomers at the end of elongating filaments. By following actin-propelled microspheres using three-dimensional laser tracking, we find that the movement of beads adhered to growing actin networks is consistent with an object-fluctuating Brownian ratchet. Elasticity of actin networks has been shown to arise in part from the resistance of filaments under extension. Using atomic force microscopy, we find that dendritic actin networks exhibit nonlinear stress softening behavior that points to an important role for filaments under compression. Together, these results raise new questions about how actin network architecture is involved in the propulsion and guidance of crawling cells.