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Hydrodynamic analysis and mechanisms of ciliary beating[1]
ASHOK SANGANI, KENNETH FOSTER, Syracuse University — The scaffold of a cilium or eukaryotic flagellum, known as the axoneme, consists of nine microtubule doublets surrounding a pair of singlet microtubules. Attached to each doublet are periodically-spaced dynein motors that use energy from ATP hydrolysis to exert force on the neighboring doublet causing it to slide away from the cell body. In spite of the several theories that have been put forward over the last several decades to explain how these motors work collectively to produce steady beating this question remains unresolved: we shall show that the forces generated during the beating as determined from the detailed hydrodynamic analysis are inconsistent with the predictions of the existing theories. We shall also use the experimental data available in the literature to present empirical results for the beat properties, i.e. the frequency, amplitude, wavelength, and energy dissipation, as functions of ATP concentration and fluid viscosity. The power dissipated and the energy per wavelength are approximately the same independent of the viscosity of the fluid and the ATP concentration. We use these observations to suggest a new hypothesis regarding how the cilia beat.

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