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The Fidelity of Adaptive Phototaxis IDAN TUVAL, Mediterranean Institute for Advanced Studies, IMEDEA (UIB-CSIC), KNUT DRESCHER, Princeton University, RAYMOND GOLDSTEIN, DAMTP, University of Cambridge —
Along the evolutionary path from single cells to multicellular organisms with a central nervous system are species of intermediate complexity that move in ways suggesting high-level coordination, yet have none. Instead, organisms of this type possess many autonomous cells endowed with programs that have evolved to achieve concerted responses to environmental stimuli. Here experiment and theory are used to develop a quantitative understanding of how cells of such organisms coordinate to achieve phototaxis, by using the colonial alga Volvox carteri as a model. It is shown that the surface somatic cells act as individuals but are orchestrated by their relative position in the spherical extracellular matrix and their common photoresponse function to achieve colony-level coordination. Analysis of models that range from the minimal to the biologically faithful shows that, because the flagellar beating displays an adaptive down-regulation in response to light, the colony needs to spin around its swimming direction and that the response kinetics and natural spinning frequency of the colony appear to be mutually tuned to give the maximum photoresponse. These models further predict that the phototactic ability decreases dramatically when the colony does not spin at its natural frequency, a result confirmed by phototaxis assays in which colony rotation was slowed by increasing the fluid viscosity.

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