Biophysics
Course Number: PY571
Instructor: Pankaj Mehta
Spring 2020
http://physics.bu.edu/~pankajm/PY571.html

TH 11-12:30 SCI B58
Office Hours: M 2-3pm SCI 323 and by appointment (or just stop by)

Biological physics is one of the fastest growing and exciting fields of physics. Living systems differ from most inanimate matter in crucial ways. They operate out of equilibrium and often possess very little or no symmetry. This course will explore the "physics of living systems" drawing upon ideas in statistical physics. We will also try to emphasize new experimental techniques as well as theoretical concepts.

Prerequisites: The course assumes a familiarity with rudimentary statistical physics. The course assumes a knowledge of linear algebra, differential equations and probability theory, as well as comfort programming in Python, MATLAB or another programming language.

Readings: The course will draw on various resources including papers. These will be posted on the course website. We will also regularly try to do "journal clubs" where we read classic papers on a subject.

Grading: 75% of the grades will be based on biweekly HW assignments. The remaining 25% will be based on a

Course Outline:

1 Introduction
1.1 What is life?
1.2 What is biological Physics?

2. Reproduction
2.1 Von Neumann's – Biologist first theorists
2.2 Phenomenological growth laws

3. Chemical Kinetics and Thermodynamics
3.1 Understanding chemical kinetics
3.2 Relating chemical kinetics to thermodynamics

4. Working out of Nonequilibrium
4.1 Kinetic Proofreading
4.2 Transducing free energy- Molecular motors
4.3 Experimental techniques – optical traps and all that

Interlude: Introduction to Probability

5 Polymer physics of Proteins:
5.1 Protein as polymers
5.2 Polymers and random walks
5.3 Worm-like Chain Model (WCM)

5.4 Proteins as designed molecules
5.5 Random Energy Model
5.6 Glass transition and protein folding
5.6 Engineering higher order function: Allostery
5.7 MWC Model

Reading: TBD

6. Thinking about stochasticity: case study of gene expression
6.1 Noise in gene expression
6.2 Measuring noise
6.3 Gillespie Algorithm – Monte-Carlo simulations

7 Engineering a Eukaryotic Signal Cascade: Photon counting and early vision

7.0 Overview of phototranduction: some experiments
7.1 Molecules involved in signaling pathways
7.2 Push-pull amplification: gain and time scale
7.3 Why so many stages?
7.4 A brief digression on information theory
7.5 Signal, noise and information in a cascade
7.6 Role of feedback

Reading: Bialek Chapter 2; Sengupta Modeling Biomolecular Networks Chapters 3+4; Detwiler et al 2000;

8. Computational Neuroscience and Biophysics
8.0 Hodgkins-Huxley
8.1 The Hopfield Model
8.2 The statistical physics of the Hopfield Model
8.3 Grid cells, Place Cells, and Attractors
8.4 Attractor Models and disordered systems

Reading: TBD

9. Ecology
9.1 Understanding ecology
9.2 Simple low-dimensional models and the bifurcation zoo
9.3 Niche Theory
9.4 Towards a statistical physics of ecology

10. Evolution

Reading: Lecture Notes