ME724A: MECHANICS OF BIOLOGICAL MEMBRANES (3-0-0-9)

Organization of animal cells; Structure and function of cell membrane; Role of fluid lipid bilayers in cell functionality; Experimental methods to study membranes; Self assembly of lipid bilayer, Brief review of differential geometry concepts; Development of elasticity models of membranes; Stable equilibrium shapes of red blood cells; shapes of phase separated fluid lipid bilayer vesicles; Adsorption of proteins to lipid membrane; Special topics from current research.

Lecturewise Breakup

I. Introduction (4 Lecture)
   1. Organization of animal cells (1 lecture)
   2. Structure and function of cell membranes (1 lecture)
   3. Role of fluid lipid bilayer in cell functionality and Experimental methods to study membranes (2 lecture)

II. Self assembly of lipid bilayer (5 lectures)
   1. Thermodynamics of self assembly (3 lectures)
   2. Self assembly of lipids – shape and aggregate structure (2 lecture)

III. Review of differential geometry (8 Lecture)
   1. Introduction to membrane elasticity – stretching and bending (1 lecture)
   2. Differential geometry – curvilinear coordinates (1 lecture)
   3. Curvilinear coordinates on a surface (1 lectures)
   4. Covariant and contravariant derivatives (1 lecture)
   5. Mainardi-Codazzi relations (1 lecture)
   6. Ricci’s lemma, Surface divergence, Green’s theorem (3 lectures)

IV. Elasticity models for lipid bilayer (9 lectures)
   1. Development of elasticity models for lipid bilayer (3 lectures)
   2. Derivation of stress equilibrium equations of a lipid bilayer (1 lecture)
   3. Shape analysis of a red blood cell (3 lectures)
   4. Shape analysis of a two phase lipid bilayer vesicle (2 lectures)

V. Adsorption of proteins to membranes (7 lectures)
   1. Review of relevant thermodynamic concepts (2 lectures).
   2. Adsorption of proteins to flat surface using van der Waals and Bragg Willimas gas models (3 lectures)
   3. Adsorption of proteins to cylindrical and spherical membrane tubes (2 lectures)

VI. Additional topics – a few topics to be selected from below (7-9 lectures)
   1. Monge parameterization of surface and membrane fluctuations
2. Adhesion of cells and vesicles to substrates
4. Diffusion of proteins and domain in the membrane surface.

References

5. Relevant journal articles.