**BIOS 2400: Mathematical Models in Biology**

Spring Semester 2018, 3 credits TuTh 9:30 – 10:45am Location: Cherry Emerson 320

# Instructors

Dr. **Sam Brown**

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# Teaching Assistants

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* Office hours: Friday 1-3pm & by appointment

# Overview

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

* *Techniques* such as sensitivity analysis, solving for equilibria, evaluation of trade-offs, and how to formulate verbal arguments into quantitative models.
* *Computational simulations* using online software applets, and Microsoft Excel
* *Exercises* that support a thorough understanding of the concepts and practices of stochastic and dynamic modeling.

# Prerequisites

Integral Calculus (MATH 1552 or MATH 1555), Linear Algebra (MATH 1553), and Biological Principles [BIOS 1107 and (1107L or 1207L) or BIOL 1510 or BIOL 1511]. We assume you are comfortable with basic use of Microsoft Excel. Familiarity with simple probability and statistics concepts 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 statistics as needed. We will teach you the mathematics and software implementation that you need for the course. *This course fulfills the Quantitative Biology requirement for the B.S. in Biology at Georgia Tech.*

# 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 which profession you choose. You will develop the skills to:

1. Graphically and verbally represent vague problems.
2. Represent hypotheses quantitatively.
3. Analyze models with basic techniques: simulation, equilibria, stability, assumptions, sensitivity analysis, validation.
4. Model stochastic processes.
5. Communicate model results in in written, graphical, and verbal forms to a target audience, combining mathematical concepts and textual or oral explanations of the model results.

# 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. Students will assist each other in understanding the material and in developing skills such as translating scenarios to equations, using computer software, and designing figures and tables.
3. Because of the heavy emphasis on group work, it is important that you attend each and every class, that you arrive on time, and that you stay for the entire class period.

Some class days will be devoted to in-class computer modeling exercises. These days will be announced at least one day in advance. You will be asked to bring laptop computers to class to work on these assignments (it's a good idea to bring a laptop computer to class "just in case").

# Course policies and assignments

***Participation***: There will be frequent in-class exercises that will constitute part of your participation grade. These will assess your comprehension of lecture material and can take place in any class. If you are unable to attend class due to illness or another type of excused absence, please email the course instructors. Important: in-class use of cell phones or computers for purposes unrelated to course activities is not allowed.

***Take-home exams***: There will be two non-cumulative take-home exams. Think of these exams as rigorous homework assignments. Hard copies of your answers will be due at the beginning of class on 2/22 and 3/38. In addition, .pdf versions of your answers will need to be uploaded to T-square. If you use any sources other than class notes or your own original ideas, you must cite these sources (use standard formatting as per scientific journals). Students are allowed to research their answers over the internet and discuss questions with other members of class (science is collaborative after all). However, take-home exams must represent the work of individual students. In other words, make sure that your answers are your own. Violation of these policies will be in violation of the Georgia Tech Honor Code. *Late take-home exams* will be accepted up to 4 days late, with 15% deducted per 24-hour period that it is late.

***In-class exams***: There will be two non-cumulative in-class exams. Exams will represent the work of the individual and no collaboration or outside resources (notes, textbook, internet) will be permitted during the examinations.

***Group Project***: The last unit of the course will focus on a project that you will develop in groups of 2- 3 students. You will be able to choose a biological problem from a common theme, identify a specific goal, and create a mathematical model to accomplish that goal. Each group will give an oral presentation during the final exam period. Each student in a group will earn the same base grade for the group’s presentation. Confidential peer evaluations will be submitted and may be used to adjust an individual’s grade on the project. You may not discuss your peer evaluations with any classmate at any time.

***Policy on late assignments and missed exams:*** Late assignments will be penalized by 10% per day. There will be no make-up exams. Excused absences for these must be Institute-approved or excused by the Dean of Students. Excused missed assessments will be replaced by the weighted average of your other assessments.

# Evaluation

* Class participation (in-class exercises) 20%
* Take-home exams (2) 30%
* In-class exams (2) 30%
* Group Project 20%

# Resources

* *A Biologist's Guide to Mathematical Modeling in Ecology and Evolution* by S Otto and T. Day (this textbook not required, but it is a fantastic introduction to the subject)
* Short papers and book excerpts, as assigned
* Online software applets
* T-square: [http://tsquare.gatech.edu](http://tsquare.gatech.edu/)
* Microsoft Excel (Windows or Mac OS X)

# 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 Office of Disability Services (http://disabilityservices.gatech.edu).

# Academic Integrity

Although you are allowed to discuss questions to take-home exams with your classmates, it is important that you submit your own work. There is a zero-tolerance re: plagiarism. If you have any questions about what constitutes plagiarism, please email the course instructors. 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://policylibrary.gatech.edu/student-affairs/academic-honor-code> <http://policylibrary.gatech.edu/student-affairs/code-conduct>

Any violations of the Georgia Tech Honor Code will result in referral to the Office of Student Integrity with a 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.

# Schedule

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| --- | --- | --- |
| Feb 22 | In-class exam #1 |  |

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| Mar 13 to Mar 15 Individual based models | | Take home exam #2 due 3/27 |  |
| Mar 20 to Mar 22 | *SPRING BREAK* | – | |

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| Apr 19 | In-class exam #2 |  |

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| May 1 | Presentations of group projects |  |

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

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| Jan 23 to Jan 24 Interactions | Take home exam #1 due 2/1 |  |

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| **Spring 2015** | **Topic** | **Assignment** |
| Jan 9 to Jan 11 | Introduction to modeling |  |
| Jan 16 to Jan 18  Jan 30 to Feb 1 | Population growth  Probability |  |
| Feb 6 to Feb 8 | Genetic drift |  |
| Feb 13 to Feb 15 | Natural selection |  |
| Feb 20  Feb 27 to Mar 6 | Project workday  Equilibria |  |
| Mar 8 | Project workday |  |
| Mar 27 to Mar 29 | Infectious diseases |  |
| Apr 3 to Apr 5 | Game theory |  |
| Apr 10 to Apr 12 | Spatial models |  |
| Apr 17  Apr 24 | Project Workday  Project Workday |  |