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Quantifying and controlling microbial swimming

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Interactions between swimming cells, surfaces and fluid flow are essential to many microbiological processes, from the formation of biofilms to the fertilization of human egg cells. Yet, relatively little remains known quantitatively about the physical mechanisms that govern the response of bacteria, algae and sperm cells to flow velocity gradients and solid surfaces. A better understanding of cell-surface and cell-flow interactions promises new biological insights and may advance microfluidic techniques for controlling microbial and sperm locomotion. In this talk, I will summarize our recent efforts to quantify the surface interactions of bacteria, unicellular green algae and mammalian spermatozoa. This joint experimental and theoretical work shows that the subtle interplay of hydrodynamics and surface interactions can stabilize collective bacterial motion, that direct ciliary contact interactions dominate surface scattering of eukaryotic biflagellate algae, and that rheotaxis combined with steric surface interactions provides a robust long-range navigation mechanism for sperm cells.