Syllabus: Dynamics of Biological Systems II: Tools for Mathematical Biology (Biol. 306), Fall 2011

The purpose of models is not to fit the data but to sharpen the questions.
–Samuel Karlin, 11th R.A. Fisher Memorial Lecture, Royal Society, 1983.

Course Description

Building on the material in Biology 300, this course focuses on the mathematical tools used to construct and analyze biological models, with examples drawn largely from ecology but also from epidemiology, developmental biology, and other areas. Analytic "paper and pencil" techniques are emphasized, but we will also use computers to help develop intuition. By the end of the course, students should be able to recognize basic building blocks in biological models, be able to perform simple analysis, and be more fluent in translating between verbal and mathematical descriptions.

Prerequisite: Biology 300 or MATH 224 or MATH 228 or consent of instructor.

Course Objectives

- To master basic techniques used in the modeling of biological systems
- To become more fluent in translating biological ideas into mathematical models and mathematical expressions into their biological meanings
- To develop intuition about dynamical behavior

Instructor

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Office hours

Tues., 11:15–12:15, Wed., 4:30–5:30. During the semester I am happy to meet with anyone enrolled in this course. I would like especially to meet with students with disabilities who are registered with the Coordinator of Disability Services (368-5230) and who may need individual arrangements.

Textbooks

- Selections from *Ecological Dynamics*, W.S.C. Gurney and R.M. Nisbet, Oxford University Press, New York, 1998; *Mathematical Models in Biology*, Leah Edelstein-Keshet, SIAM, 2005; *Matrix Population Models, 2nd ed.*, Hal Caswell, Sinauer Associates, Sunderland, MA, 2001; *Dynamic Models in Biology*, Stephen P. Ellner and John Guckenheimer, Princeton University Press, 2006. These will be sold as a course reader.

Course outline

- Discrete time models
  - One-species models, including equilibrium and stability
  - Stage-structured models, including an introduction to matrix algebra, finding the stationary stage distribution, and sensitivity and elasticity analyses
- Continuous time models
  - One-species models
  - Two-species models, including equilibrium and stability
- Diffusive movement
  - Random walks and diffusion
  - Spread rates and the influence of geometry
  - Reaction-diffusion equations: steady states, and traveling waves
- If we have time: topic(s) based on student interest and instructor competence. Past topics have included game theory and spectral analysis.

Assessment

Mathematics is a language, and like any other language, you can't really learn it if you aren't using it. I'll be giving you weekly problem sets so that you can practice your skills. Homework is due at the beginning of class, and 10% will be subtracted for every day that homework is late. Some of your grade will also come from class participation. Research shows that students learn better when they're asked to actively grapple with new information instead of passively receiving it. Class is also more fun if I'm not the only one talking. Accordingly, we'll be doing some in-class exercises and I'll be asking for questions, intuitions, insights, and wild speculation as we develop new models—I expect everyone to join in. In lieu of midterms and finals, there will be a modeling project based on a published paper of your choice. I encourage you to help each other with the homework and the modeling projects, but the final product should be your own, and, just as with a published paper, any interactions with each other that you find helpful should be acknowledged in an "Acknowledgements" section. (Yes, I expect to see acknowledgement sections for problem sets as well as the modeling projects.)

Homework (problem sets): 60%
Modeling project: 40%

For the project, the anaylsis will count for 75% of your grade and the quality of the writeup (including grammar, sentence structure, organization, etc.) will count for 25%.

Modeling project

In lieu of midterms and a final, you will each do a modeling project. For this project, you will reproduce the analysis of part of a published paper (filling in the missing steps, so to speak), extend the model in some way, and write a short paper presenting your work. Your write up should explain the model (what's being modeled? what assumptions were made? what do the equations mean?) and present your analysis of both the original model and your extension in a clear, logical fashion. Ultimately, scientific work needs to be communicated and understood in order to be valuable, so the clarity of your presentation will contribute to your grade. While I encourage you to help each other with the modeling project, the papers must be your own work.

We'll start the projects after we've covered a sufficient amount of material in class, so I'll let you know about dates as classes progress.

> *Que nous sert-il d'avoir la panse pleine de viande si elle ne se digère? Si elle ne se transforme en nous? Si elle ne nous augmente et fortifie? –Michel Eyquem de Montaigne*
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> *(What use is it to have a belly full of meat if it is not digested? If it does not transform itself within us? If it does not augment and strengthen us?)*