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Transport by Collective Flagellar Beating Facilitates Evolutionary Transitions to Multicellularity MARTIN SHORT, CRISTIAN SOLARI, SUJOY GANGULY, JOHN KESSLER, RAYMOND GOLDSTEIN, University of Arizona, THOMAS POWERS, Brown University — A central problem underlying the evolution from single cells to multicellular organisms is the relationship between metabolic requirements and environmental metabolite exchange with increasing size. For organisms that form spherical colonies such as the volvocalean green algae, there is a bottleneck if diffusion alone governs nutrient uptake as they increase in size, for the diffusive flux is linear in the radius while the requirements of surface somatic cells grow quadratically. Using Volvox as a model organism, we examine experimentally and theoretically the role that advection of fluid by surface flagella plays in enhancing nutrient uptake. We show that the fluid flow driven by the coordinated beating of those flagella produces a boundary layer in the concentration of a diffusing solute which renders the metabolite exchange rate quadratic in the colony radius. This bypasses the diffusive bottleneck, facilitating evolutionary transitions to multicellularity which may be driven by other environmental factors. These results suggest that flagella may have evolved not only for motility, but also to enhance metabolite exchange.

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