Biochem 102a Quantitative Approaches to Biochemical Systems, 2009

Section 1: Schemes, Mechanisms, and Macroscopic Kinetics (10)

8/27	What is a mechanism? Why bother with rate constants?	
8/31	The simplest first-order reaction: A->B	
9/2	Use of spreadsheet for numerical solution of diff eqs	
9/3	Microscopic reversibility A<=>B	
9/7	No class	
9/9	General solution of linear diff eq, examples	
9/10	More complicated relaxations – sequential reactions A->B->C, A<=>B->C	
9/14	Relaxation to equilibrium – fast reaction methods	
9/16	Enzyme kinetics – steady state solutions	
9/17	MM & BH mechanisms, meaning of kinetic parameters	
9/21	Burst kinetics	

Section 2: Stochastic Behavior of Single Molecules (9)

9/23	Chaos and determinism. Lightbulb statistics	
9/24	More lightbulbs and the pdf	
9/28	No class	
9/29	Brandeis Monday! pdf for a single molecule	
9/30	Using the pdf - mean, variance	
10/1	Survivor function – going from Poisson params to rate constants	
10/5	No class	
10/7	EXAM	CM away
10/8	Real measurements – analyzing single channels	Guest host - Kene Piasta
10/12	Multistate kinetics 1: single channel gating and block	
10/14	More single molecule stories	
10/15	Multistate kinetics 2: first passage time problem	

Section 3: Diffusion and Molecular Transport Processes (6)

10/19	Macroscopic diffusion, Fick's law	CM away - Guest host, Jeff Gelles
10/21	Random walk treatment of diffusion	CM away - Guest host, Jeff Gelles
10/22	Einstein's PhD thesis	CM away - Guest host, Jeff Gelles
10/26	Smoluchowski limit to reaction rates	
10/28	Diffusion to capture	
10/29	Reduction of dimensionality, Sliding on DNA	

Section 4a: Basic Principles of X-ray Diffraction (6)

11/2 Learn to love the cosine: adding waves
11/4 Ducks in a row: adding many waves
11/5 Biochem-Biophys Retreat - no class
11/9 Scattering vector and general diffraction
11/11 Indexing a crystal lattice: learn to love HKL
11/12 Going backwards: Fourier synthesis and the phase problem
11/16 Solving the phase problem for proteins

Section 4b: Optical Spectroscopy (5)

11/18 Molecules and radiation: Quantum mechanics from 30,000 feet
11/19 Absorption spectroscopy
11/23 Fluorescence, 1
11/25 Fluorescence, 2
11/30 Fluorescence, 3
12/2 **EXAM**

Course Information

Instructor: Chris Miller (cmiller@brandeis.edu) - Volen 415 - 6-2340
M, W, Th, 11 AM, SS 014

What is the course about?

Understanding biological phenomena often comes down to comprehending the structures of the molecules that participate in biochemical processes and the ways that these molecules work 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. All such experiments involve making and interpreting quantitative chemical and physical measurements on biochemical systems.

This is not a laboratory course, nor will it teach the details of how to use specific techniques. Instead, the course covers *basic principles* that underlie a 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 aim here is to equip students with some of the basic attitudes, approaches, and knowledge they will require to read, critically evaluate, and ultimately contribute to original research literature in macromolecular biochemistry and biophysics.

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, stochastic processes, fourier series. Students have seen most of these before but usually have not had much practice actually using them. My object here is not to torture students but rather to empower them by teaching a few of these tools and 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). I will assume that you already are familiar with fundamental chemistry concepts like Gibbs free energy and chemical equilibrium 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 very, very 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 uses sections from two texts:

> Fersht, A. (1999). *Structure and Mechanism in Protein Science.* New York, WH Freeman.
>
> Berg, H. C. (1983). Random walks in biology. Princeton, N.J., Princeton University Press. (This is a cheap paperback and an absolute gem - really worth owning.)

Some of you may already have these texts, but if you don't, you will not need to buy them, as the relevant sections will be posted on LATTE. You should also have available an introductory biochemistry text in case you need to refresh your memory of some of the background material.

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 me 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. I 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. I will not look at problem sets turned in after the due date. Do not hesitate 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. I usually begin each lecture by summarizing the most important point to be discussed, so come on time.

Questions. ***I welcome your questions both in and out of the lectures.*** I want to help you understand this material. Do not hesitate to see me in my office or lab if you have questions about the course, lectures, problems, etc. I do not keep office hours but am always available to be dropped in on, except when I am traveling.

Exams. There will be two exams. If you miss an exam, you will receive a failing grade, and 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 immediately upon starting the course; see the Brandeis University Bulletin for details.

Grades. Final grades will be determined based on exam scores and your class participation, along with bribes, the phase of the moon, and my mood on grading day.

Monkey-points. Whenever you catch me making a mistake in lecture - either a dumb error in algebra or a deep one in analysis, do not restrain yourself from shouting out "**MONKEY**!" and pointing out the mistake for all to see. You will get extra points in the final grading-mix for each time you make a monkey out of me in front of the class.