CELLULAR BIOPHYSICS: A FRAMEWORK FOR QUANTITATIVE BIOLOGY

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PRE-REQUISITES :
1) BSc/BE/BTech 2nd year
2) BSc level knowledge of Classical mechanics
3) MSc level knowledge of Cell and molecular biology
4) MSc level knowledge of Biochemistry
5) Basic python programming

INTENDED AUDIENCE : 3rd year B.Sc, 1-2 year M.Sc. students in Biology and Physics

INDUSTRY SUPPORT :
1) Microscopy companies
2) Centrifuge companies
3) Spectroscopy companies

COURSE OUTLINE :

Given than most biological systems are in fact out of equilibrium, this course will touch upon some of the most recent theoretical and experimental approaches to understand the out of equilibrium aspects of biophysics. To this end we make a thermodynamics detour to answer the question posed by Schroedinger: “What is life?” We then consider a diversity of cell types to ask how the hierarchies of molecules and cells integrate. The question of how stochastic processes lead to deterministic outcomes will be briefly touched upon. Research paper reading will highlight case studies of the successful application of physics biological problems.

ABOUT INSTRUCTOR :

Prof. Chaitanya A. Athale has obtained his MSc in Zoology from Pune University in 1996. He received a PhD from the University of Heidelberg, Germany in Biology with magna cum laude in 2003 working on the topic of diffusion inside cells using a combination of stochastic simulations, cell biology and microscopy. Since then he worked from 2003-5 as a postdoctoral fellow at Harvard Medical School’s Mass chusetts General Hospital on simulating avascular tumour growth and from 2005-9 as a fellow in the EMBL Heidelberg working on self organizing principles of microtubule spindle assembly. Since 2009 he has worked as a faculty in the Division of Biology at IISER Pune first as Assistant Professor and since 2016 as Associate Professor. His lab works at the interface of experiment and theory on the role of microtubule-motor mechanics and systems level properties in cell shape. He also has a peripheral interest in bacterial biophysics and synthetic cell biology.

COURSE PLAN :

Week 1: Concepts in fluid dynamics as they apply to cellular scale life
Week 2: Diffusion & Macromolecular crowding
Week 3: Dynamics of macromolecules: Cytoskeleton
Week 4: Molecular motors and Brownian Ratchets
Week 5: The rate equation paradigm and genetic networks
Week 6: Noise in biological systems
Week 7: Turing patterns in embryogenesis
Week 8: Mechanics in embryogenesis and Future directions