43g Polymer Physics of the Cytoskeleton

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While the importance of mechanics and force in many biological processes is increasingly appreciated, the mechanical response of the cytoskeleton and its physical origin remain poorly understood. In this work we utilize four complimentary techniques to probe cell mechanics. These include the recently developed two point microrheology and more traditional techniques such as magnetic twisting cytommetry and other techniques involving tracer particles. In combination, these techniques have the novel ability of probing cell mechanics over a wide range of frequency, length scale, geometry and driving (applied torques or innate thermal driving) in a single cell. We find a remarkably simple, but rich, consensus behaviour that, when interpreted with recent advances in polymer physics, strongly suggests the cell behaves as a network of semi-flexible polymers, like actin or intermediate filaments, cross-linked by extensible proteins with unfoldable domains, like filamin or plectin. Specifically, the low frequency, weak power-law response can be explained by protein domains unfolding. The high frequency response is due to the length scale dependence and single filament dynamics of semi-flexible polymers. Furthermore these results are robust to ATP depletion and independent of any cortical effects. Most importantly this work suggests a mechanical picture of the cell that is compatible with cell signalling. These conformation changes should be detectable and possibly integrated by the cell to measure complex quantities like shape and material compliance.