PHYSICS OF BIOLOGICAL SYSTEMS

PROF. MITHUN MITRA
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IIT Bombay

PRE-REQUISITES : Statistical Mechanics (Preferred, not a hard prerequisite)

INTENDED AUDIENCE : All Engineering students

COURSE OUTLINE :
The application of physical principles to biological systems is an exciting and rapidly evolving field of research. Methods of equilibrium and non-equilibrium statistical physics, stochastic processes, non-linear dynamics and polymer physics, among others have helped understand the guiding principles of a variety of biological processes. In this course, we will attempt to provide an introduction to the physics of biological systems using theoretical tools, with examples from diverse areas of biology such as pattern formation, low Reynolds number fows, cytoskeleton and motors and transport in cells, gene expression and chromatin organisation, among others.

ABOUT INSTRUCTOR :
Prof. Mitra is a theoretical physicist with a training in statistical mechanics and soft condensed matterphysics. His research focuses on understanding the physics of living systems, using both theoretical and simulation methods. In particular, some of the topics he is interested in include transport inside cells, the packaging of chromosomes in nuclei, and the physical principles underlying morphogenesis and growth of embryos.

COURSE PLAN :

Week 1**:** Introduction to Biophysics, Spatial and temporal scales

Week 2**:** Random walks and diffusion in biology, FRAP, cell signaling

Week 3**:** Diffusion and capture processes, Mean capture times

Week 4**:** Fluid flows in biology, viscosity and Navier Stokes equation

Week 5**:** Life at low Reynolds number, Scallop theorem and bacterial flagella

Week 6**:** Equilibrium Statistical Mechanics: Energy, entropy, free energy

Week 7**:** Two-state systems, cooperative binding, Haemoglobin

Week 8**:** Polymers and biopolymers, Entropic elasticity, persistence length

Week 9**:** Force spectroscopy, HP model of protein folding, Chromosome models

Week 10**:** Life in crowded environments, Depletion forces

Week 11**:** Biological dynamics and rate equations, motors and filaments

Week 12**:** Pattern formation in bology, Reaction-diffusion systems