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A Simplified Model for the Optical Force exerted on a Vertically Oriented Cilium by an Optical Trap and the Resulting Deformation[1]

IAN LOFGREN, ANDREW RESNICK, Cleveland State University — Eukaryotic cilia are essentially whiplike structures extending from the cell body. Although their existence has been long known, their mechanical and functional properties are poorly understood. Optical traps are a non-contact method of applying a localized force to microscopic objects and an ideal tool for the study of ciliary mechanics. Starting with the discrete dipole approximation, a common means of calculating the optical force on an object that is not spherical, we tackle the problem of the optical force on a cilium. Treating the cilium as a homogeneous nonmagnetic cylinder and the electric field of the laser beam as linearly polarized results in a force applied in the direction of polarization. The force density in the polarization direction is derived from the force on an individual dipole within the cilium, which can be integrated over the volume of the cilium in order to find the total force. Utilizing Euler–Bernoulli beam theory, we integrate the force density over a cross section of the cilium and numerically solve a fourth order differential equation to obtain the final deformation of the cilium. This prediction will later be compared with experimental results to infer the mechanical stiffness of the cilium.

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