Fluid Dynamics of Living Systems (M16)

Non-Examinable (Graduate Level)

Eric Lauga

Biology is dominated by transport problems involving fluid flows, from the transport of nutrients and locomotion to flows around plants and the circulatory system of animals. These problems occur over a broad spectrum of time and length scales, making them relevant to fluid mechanics research over the entire range of Reynolds numbers, from turbulent wakes behind flapping birds, to unsteady flows in the heart and Stokes flows inside cells. In this course, we will take a journey through the natural world and study several examples where flows are directly relevant to biology at the levels of cells and organisms. The emphasis will be using mathematical modelling, aiming to link experimental phenomenology of biological flows to solvable mathematical models.

The course topics will include, time permitting:

Extracellular flows

1. Blood flow and the microcirculation
2. Waving transport of fluids
3. Active suspensions
4. Locomotion of swimming microorganisms

Intracellular flows

5. Cytoplasmic streaming
6. Flows and transport in membranes
7. Polymeric fluids and cellular rheology
8. Capillary forces inside cells.

Prerequisites

Undergraduate fluid dynamics, vector calculus and mathematical methods.

Literature

Whenever possible the link will be made with research in each of the topics discussed in the course, so the lectures will be accompanied by a reading list of recent papers. Some relevant articles and books include:

1. Secomb (2017) *Annu. Rev. Fluid Mech.* **49**, 443.
2. Jaffrin & Shapiro (1971) *Annu. Rev. Fluid Mech.* **3**, 13.
3. Saintillan & Shelley (2013) *C. R. Physique* **14**, 497.
4. Lauga (2020) *The Fluid Dynamics of Cell Motility*, Cambridge University Press, UK.
5. Goldstein & Van De Meent (2015) A physical perspective on cytoplasmic streaming *Interface Focus* **5**, 20150030.
6. Saffman & Delbrück (1975) *Proc. Natl. Acad. Sci. USA* **72**, 3111.
7. Spagnolie (Editor) (2015) *Complex Fluids in Biological Systems*, Springer, UK.
8. Gouveia et al. (2022) *Nature* **609**, 255.