Jeffrey Guasto

Tufts University

The function, failure, and evolution of flagella

Motile single cells play integral roles in biophysical processes ranging from human reproduction to biofilm formation, where cells utilize flagella – long, thin actuated appendages – as a ubiquitous means of locomotion in their low Reynolds number environment. In this seminar, I will discuss two experiments using high-speed video microscopy to uncover surprising biomechanics in bacterial flagella and broad kinematic relationships among sperm motility. In the first part of the talk, I describe the motility of uniflagellated bacteria, which seemingly have just one degree of freedom: a rotary motor that drives a corkscrew-like flagellum, propelling the cell either forward or backward. However, some bacteria can use their propulsive thrust to induce a buckling instability in the flagellum, making it bend off axis, and thus reorienting the cell in a new direction, which is an essential component of motility. In the second part of the talk, I focus on the kinematics of sperm motility, and show that while evolution and ecology are dominated by phylogenetic analysis, we must account for physical interactions mediated by cell form and function to fully understand evolutionary paths. Through the quantitative comparison of sperm flagellar kinematics from eight diverse species ranging from marine invertebrates to humans, we find striking similarities between genetically dissimilar organisms, which is suggestive of sweeping biological optimization for flagellar locomotion and points toward the environmental as the primary driver of sperm evolution. These results reinforce the vast potential of nature as a rich source of bio-inspired solutions to complex engineering problems, especially at the microscale.