TCIS, Hyderabad

Course: Mechanobiology

Start Date: 08.08.2017

Coordinates (Preferred): Tuesday and Thursday: 9:30 – 11:00 am

Instructor: Tamal Das

Syllabus: Physical forces affect biological entities at different level. Although the role of different surface and body forces in morphogenesis was envisioned about a century ago, it is only recently that we have begun to appreciate the existence and the importance of the force-induced changes that incessantly occur at molecular, cellular, and tissue level. For example, forces operating at the molecular level can alter the protein-protein reaction kinetics by opening cryptic binding sites or altering conformation. Forces exerted by the cells and on the cells have been shown to determine the differentiation and fate of cells and have profound implication in cancer. Finally, intercellular mechanical forces critical influences how a developing organ or organism would fold to assume its three-dimensional structure. In this course, we intend to generalize the scattered information on this topic to isolate the core concepts, exploring state-of-the-art mechanical and biochemical characterizations at milli-, micro-, and nano-meter scales.

- **Brief introduction to mechanical force:** Basics of classical mechanics, mechanics of solids and fluids, with examples from biology. Introduction to viscoelasticity and surface tension and how do they operate at cellular and tissue level. Concept of scaling in biology. Biology by the numbers.
- **How do the cells generate force?** Cell as a chemical machine. Thermodynamics, rate-kinetics, and mechanics. Effect of intercellular and intra-cellular forces at molecular- and meso-scale. Concept of forced induced unfolding of proteins and DNA. Force-dependent reaction kinetics of slip and catch bonds. Forces during cell division.
- **Biology, Chemistry, and Physics of cellular force-bearing structures:** Molecular and meso-scale perspective. Acto-myosin network, Microtubules, Intermediate filaments, Different cell-cell junctions, Extracellular matrix (ECM), Cell-ECM adhesions. Molecular motors.
- **How can we measure forces at molecular and cellular level?** Traction force microscopy, micropillar assays, monolayer stress microscopy, atomic force microscopy, optical traps, molecular tension sensors.
- **Forces in tissue and organism development:** Forces that shape a developing embryo. Forces in the epithelium. How the cells build the tissue stiffness: molecular assembly and collective effect. Epithelial constriction, invagination, bending, folding, and hydraulic fracture. Density-dependent and independent jamming and unjamming of the epithelium. Force measuring techniques at tissue level: current approaches and limitations.
- **Effect of fluidic forces:** Development of heart and blood vessel. Different flow types and their biochemical effect. Rheology of blood. Introduction to microfluidics as the blood-vessel mimic.
- **Mechanobiology of human diseases:** Cardio-vascular diseases, aging, and cancer.

Primary Text / Reference Books:

Introduction to the Physics of Fluids and Solids by James S. Trefil, Dover Books on Physics.

Physical Biology of the Cell by Rob Phillips *et al.*, Garland Science

Biological Physics: Energy, Information, Life by Philip Nelson, W.H.Freeman & Co Ltd

Biological Physics of the Developing Embryo by Gabor Forgacs and Stuart A. Newman, Cambridge University Press

Evaluation Method (Weightage for Internal Assessment, Mid Term / Term End exams, Presentations etc.):
Mid-term (20%) and final exam (50%). Internal assessment and presentation (30%).