**Biochem 102a    Quantitative Approaches to Biochemical systems**

## Course Outline

### Section 1: Schemes, Mechanisms, and Macroscopic Kinetics

8/30 What is a mechanism? Why bother with rate constants?
Math warmup prob handout
9/3 Labor Day, no class
9/5 A simple reaction: A->B
9/6 Use of spreadsheet for numerical solution of diff eqs
9/10 Microscopic reversibility A<=>B
9/12 General solution of linear diff eq, examples
9/13 No class
9/17 Relaxation to equilibrium – fast reaction methods
9/19 More complicated relaxations – sequential reactions A->B->C, A<=>B->C
9/20 Enzyme kinetics – steady state solutions
9/24 MM & BH mechanisms, meaning of kinetic parameters
9/26 Burst kinetics
9/27 EXAM

### Section 2: Statistics of Single Molecules

10/1 Chaos and determinism. Lightbulb statistics
10/3 More lightbulbs and the pdf
10/4 No class
10/8 pdf for a single molecule – mean, variance
10/9 Experimental measurements – single channels, single enzymes
10/10 Survivor function – going from Poisson params to rate constants
10/15 Multistate kinetics 1: single channel gating and block
10/17 Multistate kinetics 2: first passage time problem
10/18 - Biochem retreat - no class
10/22 Binomial distribution and mesoscopic noise analysis

### Section 3: Diffusion and Molecular Transport Processes

10/24 Macroscopic diffusion, Fick's law
10/25 Random walk treatment of diffusion
10/29 Einstein's PhD thesis
10/31 Smoluchowski limit to reaction rates
11/1 Diffusion to capture
11/5 Reduction of dimensionality, Sliding on DNA
11/7 Chromatography, . Binomial distirbution
11/8 Chromatography, 2
11/12 Sedimentation
11/14 EXAM

**Section 4: Spectroscopy**

11/15 Molecules and radiation: Quantum mechanics from 30,000 feet
11/19 Absorption spectroscopy,1
11/21 Absorption spectroscopy, 2
11/22 - No class
11/26 Fluorescence, 1
11/28 Fluorescence, 2
11/29 Fluorescence, 3
12/3 Magnetic resonance, 1
12/5 Magnetic resonance,2
12/6 Magnetic resonance, 3

FINAL EXAM given in exam period

**Course Information**

Instructors: Chris Miller (cmiller@brandeis.edu), Jeff Gelles (gelles@brandeis.edu)
M, W, Th, 11 AM, Kosow 116

## What is the course about?

Understanding biological phenomena frequently comes down to comprehending the structures of the molecules that participate in biochemical processes and the ways that these molecules function and interact. Biochemistry textbooks are packed to the brim with such information, but where does this knowledge come from in the first place? A great deal of our knowledge about biochemical processes comes from just two basic types of laboratory experiments. First, we explore the ***mechanisms*** of biochemical reactions by measuring the rates of various reaction steps. Second, we infer the ***structures*** and behavior of biological molecules from the ways that they interact with electromagnetic radiation. A common feature of all such experiments is that they involve making and interpreting quantitative chemical and physical measurements on biochemical systems.

This is not a laboratory course; it is not intended to teach the details of how to use specific techniques. Instead, the course covers the basic principles that underlie a wide range of quantitative biochemical experiments. Many of these principles arise from physical chemistry (the study of large collections of molecules), and their applications to real systems are worked out via mathematics. The intention here is to equip students with some of the basic attitudes, approach, and knowledge they will require to read, critically evaluate, and ultimately contribute to original research literature of the field.

Another purpose of this course is to gain experience with mathematical methods in common use in the quantitative treatment of biochemical problems – linear differential equations, concepts of probability, statistics, and stochastic processes. Students have seen most of these before but usually have not had much practice actually using them. Our object here is not to torture but to empower students by teaching a few of these tools and essentially demystifying them so that when they are encountered in the biochemical literature later on, they will be seen as useful friends rather than as obscure tormentors.

## Required Preparation

The course requires knowledge of basic biochemistry at the level covered in a good introductory college biochemistry course (e.g., Bchm 100). We will assume that you already are familiar with fundamental chemistry concepts like Gibbs free energy and chemical equilibria and that you have had at least some previous exposure to basic chemical kinetics. **A *calculus-based* introductory physics course is an essential prerequisite.** You should be familiar with the properties of common mathematical functions such as polynomials, logarithms, exponentials, and trig functions. You must also to be able to **differentiate and integrate with ease** and also to apply calculus to the solution of simple physical problems.

## Readings

The course requires the two texts:

Fersht, A. (1999). *Structure and Mechanism in Protein Science.* New York, WH Freeman. (This is also used in Bchm 101a)

Berg, H. C. (1983). Random walks in biology. Princeton, N.J., Princeton University Press. (This is a cheap paperback and an absolute gem.)

Readings from other texts will be assigned for some sections of the course. You should also have available an introductory biochemistry text in case you need to refresh your memory of some of the background material. Most other readings can be printed out from the E-Res server (see below).

The following supplemental reference books have been put on reserve:

- van Holde, K. E., W. C. Johnson, et al. (1998). *Principles of Physical Biochemistry.* Upper Saddle River, N.J., Prentice Hall. (Qp517.p49 v36 1998).
- Cantor, C. R. and P. R. Schimmel (1980). Biophysical chemistry. San Francisco, W. H. Freeman. (Qh345 .c36).
- Tinoco, I., K. Sauer, et al. (1985). Physical chemistry : principles and applications in biological sciences. (2nd ed.) Englewood Cliffs, N.J., Prentice-Hall. (Qh345 .t56 1985).

## Electronic Resources

All materials, handouts, etc, can be found on the **Latte** website for Bchm 102.

## Course Organization

**Problem sets.** Much of the material covered in the course cannot really be understood just by listening to someone jabber on about it; you have to try it out for yourself. For that reason, the ***problem sets are the most important part of the course***. There will be problem sets over the course of the semester. These must be turned in at the end of the lecture on the due date. We will grade and return them, but the grades are merely for your information; problem set grades have almost no effect on your grade for the course. Late problem sets will not be accepted for grading. Feel free to collaborate with other students on the problem sets if you feel that this will help your understanding of the material.

**Lectures.** See the course schedule for dates of lectures. Class starts promptly at 11:10. We usually begin each lecture by summarizing the most important point to be discussed that day, so come on time.

**"Lab" sessions**. Throughout the semester, we will have several extra 2-hour "lab" sessions at times to be arranged. These will provide hands-on experience in some of the calculational techniques we are endeavoring to convey. Many of these will involve computer-lab work for numerical solutions and simulations.

**Questions.** We welcome your questions both in and out of the lectures. Do not hesitate to see either of us in our offices or labs if you have questions about the course, lectures, problems, etc.

**Exams**. There will be three exams. Each exam may cover some material all the way back to the beginning of the course. If you miss an exam, you will receive a failing grade. As it is essentially impossible to prepare two equivalent exams in this subject, no makeup exams will be given. In exceptional circumstances in which a student is absent from an exam due to a documentable emergency beyond the student's control, an oral exam will be given. Any student requiring special academic accommodations in the exams or lectures should make arrangements with the coordinator immediately upon starting the course; see the Brandeis University Bulletin for details.

**Grades.** Final grades for the course will be determined based on exam scores and your class participation, along wi
th bribes, the phase of the moon, and our mood on grading day.