BIOL 2400: Mathematical Models in Biology

Fall Semester 2006, 3 credits

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Text and Software

Britton, Nicholas F. 2003. Essential Mathematical Biology. Springer-Verlag, London. *Available in the bookstore.*

Other short papers, as assigned.

Microsoft Excel (Windows 2000/Windows XP/Mac OS X) and Populus (free download for Windows 2000/Windows XP/Mac OS X/Linux), available at http://www.cbs.umn.edu/populus/Download/download.html. These software packages are also installed on the Biology Computer Lab computers.

Overview

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

techniques such as rapid prototyping, sensitivity analysis, evaluation of trade-offs, risk analysis, and modeling as a form of communication;

software such as Microsoft Excel, Populus, and potentially Mathematica, to support a thorough understanding of the

concepts of stochastic and dynamic modeling using mathematics as structural and logical tools.

Instructional format

Three hours each week are scheduled for the class. While there will be some individual assignments, the course is designed around students formulating and solving problems in small cooperative groups of three or four. Group members will shuffle for each assignment. 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, and writing.

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. Under no circumstances may you use web-based or Internet sources, except where explicitly prescribed. 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 writeup of the homework. Violation of this policy is a violation of the GT Honor Code.

Class participants will define other guidelines for group work during class on Friday, 25 August. The space below is intended for you to make note of those guidelines on which the class agrees.

Course policies

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. Part of your project grade will be determined by self-evaluation and evaluation from other group members.

All grading disputes must be settled within one week of the assignment's or exam's return date.

While much of your work will be in collaborative groups, insights 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.

Evaluation

Regular assignments (insights, modeling exercises)	50%
Mid-semester examination (Friday, 10/13/2006)	20%
Final (group) project	30%

Schedule of Topics and Assignments (subject to modification)

WEEK OF	TOPIC	READING	ASSIGNMENT
8/21	What is a model? Heuristics and mathematics in models	May, R. M. 2004. Uses and abuses of mathematics in biology. Science 303: 700-793. (distributed in class)	
8/28	Bacteria take over the world: single-species population models		Populus exploration due 8/28; Insight 1 due 9/1
9/4	Unexpected consequences of eating and being eaten: interacting species models		Model 1 due 9/4; Insight 2 due 9/8
9/11	How do you model a mess? Strategies from metapopulations and ecosystems	Scheffer, M., S. R. Carpenter, J. A. Foley, C. Folke and B. Walker (2001). Catastrophic shifts in ecosystems. Nature 413: 591-596. (available online through GT Library e-journals)	Insight 3 due 9/15

WEEK OF	TOPIC	READING	ASSIGNMENT
9/18	In sickness and health: infectious disease models; models of other contagious processes		Model 2 due 9/18; Insight 4 due 9/22
9/25	How do diseases persist? Macroparasites; virulence; selection		Insight 5 due 9/29
10/2	Let's play a game: Selection, game theory		Insight 6 due 10/6
10/9	How to make something small move		Model 3 due 10/9; Midterm exam 10/13; Insight 7 due 10/13
10/16	More small movement (*no class Monday; Fall Recess*)		Insight 8 due 10/20
10/23	Microscopic networks		Insight 9 due 10/27
10/30	From chaos, order: Turing		Model 4 due 10/30; Insight 10 due 11/3
11/6	"Real-world" examples of models: Monk seals and slime mold	Starfield, A. M., J. D. Roth, and K. Ralls. 1995. "Mobbing" in Hawaiian monk seals: The value of simulation modeling in the absence of apparently crucial data. Conservation Biology 9: 166-174. Ralls, K. and A. M. Starfield. 1995. Choosing a management strategy: Two structured decision-making methods for evaluating the predictions of stochastic simulation models. Conservation Biology 9: 175-181. (both distributed in class)	Insight 11 due 11/10
11/13	How to Build a Model: Quasispecies and climate warming	Rupp, T. S., A. M. Starfield, and F. S. Chapin, III. 2000. A frame-based spatially explicit model of subarctic vegetation response to climate change: Comparison with a point model. Landscape Ecology 15: 383-400. (available online through GT Library e-journals)	Insight 12 due 11/17

WEEK OF	TOPIC	READING	ASSIGNMENT
11/20	Now what do I do with it? Modeling models and choosing among them (*no class Friday; Thanksgiving*)		(No insights due this week)
11/27	Modeling real-world complexity: from the origins of life to economics		Insight 13 and comprehensive collection of insights due 12/1
12/4	You're the Experts: Presentation of Final Projects		
12/11	No lectures; Finals Week		Final project write-up due Tuesday, December 12, 5:00 pm