Cellular Biomechanics: Collective Dynamics of Motor Proteins

Motor proteins are enzymes that convert chemical energy into mechanical work in the cell. They perform a multitude of vital roles including motility, cell division, long-range transport, ATP production, and sensing, and are present in all forms of life from bacteria to humans. For instance, the motor protein myosin-1 is the active element in muscle contraction. Bacterial flagella are powered by rotary motor proteins. Another type of motor protein, dynein, powers flagella and cillia in eukaryotes, such as in sperm. The motor protein prestin is thought to provide the feedback mechanism that increases frequency differentiation and sensitivity in hearing. During mitosis, motor proteins are implicated in the positioning of chromosomes during metaphase. Another motor protein then cleaves the two halves apart in anaphase. The ubiquity of motor proteins in biology makes understanding their mechanisms of utmost importance.

We are currently focused on kinesin-1, which is a processive molecular motor that converts the energy from ATP hydrolysis and Brownian motion into directed movement. Single-molecule techniques allow the experimental characterization of kinesin in vitro at a range of loads and ATP concentrations. Mounting evidence suggests that in the cell, several kinesin motors work collectively to transport a cargo. We develop models capable of describing the collective behavior of several coupled motors.

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