Biological Physics (M24)

Professor R.E. Goldstein

This course will provide an overview of the physics of living systems, with an emphasis on their mathematical description. The range of subjects and approaches, from phenomenology to detailed calculations, will be of interest to students from applied mathematics, physics, and computational biology.

The topics to be covered span the range of length scales from molecular to ecological, with emphasis on key paradigms. They include: *Microscopic Physics* – van der Waals forces, screened electrostatics, interactions of extended bodies; *Fluctuations and Brownian Motion* – Equipartition, fluctuating continuous objects, diffusion, polymers and entropic forces; *Biological Filaments* – differential geometry, elasticity, constraints, variational principles, elastohydrodynamics, instabilities; *Membranes* – differential geometry, Helfrich model, fluctuations, shapes and shape transformations; *Cellular Motion* – cell swimming, flagella and low-Re locomotion, hydrodynamic interactions; *Biological Pattern Formation* – chemical kinetics, reaction-diffusion systems, Turing instability, chemotaxis.

Prerequisites

Statistical physics, fluid mechanics, electromagnetism, and dynamical systems constitute the appropriate background for this course.

Literature

1. R.E. Goldstein and E. Lauga. *Biological Physics and Fluid Dynamics: A Graduate Course in 24 Lectures* (2023). Available at https://www.damtp.cam.ac.uk/user/gold/pdfs/teaching/BPFD/BPFD.pdf

2. P. Nelson. *Biological Physics*. W.H. Freeman (2007).

3. J.D. Murray. *Mathematical Biology I. & II.* Springer (2007, 2008).

4. J.N. Israelachvili. *Intermolecular and Surface Forces*. 2nd edition. Academic Press (1992).

5. E.J.W. Verwey and J.Th.G. Overbeek. *Theory of the Stability of Lyophobic Colloids*. Elsevier (1948).

6. M. Doi and S.F. Edwards. *The Theory of Polymer Dynamics*. OUP (1986).

7. E. Lauga. *The Fluid Dynamics of Cell Motility*. CUP (2020).

8. D. Bray. *Cell Movements*. Garland (2000).

Additional support

Four examples sheets will be provided and four associated examples classes will be given. There will be a revision class in the Easter Term.