

Biological Flows (M16)

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Biology is rich with transport phenomena governed by fluid flows, from the circulation of blood and the movement of nutrients to the locomotion of microorganisms and the flows around plants and animals. These flows span an extraordinary range of time and length scales.

This course explores the mathematical foundations of biological fluid dynamics, focusing on how fluid flows shape and enable life at the cellular and organismal levels. These biological systems provide compelling case studies in mathematical modelling in fluid mechanics, while introducing physical regimes and biological processes that differ fundamentally from those encountered in more familiar fluid flows.

The first part of the course focuses on internal flows within cells and tissues, examining blood flow, transport driven by cilia and peristalsis, and mechanisms of enhanced transport by active flows. The second part turns to external flows, focusing on the locomotion of cells and organisms and their interactions with the surrounding fluid.

Through these diverse examples, students will develop an understanding of the fluid mechanics underlying biological function, with particular emphasis on regimes in which viscous effects dominate. Alongside core techniques in mathematical modelling, the course introduces fundamental concepts in both fluid mechanics and biology, illustrating how mathematical models can be used to uncover the physical principles governing biological transport.

Prerequisites

Undergraduate fluid dynamics, vector calculus and mathematical methods.

Literature

1. S. Vogel (1994) *Life in Moving Fluids*, Princeton University Press, USA.
2. T. W. Secomb (2017) *Annu. Rev. Fluid Mech.* **49**, 443.
3. E. Lauga (2020) *The Fluid Dynamics of Cell Motility*, Cambridge University Press, UK.
4. M. Y. Jaffrin & A. H. Shapiro (1971) *Annu. Rev. Fluid Mech.* **3**, 13.
5. R. E. Goldstein & J.-W. van de Meent (2015) *Interface Focus* **5**, 20150030.
6. G. I. Taylor (1953) *Proc. Roy. Soc. A* **219**, 186.

Additional support

Three examples sheets, three examples classes (two in Michaelmas, one in Lent) and a revision class (Easter).