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Depolymerization-driven flow and the crawling of nematode sperm

CHARLES WOLGEMUTH, UCONN Health Center

Cell crawling motility is integral in many biological and biomedical processes, such as wound healing, cancer metastasis, and morphogenesis. A complete understanding of the mechanisms by which cells crawl is still lacking, but it is known to entail at least three separate physical processes: (i) cytoskeletal extension at the front of the cell; (ii) adhesion to the substrate at the cell front and release at the rear; and (iii) advance of the cell body. In most cells, the cytoskeletal network is composed of actin. The mechanism by which force is generated to drive translocation of the cell body is still debated. Originally, this force was attributed to an actomyosin system similar to muscle. However, nematode sperm utilize a cytoskeleton composed of a network of Major Sperm Protein (MSP) that forms non-polar filaments for which molecular motors have not been identified. The motility of these cells still exhibits all three fundamental processes required for standard crawling motility. Experiments suggest that depolymerization of the cytoskeletal network is the force-producing mechanism for pulling up the rear. In this talk I will present a mechanical model that describes how depolymerization of the cytoskeleton can drive motility. This model accounts for both cytoskeletal displacements and cytsolic (the fluid component of the cell) flow. The model accurately fits in vitro data using nematode sperm extracts where depolymerization induces contraction of MSP polymer bundles. Application of this model to cell crawling produces testable predictions about how the size and shape of a cell affect crawling speed. Experiments using *Caenorhabditis elegans* sperm show good agreement with the model predictions. Interestingly, the model requires that cells are anisotropically elastic, being more stiff in the direction of motion than perpendicular to it. A simple physical picture can account for this anisotropy. The model also predicts that cell speed increases with anisotropy and with depolymerization rate.