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The Optimal Elastic Flagellum SAVERIO SPAGNOLIE, ERIC LAUGA, UC San Diego — We address the question of optimality for slender swimming bodies or flagella in viscous fluid environments. Our novel approach is to define an energy which includes not only the work performed against the surrounding fluid, but also the energy stored elastically in the bending of the body, the energy stored elastically in internal shearing (such as the relative sliding of microtubules internal to a flagellum), and viscous dissipation due to the presence of an internal fluid. The shape of the optimal periodic planar wave is determined numerically and in some cases analytically which maximizes a related efficiency measure. We find that bending or internal dissipation costs regularize the optimal shape, but elastic shearing costs do not. For bodies of finite length, we show that the number of wavelengths expressed by the body is determined by a competition between bending costs and the work done on the fluid associated with body rotations. The hydrodynamic efficiency is shown to be less sensitive to the morphology than the bending costs, which may help us to better understand the locomotory forms observed in nature.

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