

## Biophysics (Phys. 4251/Phys. 8803GM) Syllabus

TTh 9:30-10:45

Instructor: JC Gumbart

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Office Hours (by appointment or whenever you catch me!)

Fall 2017

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### Description

This course will introduce how physical concepts can be used to gain insight into the working of biological systems *at a molecular level*. The material will pull from all areas of physics, but particularly classical and statistical mechanics, with a bit of EM and QM thrown in. While the mathematics is not onerous, students should feel comfortable with simple matrix and differential equations as well as plotting and manipulating data. Finally, no prior knowledge of biology is required – just a desire to learn a different way of thinking about complex systems!

### Learning Outcomes

After completion of this course, students will be able to (1) read and understand molecular biophysics papers, (2) analyze data from common biophysical experimental methods, (3) design a *testable* model of a biophysical phenomenon or system, including writing code for modeling and/or analysis, and (4) communicate their results, both orally and in writing.

### Textbooks

Physical Biology of the Cell by Phillips, Kondev & Theriot, 2<sup>nd</sup> edition (recommended)

Physical Models of Living Systems, Philip Nelson, 1<sup>st</sup> edition (suggested)

### Grading

**Class Participation (10%):** Students are to be expected to attend all classes and actively participate. A significant amount of learning will come from the discussions in class. The instructor will note class participation and count it toward the final grade. Extensive use of mobile devices will result in losing credit for that day. Up to two absences will be excused without penalty.

**Homework (50%; 40% for graduate students):** Approximately 6-8 homework sets with problems involving visualization and analysis of biological structures with the program VMD, pencil-and-paper calculations using equations derived in class, and analyzing simple models using Python. Homework will be turned at the beginning of class on the due date. Late homework will be accepted with a 10% penalty for one extra day, 25% penalty for two extra days. Extensions may be granted under specific extenuating circumstances, *negotiated in advance*.

**Papers (10%):** The ability to critically read and digest the scientific literature is a skill that has to be *learned*. Therefore, we will read a few biophysics papers and devote part of a class day to discussing each. Before we discuss them in class, you will write a one-page critique of the paper and turn it in at the beginning of class. The critiques will be scored as 1, 0.5 or 0. If your critique clearly demonstrates that you have read the paper, you will get a 1. If you copy abstract/summary or other parts of the paper, you will get a zero. If you have read the paper but completely missed the point, you will get a 0.5. Missing critiques will be scored as zeros. **No late critiques will be accepted.**

**Project (30%; 40% for graduate students):** In the second half of the term, you will have to carry out a project in which you model a chosen biophysical phenomenon or system. The basis for this project will either be a well-known phenomenon (e.g., propagation of neural excitations) or an experimental paper on a particular protein. In the former case, you will have to design and implement a mathematical model in code, with which you can produce and analyze output for comparison with real data. In the latter case, you will determine a pertinent question about the protein and design a set of molecular dynamics simulations to answer it, including coding your own analysis scripts using VMD. You will have to present the project to the class as well as in a paper to be turned in during finals week. This paper will need to be in a form suitable for publication, with specific formatting provided in class.

## Grading Scale

Your final grade will be assigned as a letter grade according to the following scale:

A	90-100%	B	80-89%
C	70-79%	D	60-69%
F	0-59%		

## Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please visit <http://osi.gatech.edu/content/honor-code>. Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

## Accommodations for Individuals with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services (often referred to as ADAPTS) at (404) 894-2563 or <http://disabilityservices.gatech.edu/>, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter.

**Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.**

## Collaboration & Group Work

Collaboration on homework is reasonable, but the final product turned in should be the student's own work. If identical assignments are turned in, all students involved will receive zeros.

## Student-Faculty Expectations

At Georgia Tech we believe that it is important to continually strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech, while in this class.

## **Schedule (very approximate!)**

Week 1, 8/22, 8/24: introduction to biology: messy, hot, and crowded  
visualization with VMD, four classes of biomolecules. Stat mech.

2, 8/29, 8/31: stat mech, randomness, and distributions

3, 9/5, 9/7: **discuss Gunawardena 2014**; amino acid properties, pKas

4, 9/12, 9/14: polymer theory, FJC/WLC models; DNA/RNA structure, bending/packing

5, 9/19, 9/21: protein folding; electrostatics

6, 9/26, 9/28: **discuss Wang 1997**; diffusion; crowding

7, 10/3, 10/5: chemical equilibrium, rate equations, cytoskeleton; **discuss class projects**

8, 10/12: membranes; curvature

9, 10/17, 10/19: molecular motors (e.g, ATP synthase, kinesin/myosin)

10, 10/24, 10/26: **discuss Yildiz 2003**; bioelectricity (ion channels, Nerst potential, Hodgkin-Huxley model, etc.)

11, 10/31, 11/2: bioelectricity (cont.); central dogma, genetic code; gene regulation

12, 11/7, 11/9: gene structure, mutation; bioinformatics; protein synthesis

13, 11/14, 11/16: protein structure determination; **discuss Zhao 2013**; QM in biology (photosynthesis, excitation transfer, etc.)

14, 11/21: **PRESENTATIONS**

15, 11/28, 11/30: **PRESENTATIONS**

16, 12/5: **PRESENTATIONS**

**NO FINAL EXAM** – turn in final report