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The sperm flagellum counterbend phenomenon HERMES GADELHA, EAMONN GAFFNEY, ALAIN GORIELY, University of Oxford — Recent observations of flagellar counterbend in sperm show that the mechanical induction of curvature in one part of a passive flagellum induces a compensatory countercurvature elsewhere. This apparent paradoxical effect cannot be explained using the standard elastic rod theory of Euler and Bernoulli, or even the more general Cosserat theory of rods. Here, we develop a mechanical model capable of predicting the curvature reversal events observed in eukaryotic flagella. This is achieved by allowing the interaction of deformations in different material directions, by not only accounting for structural bending, but also the elastic forces originating from the cross-linking mechanics. Large amplitude configurations can be described analytically and an excellent match between the model and the observed counterbend deformation was found. This allowed a simultaneous estimation of multiple sperm flagellum material parameters, namely the cross-linking sliding resistance, the bending stiffness and the sperm head junction compliance ratio. Our analysis demonstrates that the counterbend emerges as a fundamental property of sliding resistance, which also suggests that cross-linking proteins may contribute to the regulation of the flagellar waveform in swimming sperm via counterbend mechanics. Finally, we investigate how the counterbend-type dynamics in sperm flagella is affected by viscous dissipation.

Hermes Gadelha
University of Oxford

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