PH 553: BIOLOGICAL PHYSICS (4-0-0: 4)

Physical Biology

Physical biology of the cell; the stuff of life: four great classes of macromolecules; different physical models in biology; quantitative models and the power of idealization: springiness of stuff, the unifying ideas of biology, mathematical toolkit, biology by the numbers, cells and their contents: an ode to E. Coli; cells and structures within them.

Thermodynamics of Living Systems

Energy and the life of cells; equilibrium models: proteins in "equilibrium", cells in "equilibrium", minimizing the potential Energy; the mathematics of superlatives; Hooke's law: actin to lipids; entropy and hydrophobicity; Gibbs and the calculus of equilibrium; an ode to ΔG; the statistical mechanics of gene expression; Boltzmann distribution & entropy; Osmotic pressure & forces: Interstrand interactions of DNA; Law of mass action; applications of the calculus of equilibrium; random walks and structure of macromolecules; DNA as a random chain; single molecule mechanics.

Dynamics of Biomolecules

The mathematics of water: water as a continuum, F=ma for fluids, the Newtonian fluid and the Navier–Stokes equations; fluid dynamics of blood; life at low Reynold's number; diffusion in the cell; diffusive dynamics: Fick's law, The Smoluchowski equation, The Einstein relation; biological statistical dynamics; molecular motors; translational motors: myosin; biased random walk.

Biological Electricity & Quantum biology

The charge on DNA and proteins; electrostatics for salty solutions: the charged life of a protein, Poisson–Boltzmann equation, viruses as charged spheres; the role of electricity in cells; the charge state of the cell; the action potential; quantum mechanics for biology: photosynthesis, the particle in a box model, bioenergetics of photosynthesis; vision: microbial phototaxis and manipulating cells with light; relationship between eye geometry and resolution, photoreceptor cell.

Physical Methods in Biology and Medicine

X-ray crystallography, fluorescence spectroscopy, electron microscopy, nuclear magnetic resonance, atomic force microscopy, tomography, sonograms, radiation therapy, pacemakers

Text Books and References:

1. P. Nelson, "Biological physics: Energy, Information, Life", W. H. Freeman
2. R. Cotterill, "Biophysics: An Introduction", Willey
3. R. Glaser, "Biophysics", Springer
4. R. Nossal and H. Lecar, "Molecular & Cell Biophysics", Addison-Wesley
5. C. R. Cantor and P. R. Schimmel, "Biophysical Chemistry: Part-I, II and III", W. H. Freeman