Disassembly-driven contraction of an F-actin network transports chromosomes in starfish oocytes

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Abstract

While contraction of sarcomeric actomyosin assemblies is well understood, this is not the case for disordered networks of actin filaments (F-actin) driving diverse essential processes in animal cells. For example, at the onset of meiosis in starfish oocytes a contractile F-actin network forms in the nuclear region transporting embedded chromosomes to the assembling microtubule spindle. Here, we addressed the mechanism driving contraction of this 3D disordered F-actin network by comparing quantitative observations to computational models. We analyzed 3D chromosome trajectories and imaged filament dynamics to monitor network behavior under various physical and chemical perturbations. Strikingly, these observations are well explained by viscoelastic and agent-based models implementing a disassembly-driven contractile mechanism rather than myosin motor activity. Reconstitution of this contractile system *in silico* reveals a novel, remarkably simple and robust architecture of an intracellular transport system adapted for the function to prevent aneuploidy in the large oocyte.