BIOL 2400: Mathematical Models in Biology

Fall Semester 2008, 3 credits
T/Th 1:35 – 2:55 pm
204 Cherry Emerson

Instructors

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Overview

This is an active-learning class that explores mathematical models from several domains in biology, including epidemiology, ecology, and evolution. The course is built around a series of assignments that introduce students to:

techniques such as rapid prototyping, sensitivity analysis, evaluation of trade-offs, and modeling as a form of communication;
software such as Microsoft Excel, to support a thorough understanding of the
concepts and practices of stochastic and dynamic modeling using mathematics as a structural and logical tool.

Prerequisites

One year of calculus (differential and integral) and one year of biology are required for the course. We assume you are comfortable with basic use of Microsoft Excel. Familiarity with simple probability and statistics concepts (probability distributions, t-tests, simple linear regression) is helpful but neither assumed nor required.

This is not a course in probability and statistics, nor does it require extensive mathematics. We will use some differential and integral calculus, simple matrix algebra and linear algebra, and simple statistical analysis as needed. We will teach you the mathematics and software implementation that you need for the course.

Learning Objectives

By the end of the course, you will develop several skills that will serve you as a scientist and responsible citizen, no matter what profession you choose. These skills include:

1. Graphically and verbally representing vague problems.
2. Quantitative representation of hypotheses (equations).
3. Basic model analysis: simulation, equilibria, stability, assumptions, sensitivity analysis, validation.

4. Modeling stochastic processes.
5. Communicating model results targeted to your audience, in the most economic and efficient ways possible.

Instructional format

Three hours each week are scheduled for the class. Class time will be approximately equally divided among short "mini-lectures" and group problem-solving exercises or discussions.

The course is designed around students formulating and solving problems in small cooperative groups. The following rules apply to all group work:

1. Everyone is responsible for making sure that all group members contribute.
2. Assist each other in understanding the material and in developing skills such as translating scenarios to equations, using computer software, writing model reports, and designing figures and tables.
3. Each group will prepare a joint (single) report. Each member of the group should sign the report, thereby indicating agreement with the group's conclusions, contribution to the report, and understanding of its contents. If you use any sources other than class notes or your own original ideas, you must cite the source(s). Violation of this policy is a violation of the GT Honor Code.
4. You will work collaboratively with other members of your group, but collaboration between or among groups is not authorized, whether on the conceptualization, development, interpretation, or write-up of the homework. Violation of this policy is a violation of the GT Honor Code.
5. You may not discuss your peer evaluations (described below) with any classmate at any time. Violation of this policy is a violation of the GT Honor Code and will result in a failing grade for that assignment.

Some class days will be devoted to in-class modeling exercises. These days will be announced at least one class in advance. You are invited and encouraged to bring laptop computers to class to work on these problems.

Course policies and assignments

Group work: Because of the heavy emphasis on group work, it is important that you attend each and every class, that you be on time, and that you stay for the entire class period. Each student in a group will earn the same grade for the group's work. Peer evaluations will be submitted with each group assignment and may be used to adjust an individual's grade on the assignment. More details will be provided with the first assignment.

Participation: There will be short, in-class exercises that will constitute part of your participation grade. These will assess your comprehension of recent lecture material and can take place in any class period.

Insights assignments: These short weekly reflections will be turned in on T-square. We will provide more details in class.

While much of your work will be in collaborative groups, *Insights* assignments and the midterm examination are individual assignments. You may not collaborate with anyone inside or outside of the class on these. Any violations of the GT Honor Code will result in referral to the Office of Student Integrity and penalty ranging from no credit for the assignment in question, to a grade of "F" for the class. We don't want to see you fail, and we will be glad to answer questions about class activities and the Honor Code.

Important: In-class use of cell phones or computers for purposes unrelated to course activities is not allowed.

Evaluation

Regular assignments (homework)	40%
Class participation (comprehension exercises)	10%
Mid-semester examination (~ 10/9/08)	20%
Final (group) project	30%

Final grades will be on the traditional 90-80-70 scale.

Text and Software

Adler, Frederick R. 2005. Modeling the Dynamics of Life: Calculus and Probability for Life Scientists. Thomson/Brooks & Cole: Belmont, CA (available in bookstore).
Other short papers, as assigned.
Microsoft Excel (Windows 2000/Windows XP/Mac OS X)

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 to directly to the Dean of Students.

Learning Accommodations: If needed, we will make classroom accommodations for students with disabilities. These accommodations must be arranged in advance and in accordance with the ADAPTS office (http://www.adapts.gatech.edu).

Additional Resources:

- Tsquare — http://tsquare.gatech.edu
- Tech Tutoring — http://www.undergradstudies.gatech.edu/supportTutoring.htm

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

Biol 2400 Schedule of Topics and Assignments

Note: The schedule is subject to modification. Additional readings from the primary literature and from other textbooks will be handed out in-class and posted on T-square.

I. Introduction to Modeling in Biology
Readings: Adler 1.1-1.3
19-Aug Course overview
21-Aug What is a model good for in biology?

II. Models in Time
Readings: Adler 1.5-1.7
26-Aug Dynamics of individuals & populations
28-Aug Dynamics of individuals & populations

Readings: Adler 3.1-3.2, 4.1
2-Sep Dynamics of individuals & populations
4-Sep Disease dynamics

Readings: Adler 5.1-5.3
9-Sep Disease dynamics
11-Sep Disease dynamics

III. Chance in Biology
Readings: Adler 6.1-6.3
16-Sep Probability in biology
18-Sep Probability in biology

Readings: Allman and Rhodes (to be announced)
23-Sep Sequence evolution
25-Sep Sequence evolution

IV. Reasoning with Data
Readings: Adler 8.1, 8.3-8.5
30-Sep Statistical reasoning
2-Oct Statistical reasoning

V. Projects, Exams, Break & Review
7-Oct Final project groups and topic ideas
9-Oct Midterm exam
14-Oct Fall Break - no class
16-Oct Midterm review & thinking about models

VI. Strategic Thinking in Biology
Readings: Adler 6.4 and TBA
21-Oct Game theory
23-Oct Game theory

Readings: Adler 5.4-5.7
28-Oct Game theory
30-Oct Animal behavior

Readings: TBA
4-Nov Animal behavior
6-Nov Animal behavior

VII. Models in Space
Readings: Adler 3.3
11-Nov Spatial models
13-Nov Spatial models

Readings: TBA
18-Nov Biological networks

VII. Final Project Focus
20-Nov In-class modeling day
25-Nov Guest presentation: "Scaling in Biology"
27-Nov Thanksgiving

2-Dec Final Project Presentations
4-Dec Final Project Presentations

Your final project replaces the final exam.