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The Physics of Cellular Motility

Cells attached to walls or in tissues can propel themselves by a variety of mechanisms. These are generally discussed in terms of the complicated biochemical feedbacks present in every cell. Here I will instead explore a physics-based approach: what is the simplest combination of physical ingredients that can allow cells to swim or to crawl through their surroundings? I will present a minimal model of cell propulsion based on an emulsion droplet of active polar liquid crystal. This object can swim through a bulk fluid by a mechanism that may (but need not) involve spontaneous symmetry breaking. When attached to a wall and subjected to suitable boundary influences, the droplet can also crawl. These results point towards a physics-based 'motility engine' whose function, although controlled by the cell's complex biochemical feedback networks, does not depend upon these for its basic operational principles.