BIO 304: Biological Function and Structure - Spring 2011

(February 9, 2011)

Instructor: Deniz Sezer
E-mail: dsezer@sabanciuniv.edu
Office: FENS G021
Office Phone: 483-9881
Web: http://myweb.sabanciuniv.edu/dsezer

Lectures: Tue 12:40-14:30 FENS L065
Thu 16:40-17:30 FENS L058

Teaching Assistant: Onur Yükselen
E-mail: onuryukselen@sabanciuniv.edu

Course Description: The aim of this course is to walk students through the main ideas and experimental techniques in structural biology following the shortest path from the significant events in the history of the field to the recent research literature. We will start by reviewing the building blocks of proteins and DNA and discussing the physical principles determining their structures. The connection between biomolecular structure and function will be established by introducing a biochemical description of binding—the simplest recognition event at the molecular scale—in terms of equilibrium and rate constants. The two major experimental techniques for biomolecular structure determination will be introduced in the context of specific examples. In particular, X-ray crystallography will reveal how hemoglobin in the red blood cells carries oxygen and how ion channels embedded in the cellular membrane conduct ions. On the other hand, NMR spectroscopy will elucidate the workings of an enzyme and look in detail at protein-DNA interactions involved in controlling the transcription of genes. Throughout, we will keep an eye on historical papers that contributed to the birth of structural biology. Emphasis will be given on the modern view that protein function is determined by structure as well as dynamics.

Who can take this course: Most of the students taking the course are expected to be undergraduate students in the biological sciences who are interested in Structural Biology. However, the course may be attractive to engineering and physical science students looking for first exposure to modern molecular biology. After surmounting the barrier of getting familiar with the necessary biology-related vocabulary, such students will find their existing knowledge invaluable for understanding the physical principles behind biomolecular structure and the experimental techniques that will be discussed in the course.

Evaluation:

Quizzes	10 %
Homework	10 %
In-class discussion	10 %
Midterm exam	20 %
Written report and oral presentation	25 %
Comprehensive final exam	25 %

The course will consist of lectures and in-class discussions of pre-assigned research papers, both historical and recent. Short quizzes will be given to make sure that the material in the lectures has been absorbed in a timely manner. Students will be expected to have read the assigned papers carefully and critically, and to actively participate in the discussion. To ensure closer familiarity with the structural

aspects of the molecules considered in the papers, simple homework assignments, consisting of visually examining and manipulating the three dimensional molecular representations, will be given. During the semester, students will be expected to choose a biological question, which they will examine from a structural perspective using the recent research literature. In the last two weeks, they will make an in-class presentation of their findings and submit a short written report.

Detailed Course Content:

Dates	Topics (*discussion topics in italics*)
Feb 15	General information about the course
Feb 17	Introduction: Functions of biological molecules
Feb 22	Structural chemistry and protein secondary structure
Feb 24	*Helices, pleated sheets and Pauling*
Mar 1	Nucleic acids and DNA structures
Mar 3	*The double helix of Watson and Crick*
Mar 8	X-ray crystallography and protein structure
Mar 10	*Kendrew and the structure of myoglobin*
Mar 15	Cooperative ligand binding and allostery
Mar 17	*Perutz and the two states of hemoglobin*
Mar 22	Lipid membranes and transport of small molecules
Mar 24	Ion channels and the membrane potential
Mar 29	Introduction to molecular dynamics simulations
Mar 31	*Structure of the potassium channel KcsA*
Apr 5	*Ion conduction in the selectivity filter of KcsA*
Apr 7	Review for the exam
Apr 12	**Midterm Exam**
Apr 14	Introduction to nuclear magnetic resonance (NMR) spectroscopy
Apr 19 Apr 21	Semester Break
Apr 26	Biomolecular structure determination with NMR
Apr 28	Protein dynamics with NMR
May 3	Enzyme thermodynamics and kinetics
May 5	*Rates of proline isomerization with NMR*
May 10	*Intrinsic dynamics coupled to catalysis in CypA*
May 12	*Studies of CypA minor state with X-ray crystallography and NMR*
May 17	**Presentation of report**
May 19	Expression regulation and protein-DNA interactions
May 24	*NMR studies of the interaction of the lac repressor with DNA*
May 26	Overview

Textbooks:

BT Branden and Tooze, *Introduction to Protein Structure*, 2nd edition, Garland Publishing, 1999.

PR Petsko and Ringe, *Protein Structure and Function*, New Science Press, 2004.