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Dynamics of actin spring

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ABSTRACT

The conversion of chemical energy into mechanical forces that powers cell movements is a ubiquitous theme across biology. The most famous example is the dynamics of molecular motors such as kinesin-microtubule and actin-myosin complexes. Yet, not all biological movements are caused by molecular motors sliding along tubules or filaments. Biological springs and ratchets can also store and release energy to rectify motion. Recent experimental advances have led to the study of these dynamic phenomena in biology that can be rationalized using ideas from physics, mathematics, and mechanics. The acrosome reaction of horseshoe crab sperm is a simple example of a biological spring where a 60 μm-long crystalline bundle of actin filaments, tightly cross-linked by actin bundling protein scruin, straightens from a coiled conformation and extends from the cell in five seconds. To identify the basis and mechanism for this movement, we examine the possible sources of chemical and mechanical energy and show that the stored elastic energy alone is sufficient to drive the reaction. We also provide an estimate of the maximum force generated during the uncoiling by stalling the bundle using an agarose gel.