Foundations in Quantitative Biosciences (BIOL 8804)

Course Syllabus – Fall 2016

Instructors: Prof. Joshua Weitz

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Office hours: Fri, 3-4pm, CE 219

Lectures: T/Th 8:05-9:25AM, Cherry Emerson 320
Computational lab: Fri 12:05-2:55pm, Cherry Emerson 320

Sources:
Special readings to be posted on http://tsquare.gatech.edu

Course Topics: Quantitative methods key to foundational advances in the bioscience spanning distinct scales of organization from molecules, cells, organisms, populations to ecosystems. The course is organized into three major themes: (i) molecular and cellular biosciences; (ii) organismal behavior and physiology; (iii) ecology & earth systems.

Prerequisites:

(i) Enrollment in the PhD with a Major in Quantitative Biosciences;

or

(ii) Permission of instructor, contingent upon demonstration of prior coursework in mathematical methods including differential equations.

Overview
The class is organized around the understanding of key advances in the biosciences, one organizing unit at a time, in which the advances depended critically on quantitative methods and reasoning. Both foundational advances and recent challenges will be discussed. Each week, students will be exposed to:

- *methods* for developing and analyzing quantitative models;
- *logic* for how to reason given uncertainty in the biosciences;
- *computational skills* to implement and support a thorough understanding of stochastic and dynamic modeling at the interface between mathematical formalism and biological data.

The overall objective of the course is to teach graduate students how to reason quantitatively in the biosciences given uncertainty in mechanisms, rates and reliability of measurements.

Course format

Three hours each week are scheduled for the class lecture. Class time will be divided among traditional lectures and group problem-solving exercises or discussions. A component of the course will involve formulating and solving problems in small cooperative groups of three to four members.

The reading listed for each week should be done *prior* to the first lecture of the week. These papers will be the basis for in-class discussion.

In addition, a two-to-three hour recitation section will be held each week involving computational work that will serve as a prelude to problem sets.

Software: Implementation of homework requires use of (i) mathematical analysis; and (ii) MATLAB. MATLAB is available for use by all students enrolled at GT without charge. Refer to the OIT website for more details on access: http://software.oit.gatech.edu

Grading Scheme:

60% homework
15% final presentation
15% final paper
10% class participation

Final project: Final project proposals will be handed in the mid-term (date to be announced), in groups of 2-3 students. Final presentations will take place during the last week of classes, in lieu of a final exam. Final papers will be due on the date of the final exam. More information will be available later in the term.

Homework: The following rules apply to homework:

1. You are encouraged to work individually or in small groups (up to 3 students per group) to discuss concepts and approaches to solving problem sets.
2. If you use any sources other than class notes or your own original ideas, you must cite the source(s).
3. Every student must write/type their own homework solutions and associated computational code based on their own understanding of the problems.

Violation of these guidelines is a violation of the GT Honor Code.

Learning outcomes: Students will gain experience in (i) reading primary literature & presenting and interpreting data; (ii) developing standalone MATLAB code to represent multi-scale biological dynamics; (iii) connecting theoretical principles with experimental data. These

Attendance: Regular attendance in lectures is required – most lectures will include some component of group work and problem solving. Exceptions will be accepted for valid, documented reasons only, including medical or other emergencies.

Academic Integrity: Students are reminded of the obligations and expectations associated with the Georgia Tech Academic Honor Code and Student Code of Conduct, available online at:
http://www.deanofstudents.gatech.edu/integrity/policies/honor_code.php
http://www.deanofstudents.gatech.edu/codeofconduct.
Any violations will be reported directly to the Dean of Students.

Additional Resources:

- Office of Disability Services – http://disabilityservices.gatech.edu/
- T-Square — http://tsquare.gatech.edu

Updates: This syllabus is subject to modification. Any changes will be announced in class and posted on the course website.

Schedule of Topics

Introduction

Week 1: Introduction
Quantitative Models and the Biosciences (in-class discussion)
Intro to MATLAB

Unit 1: Molecular and cellular biology

Week 2: Analysis of Fluctuations I – the nature of mutations
Week 3: Bistability and gene regulation
Week 4: Analysis of Fluctuations II- noise and gene expression
Week 5: Neutral theory of molecular evolution
Week 6: Sequence analysis and comparisons

Unit 2: Organismal behavior and physiology

Week 7: Robustness and homeostasis – examples from chemotaxis
Week 8: Spikes from Hodgkins and Huxley and beyond
Week 9: Pacing and synchronization in the beating heart
Week 10: Locomotion on land, air and sea

Unit 3: Ecology and earth systems

Week 11: Predator-prey dynamics from Lotka-Volterra to the present day
Week 12: Cooperation and conflict in groups
Week 13: Spatial groups and flocks
Week 14: Lorenz model and climate

Wrapping up

Week 15: In-class preparation for final presentations (in the computer lab)
Week 16: Final presentations