Individual and Collective Dynamics of Swimming Microorganisms

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The swimming of bacteria through a fluid environment involves remarkable dynamics at the level of individual cells as well as fascinating collective behavior in dense suspensions. This talk will cover recent experimental and theoretical work in both areas. At the individual level I will focus on the dynamics of flagellar polymorphism, whereby the helical flagella whose rotation leads to locomotion can exhibit chirality reversals driven by torques produced by the rotary motors that drive them as well as by viscous stresses. A theory for these transformations, cast as coupled PDEs for the dynamics of twist and bend, is used to explain existing experiments and to motivate new ones, now underway in our laboratory. At the collective level, I describe studies of highly chaotic flows apparently driven by hydrodynamic interactions between swimming cells, particle-tracking studies of the superdiffusion in this setting, and some theoretical ideas that may explain these discoveries.