ENS 222 Spring 2015

Biological Circuits and Molecular Machines

(May 31, 2015)

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Lectures: Mon 10:40-12:30 FENS L062
Wed 10:40-11:30 FENS L027

TA: Tuğçe Oruç

Course Description: Since 21st century is the century of biology, any aspiring engineer should be equipped with knowledge of biological systems and tools to model their quantitative aspects. This course offers an introduction to molecular and cellular biology from an engineering point of view.

Evaluation:

Homework assignments	20 %
First take-home exam	25 %
Second take-home exam	25 %
In-class final exam	30 %

References:

1. David Goodsell, *The Machinery of Life*, 2nd edn., Springer, 2009.

2. Brian Ingalls, *Mathematical Modeling in Systems Biology: An Introduction*, MIT Press, 2013.

3. Steven Strogatz, *Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering*, Westview Press, 1994.

Detailed Course Content: (See next page.)

	Cells and mathematical modeling	
Feb 2	General information about the course	
Feb 4	Mathematical model of cell growth	
Feb 9	Cell growth with saturation	What is inside a cell?
Feb 11	Numerical solution of cell growth model	HW 1: Logistic growth with MATLAB
	Batteries and wires in the cell	
Feb 16	ATP hydrolysis as a battery	Equilibrium of chemical reaction
Feb 18		
Feb 23	ATP battery needs a wire (rates of reactions)	The "voltage" of the ATP battery
Feb 25	Proteins as "wires" for chemical batteries	HW 2: Adenylate kinase (ADK)
	Proteins as random machines	
Mar 2	Alternative conformations of ADK	Glucose crosses the cell membrane
Mar 4	Equilibration between inside and outside	HW 3: Equilibration in compartments
Mar 9	Membrane permeability for glucose and ions	Transporters and channels as machines
Mar 11	Protein machines are random	HW 4: Random jumps between two states
	Proteins as cyclic machines	
Mar 16	Kinetic modeling of random transitions	Random association of molecules
Mar 18	Diffusion and on rate of binding. Glycolysis	HW 5: Structure of Phosphofructokinase
Mar 23	Fast and slow processes	Approximate analysis of a 3-state cycle
Mar 25	Operational cycle of Phosphoglucose Isomerase	
Mar 30	Independent binding of multiple ligands	Glucose transporter as a 4-state machine
	First take-home exam	**Mar 30 - Apr 3**
Apr 6 Apr 8	Semester Break	
	Proteins as switches	
Apr 13	Analysis of the Glucose Transporter cycle	Ligand binding as a switch
Apr 15	Monomers, dimers, tetramers	HW 6: Modeling steps 0, 1, 2 of glycolysis
Apr 20	Making a better switch: Cooperativity	Controlling the switch: negative effectors
Apr 22	Positive effectors	HW 7: Control of cooperative switches
	Control, feedback and energy transduction	
Apr 27	Myoglobin and Hemoglobin	Control of glycolysis: Phosphofructokinase
Apr 29	Positive feedback and oscillations	HW 8: Positive feedback and oscillations
May 4	Glycolysis, citric acid cycle, respiratory chain	Proton gradient and ATP production
May 6	Proteins as energy transducers	
May 11	Membrane potential	Nernst equation
	Second take-home exam	**May 11 - May 15**
May 28	**In-class final exam**	