BIO 466/NS 566 Fall 2015

Biophysics: Molecules and Systems

(November 15, 2015)

Instructor: Deniz Sezer
E-mail: dsezer@sabanciuniv.edu
Office: FENS G021

Lectures: Tue 10:40-11:30 FENS L048
Wed 14:40-16:30 FENS G029

TA: Tuğçe Oruç

Course Description: The objective of this course is to introduce students to concepts and techniques in theoretical molecular biophysics. As an introductory course it is designed to be accessible to a wide audience with diverse background. In particular, the course aims to provide engineering and physical science students with first exposure to modern molecular biology. At the same time, it aims to equip biology students with a formal language and analytical tools for quantitative analysis of biological problems.

Some of the questions that will be addressed during the course are as follows:

- What are the memory and CPU of a living cell?
- How much information is in the genome of a living organism (in bits)? Is this information sufficient to direct the functions of the molecules involved in the processes of life?
- How do proteins "know" what shape they need to take for their proper function?
- How is the making of proteins controlled by other (dedicated) proteins? Are the control units similar to the logic gates of digital computers?
- How do these controlling proteins find their targets on the genome of the organism? How long do they have to look for the target?
- How do small molecules (including drugs) get into a cell? How fast is this process?

Evaluation:

Homework	20 %
Midterm exam (Nov 18)	30 %
Oral presentation and written report	20 %
Final exam	30 %

In the second half of the semester, students will be expected to choose a biophysical question to examine using the recent research literature. They will present their work in class during the last week of the semester and will submit a short written report of their findings by the end of the exam period.

Textbook:

PBoC. Phillips, Kondev, Theriot & Garcia, *Physical Biology of the Cell*, 2$^{\text{nd}}$ edn., Garland Science, 2012.

Detailed Course Content:

Sep 14	General information about the course	
Sep 16	How big is a cell?	How long is a genome?
	HW1: Information content of a genome	(due Sep 29)
Sep 22	–	
Sep 23	–	–
Sep 29	Molecular census of the bacterium *E. coli*	
Sep 30	What keeps DNA strands together?	Simple model of a folding protein
	HW2: Energy of a hydrogen bond	(due Oct 7)
Oct 6	Specific heat and free energy of folding	
Oct 7	Role of water in protein folding	What is special about protein sequences?
	HW3: Self-assembly of lipids	(due Oct 14)
Oct 13	Models of cell division and population growth	
Oct 14	Quantifying the cost of making a protein	Evolving towards the cost-benefit optimum
	HW4: Cost-benefit analysis of protein expression	(due Oct 21)
Oct 20	RNA polymerase, promoters, binding to DNA	
Oct 21	Probability of transcription	Regulation of transcription
	HW5: Activator makes the promoter stronger	(due Oct 27)
Oct 27	Demand theory of gene regulation	
Oct 28	–	–
	HW6: Regulatory logic of *lac* operon	(due Nov 4)
Nov 3	Logic gates from molecules	
Nov 4	Molecular Boolean networks	
	HW7: Boolean network analysis of repressilator	(due Nov 11)
Nov 10	Statistical mechanics of binding	
Nov 11	Entropy, energy and the dissociation constant	Binding of *lac* repressor to DNA
Nov 17	Microscopic view of diffusion along DNA	
Nov 18	**Midterm Exam**	
Nov 24	Solution of exam questions	
Nov 25	Diffusion in 3D	Is 1D diffusion better for finding a site on DNA?
	HW8: Passive transport and diffusion coefficient	(due Dec 2)
Dec 1	Mean time to find a target via diffusion in 1D	
Dec 2	Time to find a target via diffusion in 3D	Sliding along and jumping across DNA
	HW9: Time to find target in 1D and 3D	(due Dec 9)
Dec 8	Macroscopic view of diffusion	
Dec 9	Permeation of molecules through membrane	Acid/base properties of drugs (pK_a)
	HW10: Diffusion equation	(due Dec 16)
Dec 15	**Presentations**	
Dec 16	**Presentations**	**Presentations**
Dec 23	**Final Exam**	