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16. Applications

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How to Catch and Transport a Chromosome

This talk is concerned with the mathematical modeling and computer simulation of four related processes involving biomolecular motors, all four of which play a role in chromosome transport during cell division. These processes are: (1) dynamic instability of microtubules, (2) the biased random walk of kinesin along a microtubule, (3) depolymerization driven transport, and (4) the role of elasticity in the function of Brownian ratchet molecular motors.

Dynamic instability is the process by which a microtubule repeatedly grows and shrinks at its free end (known as the "plus" end), as though casting into the intracellular sea to catch a chromosome. Once a chromosome has been caught, the process of dynamic instability terminates, to be replaced by systematic degradation (depolymerization) of the microtubule at its plus end. This ratchets the chromosome along towards the minus end of the microtubule which is anchored in the daughter cell. During depolymerization driven transport, the chromosome is linked to the microtubule by kinesin, which paradoxically drives it towards the depolymerizing plus end, against the overall direction of transport. Theory and in vitro experiment explain how this facilitates the process of depolymerization driven transport.

The Brownian ratchet mechanism of depolymerization driven transport depends for its operation on the Brownian motion of the transported body, so it is bound to be slow for an object the size of a chromosome. We shall see, however, that the speed of transport is enhanced by the elasticity of the chromosome that is being transported.