Human sperm hydrodynamics: a computational study.

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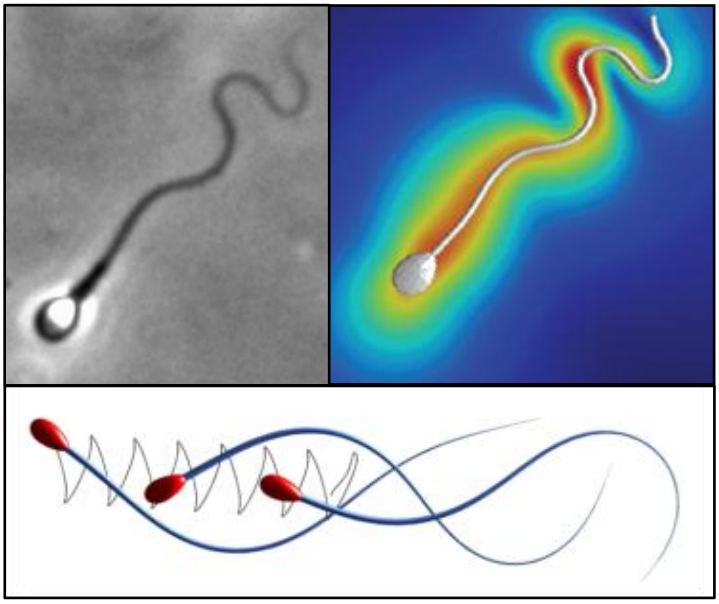

Project description: Ever wondered how sperm know where they're going? Every one of us is the consequence of a sperm cell winning the epic race through the female tract to reach the egg, covering the equivalent distance of climbing Mount Everest. Sperm cells have to endure in a variety of environments, from complex polymeric biological fluids, colloidal dispersions and acidic medium to simple and innocuous watery solutions. A crucial task for these cells is, however, to swim on small, cellular, scales, which requires intricate microfluidic actuation in order to bypass the excessive hydrodynamic friction from the surrounding environment. The human gamete ingeniously overcame such difficulty by periodically deforming whip-like, flexible cell appendages, thus inducing sufficient hydrodynamic thrust to propel fluid and consequently achieve locomotion (See Figure above). By using computation fluid dynamics (CFD) and simulation, the aim of this research project is to develop a "virtual sperm" to allow the exploration of hydrodynamical aspects of the human sperm motility. This will be achieved via direct numerical simulation of the fluid motion around the spermatozoa, carefully accounting for the complex interaction between the cell and the surrounding fluid. A bespoke numerical algorithm will be devised in C++, in conjunction with the OpenFoam library (an open source CFD toolbox). By the end of the project, the predicted high-precision numerical simulation for the human sperm hydrodynamics will be contrasted with experimental measurements of the fluid flow around sperm cells navigating in different environments.

Required skills: fluency in C++ and good knowledge in numerical methods applied to partial differential equations (PDE). Familiarity in fluid mechanics (Navier-Stokes equations) is welcome, but not required.

References:

- E. A. Gaffney, H. Gadelha et al. Mammalian Sperm Motility: Observation and Theory, *Annual Review of Fluid Mechanics* **43**, 501 (2011)
- *OpenFOAM: The Open Source CFD Toolbox*, http://www.openfoam.com/