Mathematical Biology Math 258 Fall 2011

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TTh, 1:10-2:30 PM, Hayes 311

Office Hours:
Monday 10-12 am
Tuesday 2:30-4:30
Wednesday 10-12 pm
Also By Appointment

Required Text
Allman & Rhodes. *Mathematical Models in Biology: An Introduction*. Cambridge.

Supplemental Texts (I will use passages from the following…)
Zuur et al., *A Beginner's Guide to R,* Springer.
Hastings, *Population Biology: Concepts and Models.* Springer.
Kokko, *Modelling for Field Biologists and Other Interesting People*. Cambridge.
Stevens, *A Primer of Ecology with R,* Springer.

General Course Goals and Expectations
Mathematical approaches are becoming increasingly important in all areas of biology, from gene regulation to species conservation. However, the perception persists that while math is essential in the physical sciences, biologists don't need mathematical tools and biology does not present significant challenges or applications for mathematicians. This course is designed to change that perception, by introducing substantive examples of mathematical models and applications in biology without requiring an extensive background in both subjects.

Through this course you will learn to:
1. Formulate and use mathematical models describing diverse biological phenomena, from base pair substitution in DNA sequences to the spread of epidemics. The goal is to answer biologically relevant questions using a variety of mathematical approaches.
2. Understand the utility and limitations of various modeling approaches, and critically assess existing models in the primary literature.
3. Develop or hone the computational skills necessary for a mathematical biologist. (No computing experience is assumed.)

These skills will be achieved through lectures, readings, lab projects, homework problems, and the development and presentation of independent original research. As a student, you need only a *basic* background in biology (Biol 115, 116 or equivalent) and mathematics (Math 111, 106 or equivalent), a strong interest in developing a *scientific and quantitative* understanding of how nature works, and a desire to *participate* in the learning process. As the instructor, I will give focus to our studies, assist you in attaining your own understanding of the subject, and provide both formal and informal feedback and mentorship. **Our roles require that all of us come to class sessions prepared.**

Course Outline and Calendar (subject to change…)

Week	**Topics and Activities**	**Readings**
0	Course overview and discussion	
8/30 – 9/1	Software orientation. Begin population growth. Difference equations	Allman and Rhodes Ch. 1.1 – 1.2
9/6 – 9/8	Continuous vs. Discrete Growth, Density Dependence. Differential Equations	Allman and Rhodes Ch. 1.3 – 1.4, Hastings Ch. 4
9/13 – 9/15	Structured population growth. Matrices. Eigen analysis.	Allman and Rhodes Ch. 2. Hastings Ch. 2
9/20 – 9/22	Predator-Prey & Host-Parasite Interactions. Phase planes. Equilibria.	Allman and Rhodes Ch. 3 Hastings Ch. 6, 8, 9
9/27 – 9/29	Other dynamical models. Physiology.	Allman and Rhodes Ch. 3
10/4 – 10/6	**Midterm 1 (10/4). October Break (10/6)**	
10/11 – 10/13	Molecular genetics. BP substitution. Probability.	Allman and Rhodes Ch. 4
10/18 – 10/20	Markov Chains. Jukes-Cantor and Kimura Models	Allman and Rhodes Ch. 4
10/25 – 10/27	Phylogenetic Distance and Tree Reconstruction.	Allman and Rhodes Ch. 5
11/1 – 11/3	Phylogenetic Trees – Alternative methods	Allman and Rhodes Ch. 5
11/8 – 11/10	Population Genetics. Selection.	Allman and Rhodes Ch. 6 Hastings Ch. 3
11/15 – 11/17	Genetic and Ecological Drift – **Midterm 2 (take home)**	Allman and Rhodes Ch. 6 Stevens Ch. 10
11/22 – 11/24	**Thanksgiving Break**	Allman and Rhodes Ch.7; Hastings Ch. 10
11/29 – 12/1	Infectious disease and Epidemiology SIR models.	Allman and Rhodes Ch. 7 Hastings Ch. 10
12/6 – 12/8	Evolutionary Strategies and Games **Research Colloquium:** Poster presentations	Kokko Ch. 6-7, Hastings Ch. 3
12/12	**Final Exam: Dec. 12, 8:30 – 11:30 am**	

Grades
Your course grade will be based on the following categories and their respective weights.

Attendance, Participation, and Enthusiasm (5%)
Homework (15%)
Final Project and Poster Presentation (20%)
Two Midterms (20% each)
Comprehensive Final (20%)

Homework
Homework problems will generally be assigned on a weekly basis, accompanying course readings. Collaboration on homework problems is encouraged but you must acknowledge the effort of your colleagues. Homework problems will be evaluated on a three point scale: 3=complete and correct, 2=good faith effort, 1=poor effort, 0=no effort.

Research Projects and Poster Presentations
You will conduct an independent research project on the topic of your choice. Generally, projects will be entail selecting a mathematical model from the primary literature, recreating ***some*** of the published results to demonstrate understanding of the model, then ***extending the model*** (if possible) to address a new perspective or biological question. At the end of the semester, you will present your research in the form of a poster at a Research Colloquium open to the faculty and students of the Biology and Mathematics Departments. I will evaluate both the mathematical and the biological quality of the research, as well as the quality of the poster and presentation.

Exams
The midterms and final exams cover all material, both in the readings and in the lecture. Questions will emphasize critical thinking about biological processes and model structure, applying mathematical modeling principles in new problem-solving contexts, and interpreting model output in a biological context. The first midterm will cover population growth, dynamics, and interactions. The second midterm will cover genetics, phylogeny, and evolution. The final will be approximately 1/3 new material (epidemiology and a bit of evolutionary game theory) and 2/3 comprehensive.

Attendance Policy
Class attendance is mandatory and accumulating unexcused absences will negatively affect your grade. Please contact me **before** you miss a class. At the same time, if you are sick, please stay home; just contact me, and the health center. If you are an athlete or a member of another organization that travels, it is **your responsibility** (not your coach's or advisor's) to make arrangements with me concerning missed classes **well in advance.** Failure to do so will result in unexcused absences. Coursework missed due to unexcused absences may not be made up.

Late Policy
Assignments must be turned in at the beginning of the class period on the assigned due date. If for any reason you cannot turn in your paper on the assigned date, you must contact me before class. If you are unable to visit me in person, you can leave a message via voicemail (427-5734) or e-mail (kerkhoffa@kenyon.edu). **Work that is late due to unexcused absence will decay at a rate of 1/3 grade (~3.5%) per day.**

Academic Honesty
Acquaint yourself with Kenyon's policy on academic honesty, printed in the *Student Handbook*. Adherence to standards of academic honesty is the responsibility of the student. If you have any questions or are unsure of appropriate conduct, please contact me.

Accommodating Disabilities
If you feel that you may have need for some type of accommodation(s) in order to participate fully in this class or to take exams, please feel free to discuss your concerns with me in private. Also identify yourself to Erin Salva, Coordinator of Disability Services at 427-5453 or via e-mail at salvae@kenyon.edu. All information is confidential.