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Dynamics of micro-organisms controlled by liquid crystals

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Microscale active systems such as swarms of swimming bacteria and cell tissues demonstrate fascinating dynamics that can potentially be used in applications ranging from micro-robotics to regenerative medicine. Control of this dynamics in isotropic media such as water is difficult. We describe an approach in which instead of an isotropic medium, the dynamics of micro-organisms is guided by a liquid crystal. An example with a droplet of an active bacterial suspension shows an immediate benefit of such a replacement: when placed in an isotropic fluid, the droplet experiences random Brownian motion, but once the medium becomes a nematic liquid crystal, the droplet acquires an ability to swim unidirectionally along a prescribed trajectory [1]. Other examples of liquid crystal control over the dynamics of microscopic objects include dynamic swarms of swimming bacteria [2-4] and living tissues formed by human dermal fibroblasts [5]. Director gradients and topological defects impact the biological microstructures most strongly, causing spatial variation of bacterial concentration and cell phenotype and shaping irreversible active flows. The physical mechanisms are shaped by the nontrivial effect of the orientastional order of a liquid crystal on the interactions of dynamic active units. The control of active matter by patterned liquid crystals might result in new approaches to harness the energy of collective motion for micro-robotic, biomechanical, biomedical, and sensing applications.

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