



Get your motors running: Sex, self-organization, and oscillations

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Abstract:

A key aspect of life is sexual reproduction. For successful mixing of the genetic material, molecular motors move the nucleus back and forth inside the cell. How motors work together to produce these regular large-scale movements, however, remains a mystery. To answer this question, we studied nuclear movement in fission yeast, which is driven by dynein motors pulling on microtubules. Using laser ablation of single microtubules, we show that the nuclear movement is driven by pulling forces exerted along the leading microtubules. By imaging GFP-tagged dynein motors, we find that dyneins dynamically redistribute from one part of the cell to the other. We observe single dyneins as they diffuse in the cytoplasm and attach to a microtubule. Once bound to the microtubule, dyneins perform one-dimensional diffusion along the microtubule, which may be their strategy to search for anchor proteins at the membrane. By combining quantitative live cell imaging with a theoretical model, we find that dyneins linking the microtubule to the membrane detach from the membrane in response to load forces they experience. This mechanically regulated self-organization generates asymmetric patterns of dyneins and, consequently, of forces required for nuclear movement. Our work therefore demonstrates that spatio-temporal pattern formation within a cell can occur as a result of mechanical cues, which differs from conventional molecular signaling, as well as from self-organization based on a combination of biochemical reactions and diffusion.

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