Simple swimmer at low Reynold number: Three linked spheres.

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Recommended and a commentary by Mehran Kardar, MIT.

In a talk at a symposium honoring Viki Weiskopf in 1976, Ed Purcell introduced to physicists the difficulty of "Life at low Reynolds number [later published in Am. J. Phys. 45, 3 (1977)]. In particular, his "Scallop theorem" states the impossibility of swimming by reciprocal motion (one that reverses itself) at low velocities. The ordinary scallop opens its mouth slowly and closes it swiftly, and is propelled by the inertia gained in the second step. Such a strategy would not work if the scallop was reduced to the dimensions of an ameba- since inertial effects are negligible at such scales, the miniaturized scallop would simply return to its starting point.

Since reciprocal motion is inevitable for the scallop with one degree of freedom of motion, Purcell suggested a hypothetical swimmer of three rods flexing along two hinges. He suggested that a periodic, but non-reciprocal, sequence of moves of the hinges can propel this object in one direction. While apparently simple, quantitative analysis of the hydrodynamics of the "Purcell swimmer" is rather difficult, and only recently performed [L.E. Becker, S.A. Koehler, and H.A. Stone, J. Fluid Mech. 409, 15 (2003)]. The paper by Najafi and Golestanian provides a simpler example, still quite in the spirit of Purcell, which is amenable to simple analysis. The model consists of three collinear balls, whose separations can be altered in sequence. Given the simplicity of the hydrodynamics of the system of balls, the authors can derive an expression for the net velocity of the swimmer in terms of the parameters characterizing its deformations.