Physics 420: Introduction to Biophysics – Fall 2018

Time: Tue, Fri 9:10-11:00 AM **Place:** 1311 HN
Instructor: Associate Professor Hyungsik Lim
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Office: 1237 Hunter North, 695 Park Avenue
Office hours: by appointment

Pre-requisites or Co-requisites: Permission of instructor
Description: The goal of this course is two-fold; 1) to learn how to build a simple physical model to produce testable predictions for diverse living systems from gene expression to neural networks and 2) to understand modern techniques that opened the fields of molecular biophysics.
Recommended texts:
"Physical Biology of the Cell", Rob Philips, Jane Kondev, and Julie Theriot
"Molecular Driving Forces", Ken Dill and Sarina Bromberg
"Biological Physics: Energy, Information, Life", Philip Nelson
Grading: Homework 20%: Midterms 40%: Final 40%.

Preliminary Class Schedule:

Week 1	8/28	Biology in Numbers	8/31	Random Walk Model	
Week 2	9/4	Random Walk I: DNA	9/7	Random Walk II: Protein	
Week 3	9/11	*No class*	9/14	Two-state System I	HW#1
Week 4	9/18	*No class*	9/21	Two-state System II	
Week 5	9/25	Chemical Reaction I	9/28	Chemical Reaction II	
Week 6	10/2	**Midterm #2**	10/5	Cooperativity I	HW#2
Week 7	10/9	Cooperativity II	10/12	Allostery I	
Week 8	10/16	Allostery II	10/19	Network I	
Week 9	10/23	Network II	10/26	Kinetics of Two-state System	HW#3
Week 10	10/30	Random Telegraph Model	11/2	Bursting I: Ion Channel	
Week 11	11/6	Bursting II: Transcription	11/9	**Midterm #2**	
Week 12	11/13	Excitable Membrane I	11/16	Excitable Membrane II	HW#4
Week 13	11/20	Hodgkin-Huxley Model I	11/23	*No class*	
Week 14	11/27	Hodgkin-Huxley Model II	11/30	Biophysics of Computation	
Week 15	12/4	Biotechniques I	12/7	Biotechniques II	HW#5
Week 16	12/11	Biotechniques III	12/14	**Final Exam**	

Final Exam: 12/14/2018 9:10 - 11:00 AM

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Introduction – Biology in Numbers

Random Walk Model

- Random Walk Model I: Brownian Motion and Diffusion
- Random Walk Model II: Conformation of Linear Biomolecules
- *Random Walk Model III: Motility in Low Reynolds Number

Two-State System: Adding Energy to Random Walk Model

- Two-State System I: Modulating Equilibrium by Temperature and Energy
- Two-State System II: Diffusion of Molecular Motors under Force
- Two-State System III: Conformation of Linear Biomolecules under Force

Actuation of Two-State Systems by Ligand Binding

- Laws of Chemical Reaction
- Cooperative Binding: Pauling Model
- Allostery: Monod-Wyman-Changeux Model
- Ion Channels and Transcription Factors

Two-State System with Feedback: Bistability and Oscillation

*Network of Two-State Systems with Interaction: Ising Model

Nonlinear Membrane: Hodgkin-Huxley Model

- Electrical Properties of Excitable Membranes
- Generation of Action Potentials
- Conduction of Action Potentials

Fluctuating Single Molecules

- Kinetics of Two-State System: Poisson Process
- Bistable Neuron and Information Coding
- *Two-State System with Dark State: Bursting Process

Biotechniques

- Optical Tweezer (Single-molecule Force Spectroscopy)
- Förster Resonance Energy Transfer (FRET)
- Fluorescence Correlation Spectroscopy (FCS)