

## PHYS 105: BIOLOGICAL PHYSICS

### Fall 2009

**Instructor:** Jane Kondev, Room 301; E-mail: kondev@brandeis.edu

**Office Hours:** 3-5PM, Wednesday, or by appointment.

**Meeting Time and Place:** Room 229, Tuesday and Thursday, 2:30 – 3:50.

#### **Required course work:**

Homework will be posted on LATTE usually one every two weeks. **No late homework will be accepted.** Expect fairly extensive reading assignments. A term paper will be due at the last day of classes.

#### **Grading Procedure:**

60% – Homework. 30% – Term paper. 10% – Class participation.

#### **Course Description:**

Currently biology is undergoing a revolution whereby quantitative experiments are providing us with remarkable details about the basic processes of life. The challenge posed by these experiments is to propose quantitative models that can explain the data and, most importantly, models that provide theoretical predictions for new experiments. Therefore, the battle cry 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 biological experiments. Examples of questions we will explore are: "How do bacterial cells decide what to eat?", "How do embryonic cells make patterns?", "How do bacterial cells find their middle?", and "How do plant cells harvest the energy from the Sun?". To tackle these and related questions, we will study selected topics in statistical mechanics, chemical kinetics, diffusion, and quantum mechanics, as they apply to cell and molecular biology.

#### **Course Outline**

##### **1. Cells, rulers, stopwatches and counters (2 weeks)**

- A. Sizing up cells.
- B. Timing of cellular processes.
- C. How cells do math.

##### **3. How cells make decisions (4 weeks)**

- A. Boltzman's formula and protein-DNA binding.
- B. Regulation of gene expression.
- C. Chemical kinetics and genetic circuits.
- D. Cell to cell variability of gene expression.

**4. How cells make patterns** (4 weeks)

- A. Diffusion.
- B. How an *E.coli* cell finds its middle.
- C. How the fly embryo gets its stripes.
- D. Lateral inhibition and cell differentiation.

**5. How cells eat the Sun?** (3 weeks)

- A. Photosynthesis.
- B. Electron in a box and photon absorption.
- C. Quantum mechanics of electron transfer.
- D. Carbon fixation.

**Suggested reading**

1. R. Phillips, J. Kondev and J. Theriot *Physical Biology of the Cell* (Garland Science, 2008).
2. K. Dill and S. Bromberg, *Molecular Driving Forces*, (Garland Science, 2003).
3. B. Alberts *et al.*, *Essential Cell Biology* (Garland Science, 2004).
4. M. Ptashne and A. Gann, *Genes and Signals* (Cold Spring Harbor Press, 2002).