Foundations in Quantitative Biosciences (BIOL 6750 / PHYS 6750)

Course Syllabus – Fall 2026

Instructor Information

Instructor: Peter Yunker

Office Location: 333 Cherry Emerson

Email: peter.yunker@gatech.edu

Office Hours: Thursdays 11:00am–12:00pm and by email to schedule

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Class Meetings

- **Lectures:** Monday/Wednesday 11:00am–12:15pm
- **Computational Lab / Recitation:** Friday 12:30pm–3:15pm

Course Description and Topics

This course introduces quantitative methods central to foundational and emerging advances in the biosciences, spanning multiple scales of organization from molecules and cells to organisms, populations, and ecosystems. The course is organized around three major thematic units:

1. Molecular and cellular biosciences
2. Organismal behavior and physiology
3. Ecology and earth systems

Readings will include foundational and recent papers that exemplify how quantitative reasoning and modeling enable biological discovery.

Special readings will be posted on Canvas:

Prerequisites

- Enrollment in the PhD program with a Major in Quantitative Biosciences, or Biology or Physics PhD programs; **or**
- Permission of the instructor, contingent upon demonstrated prior coursework in mathematical methods, including differential equations.

Course Overview

The course is organized around key advances in the biosciences where progress depended critically on quantitative methods and reasoning. For each topic, we will discuss both foundational advances and current challenges. Each week, students will be exposed to:

- Methods for developing and analyzing quantitative models
- Logical reasoning under uncertainty in biological systems
- Computational techniques to implement and analyze stochastic and dynamical models that connect mathematical formalism with biological data

The overarching goal is to train graduate students to reason quantitatively about biological systems in the presence of uncertain mechanisms, parameters, and measurements.

Course Format

Three hours per week are devoted to lectures, divided among traditional lectures, in-class problem solving, and group discussions. Students will regularly work in small cooperative groups of three to four participants.

Assigned readings must be completed prior to the first lecture of each week and will serve as the basis for in-class discussion.

In addition, a weekly two- to three-hour computational recitation/lab will focus on computational methods that prepare students for homework assignments.

Software

Homework assignments require:

- Mathematical analysis
- Computational implementation using MATLAB or Python

Python is freely available. MATLAB is available to all Georgia Tech students at no charge. For details, see:

Grading Scheme

- Homework: **60%**
- Final presentation: **15%**
- Final paper: **15%**
- Class participation: **10%**

Final course grades are awarded on an A–F scale, with no +/- grades.

Final Project

- **Project proposal due (midterm):** approximately November 13, 2026
- **Final presentations:** during the last week of classes (in lieu of a final exam)
- **Final paper due:** on the scheduled final exam date

Additional details and expectations will be provided later in the semester.

Homework Policy

- Students are encouraged to discuss concepts and approaches in small groups (up to three students per group).
- Any sources beyond class notes and original ideas must be cited.
- Each student must independently write their own homework solutions and develop their own computational code based on their understanding.

Violation of these rules constitutes a violation of the Georgia Tech Honor Code.

Learning Outcomes

By the end of the course, students will have gained experience in:

- Reading, presenting, and interpreting primary scientific literature

- Developing standalone computational code for multi-scale biological dynamics
- Connecting theoretical principles with experimental and observational data

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Attendance

Regular attendance is required. Most lectures involve group work and problem solving, making participation essential. Exceptions will be granted only for valid, documented reasons (e.g., medical or other emergencies).

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. Review Georgia Tech's Honor Code and the student Code of Conduct.

Any student suspected of cheating or plagiarism 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 Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services (404-894-2563) 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.

Student-Faculty Expectations Agreement

At Georgia Tech, we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. The Student-Faculty Expectations articulate some basic expectations that you can have of me and that I have of you. 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.

Updates

This syllabus is subject to modification. Any changes will be announced in class and posted on Canvas.

Schedule of Topics (Fall 2026)

Introduction

Module 1: Introduction

Quantitative Models and the Biosciences (in-class discussion)

Introduction to MATLAB and Python

August 17, 19, 21

Unit 1: Molecular and Cellular Biology

Module 2: Analysis of Fluctuations I – The Nature of Mutations

August 24, 26, 28

HW 1 due **September 4**

Recitation material: Probability distributions

- **September 7:** No class (Labor Day)
- **September 9:** Catch-up day
- **September 11:** Lab as usual

Module 3: Bistability and Gene Regulation

September 14, 16, 18

HW 2 due **September 25**

Recitation material: Stability analysis

Module 4: Analysis of Fluctuations II – Noise and Gene Expression

September 21, 23, 25

HW 3 due **October 2**

Recitation material: Gillespie algorithm

Module 5: Neutral Theory of Molecular Evolution

September 28, 30, October 2

HW 4 due **October 9**

Recitation material: Markov chains

Unit 2: Organismal Behavior and Physiology

Module 6: Robustness and Homeostasis – Chemotaxis

October 5, 7, 9

HW 5 due **October 23**

Recitation material: Enzyme kinetics

- **October 12:** No class
- **October 14:** Catch-up day
- **October 16:** No lab

Modules 7 & 8: Spikes from Hodgkin and Huxley and Beyond

October 19, 21, 23

HW 6 (covers this and next module) due **October 30**

Recitation material: Fast–slow dynamics

Modules 7 & 8: Pacing and Synchronization in the Beating Heart

October 26, 28, 30

HW 6 due **October 30**

Recitation material: Limit cycles

Unit 3: Populations and Communities

Module 10: Predator–Prey Dynamics (Lotka–Volterra to Present)

November 2, 4, 6

HW 7 due **November 13**

Recitation material: Adaptive dynamics

Abstract statement due **November 13**

Module 11: Outbreaks – Forecasting, Control, and Prevention

November 9, 11, 13

Optional HW 8 due **November 20**

Recitation material: Stochastic model–data fitting

Module 12: Cooperation and Conflict in Groups

November 16, 18, 20

Recitation material: Nash equilibria

Unit 4: Final Projects and Beyond

Module 13: Project Support (In-Class, Required)

November 23, 25 (No class Wednesday **November 25**)

Recitation material: Project support

- **November 30:** Final project consultations (in-class, optional)
- **December 1:** Final project presentations begin