PHYS 105: BIOLOGICAL PHYSICS
Fall 2007

Instructor: Seth Fraden, Office: Abelson 222 (physics); E-mail: fraden@brandeis.edu

Office Hours: By appointment.

Meeting Time and Place: Room: Abelson 239 (physics), TF, 10:40 – 12.

Required course work:
Homework will be handed out in class, usually one every two weeks. The technical level of the math, physics, chemistry and biology needed for this course is elementary. Upper division majors in any of these fields have the necessary preparation. Expect fairly extensive reading assignments; pdfs of papers and chapters from J. Kondev, R. Phillips and J. Theriot, *Physical Biology of the Cell*, will be provided. A term paper will be due at the last day of classes. There will be no written exams, but you will give and be graded on a short presentation on your term paper topic at the end of the semester.

Grading Procedure:
50% – Homework. 30% – Term paper. 20% – Presentation.

Course Description:
Currently biology is undergoing a revolution whereby quantitative experimentation is providing remarkable molecular details of the basic processes of life. The mantra of this course will be: "Quantitative data demands quantitative models!". Consequently, we will develop simple physical models of biological structure and function and use them to discuss recently published experiments. Examples of questions we will explore are: "How does one make a stopwatch from genes and proteins?", "What determines the shape of mitochondria?", "How does a bacterium feel pressure?". To tackle these and similar questions, we will study selected topics in statistical mechanics, elasticity theory, fluid dynamics, and diffusion.

Students in this course have a wide range of scientific backgrounds. One of the objectives of this course is to have students from the life and physical sciences learn from each other and learn how to work together. Thus cooperating with each other on homework and peer review of the term paper is encouraged.

Course Outline

1. **From cells to molecules** (1 week)
A. Cells - *E. coli* and *S. cerevisiae*
B. Organelles and molecular machines
C. Cell assemblies

2. **Life's processes** (1 week)
A. Timing of the central dogma.
B. Timing of the cell cycle.
C. How cells manipulate time.

3. Life in equilibrium (3 weeks)
A. Boltzman's formula.
B. Protein-DNA interactions.
C. Ligand gated ion channels.

4. Biological electricity (2 weeks)
A. Diffusion and the Nernst equation.
B. Ion pumps and channels.
C. Neuromuscular junction.

5. Membrane mechanics (2 weeks)
A. Elasticity of lipid membranes.
B. Vesicular transport.
C. Organelle shapes.

6. How cells make decisions (3 weeks)
A. Gene regulation and cell development.
B. Protein signaling.
C. Kinetic proofreading.

Suggested reading

1. Not yet in print, but Prof. Kondev is providing chapters as pdfs:
   J. Kondev, R. Phillips and J. Theriot *Physical Biology of the Cell* (Garland Science, 200?).

2. Excellent coverage of the statistical mechanics and chemical thermodynamics of biological systems:
   K. Dill and S. Bromberg, *Molecular Driving Forces*, (Garland Science, 2003).

3. A physicist's view of biology in a similar vein as Kondev's:
   P. Nelson, *Biological Physics* (Freeman and Co., 2004).

4. Any student from the physical sciences serious about QB should own this book (I'm assuming that the biologists already own it, or its big brother):
   B. Alberts *et al.*, *Essential Cell Biology* (Garland Science, 2004).