MAR13-2013-021007

Abstract for an Invited Paper
for the MAR13 Meeting of
the American Physical Society

Morphogenetic Functions of Actomyosin

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Morphogenesis refers to the generation of form in Biology. Much is known about molecular mechanisms of regulation, but little is known about the physical mechanisms by which an unpatterned blob of cells develops into a fully structured and formed organism. The actomyosin cortex is a thin layer underneath the cellular membrane that can self contract, which drives many of the large-scale morphogenetic rearrangements that are observed during development. How this cortex reshapes and deforms, and how such morphogenetic processes couple to regulatory biochemical pathways is largely unknown. I will discuss two emergent physical activities of the actomyosin cytoskeleton, an active contractile tension and an active torque, both of which can serve to drive flows and large-scale chiral rotations of the actomyosin cytoskeleton. Discussing two biological examples, polarization of the Caenorhabditis elegans zygote and epiboly during zebrafish gastrulation, I will illustrate how active tension drive flows, how molecular constituents of the cortex affect flows, and how morphogenetic patterns can be formed by coupling regulatory biochemistry to active cortical mechanics. A particular focus will be the investigation of how active chiral torques drive chiral flow, and the resulting functions of such chiral activities of the actomyosin cytoskeleton for left-right symmetry breaking in development.