Active cytoskeletal organization by motor and polymerization forces

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Abstract

Cells need to constantly change their change to perform vital functions, such as growth AND movement. Our goal is to resolve physical mechanisms that contribute to cell shape control. We study simplified experimental model systems reconstituted from purified cellular components. I will give two examples of our recent work. The first example concerns active contractility of the actin cortex, which lies underneath the cell membrane and drives shape changes by means of myosin motors. Using in vitro models, we studied how myosin motors and actin filaments self-organize into force-generating arrays. I will show that motors contract actin networks only above a sharp threshold in crosslink density. We discovered that right at this threshold, the motors rupture the network into clusters that exhibit a broad distribution of sizes, as expected in filamentous networks near a percolation threshold. But unexpectedly, we find that the motors robustly drive the networks towards a critically connected state over a broad range of crosslink densities. We explain this behavior by motor-induced crosslink unbinding. The second example I will discuss concerns cell shape polarization organized by interactions between the actin and microtubule (MT) cytoskeletons via MT end-tracking proteins (+TIPs) that also bind F-actin. We built an in vitro system involving a simplified actin-MT crosslinker molecule. We show that the interaction between MT ends and actin is sufficient to capture and re-direct MT growth along actin bundles. By keeping MT growth tightly coupled to F-actin, this mechanism allows linear arrays of actin bundles to act as templates for MT organization. Instead, when interacting with single actin filaments, MT ends become the dominant organizing factor, exerting forces that align, pull and even transport actin filaments in the direction of MT growth. We conclude that actin and MTs can influence each other's organization through coupling by +TIP proteins.