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How do cells find their centers, push out their boundaries, and spin their nuclei?: Answers to these mysteries revealed by multi-scale modeling

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ABSTRACT:

Living cells use molecular motors to convert chemical energy into mechanical work in order to perform essential functions such as cell division, cell locomotion, muscle contraction, and contraction of damaged tissue in wound repair. Molecular motors operate by using cycles of binding, hydrolysis, and release of protein-bound adenosine tri-phosphate (ATP) to modulate motor protein conformation and binding affinity in order to "walk" along the subunits of cytoskeletal filaments (actin filaments or microtubules). Although force-generating cycles of several molecular motors have been well characterized, how motors operate collectively to result in observed cell behavior on longer length and time scales is often poorly understood and involves a complex interplay of force-sensitive reaction kinetics, mechanics, and transport phenomena. I will discuss three long-standing questions in cell biology: (1) How do cells rotate the nucleus? (2) How do cells position the centrosome so precisely at the cell center? (3) How do cells push the cell membrane to form membrane protrusions during cell locomotion? In each of these cases, a multi-scale mechanistic models has shown that the observed cell behavior can arise on the long-time scale from the action of an ensemble of molecular motors operating on the sides or tips of cytoskeletal filaments.

BIOGRAPHY:

Richard Dickinson serves as Professor and Chair of the Department of Chemical Engineering at the University of Florida. He joined the Department in 1994 after receiving his B.S. in Chemical Engineering at the University of Washington, his PhD in Chemical Engineering from the University of Minnesota, a postdoctoral appointment at the University of Wisconsin, and an appointment as NATO Postdoctoral Fellow at the University of Bonn in Germany. Professor Dickinson's research is in the area of cellular/molecular bioengineering. His seminal research contributions to the fields of actin dynamics, bacterial adhesion, and cell motility has been recognized by his election as Fellow of the American Institute of Medical & Biological Engineering, an NSF Career Award, and a UF Research Foundation Professorship. He also received the R. Wells Moulton Distinguished Alumnus Award from the University of Washington Chemical Engineering Department. He has supervised or co-supervised 15 PhD students to graduation and published over sixty research articles. His commitment to excellence in engineering education has been recognized by the University-wide Teacher-of-the-Year Award, which is the highest teaching honor bestowed by the University of Florida. Professor Dickinson currently serves as Associate Editor of Chemical Engineering Education and on the Editorial Board of Cellular and Molecular Bioengineering.