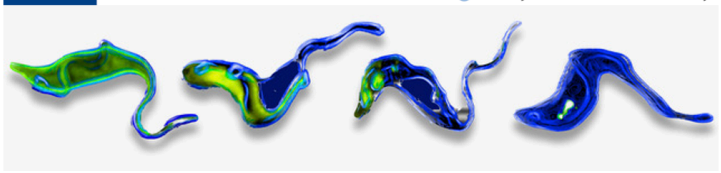

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Viscotaxis for Symmetric and Asymmetric Flagellar beat patterns

How do sperm steer? How do they change their swimming direction? How is directional motion achieved in complex environments? These are important issues to be clarified in order to understand how sperm can navigate their tortuous journey towards the egg [1,2,3]. The sperm flagellum besides propelling the cell also acts as a sensory antenna, detects environmental cues, enabling steering adjustments and beat pattern modifications for egg localization during fertilization [4,5].
Microswimmers in general often reside in gradients of temperature, chemicals, gravitation field and light [6], and can reorient and navigate along the gradients by a mechanism known as taxis. A well-known example is chemotaxis, where concentration gradients of a chemo-attractant are sensed and guide the sperm cell towards the egg cell. We investigate here another potentially relevant mechanism, viscotaxis, in which sperm reacts to gradients of fluid viscosity [6,7]. In previous research, different kinds of microswimmers have been found to respond to the vis- cosity gradients depending on their shape or hydrodynamic multipole strengths [6,7]. We use numerical simulations to investigate viscosity gradient effects on flagellum motion. Represent- ing sperm cells through a bead-spring model experiencing anisotropic, space-dependent drag, our simulations reveal positive viscotaxis, where sperm cells reorient towards areas of higher viscosity. We quantify this behaviour in form of the rotational velocity and its dependencies on various factors. Furthermore, we explore the effects of asymmetric flagella waveforms and flagella elasticity.

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