BIO 480/680 – Introduction to Biological Modeling

Course Syllabus

Instructor: Paul J. Schulte, WHI-308, 895-3300, paul.schulte@unlv.edu. Office hours: After each lecture or contact by email to arrange other times.

Text: Haefner, James W. 2005. Modeling Biological Systems: Principles and applications, 2nd ed. Springer. This text is available online through the UNLV library.

Course description: This course will present an introduction to the use of mathematical models for studying biological processes and systems. Modeling will be developed as an additional or alternative experimental approach for studying biology. We will consider the usefulness of modeling as well as the associated pitfalls. Models will often be expressed as one or more mathematical equations, with solutions obtained through computer programs. Although some of the models will use previously developed software, students will also develop the ability to write simple computer programs for modeling. (3 credits)

Additional resources: Students in the course have the option to take advantage of material available through the internet. The course has a web page accessible with a web browser:

https://faculty.unlv.edu/schulte/BIO480/

This page contains project handouts, downloadable software, and other useful resources.

Specific Learning Objectives: Upon successful completion of this course, students should be able to:

- Provide a broad definition of models as used to describe biological processes.
- Explain the modeling process from model formulation to testing.
- Describe in detail a range of models from population biology.
- Demonstrate an understanding of models based on single or systems of ordinary differential equations.
- Discuss and implement solutions methods for differential equation based models.
- Explain numerical methods for equation solving.
- Discuss the nature of randomness in stochastic models of biological processes and build models incorporating random events.
- Explain the nature of chaotic systems and one implementation from population biology.
- Understand basic methods from bioinformatics as applied to sequence alignments.

- Develop simple programs utilizing the C programming language for solving all of the models outlined above.

Exams & Grading: There will be three lecture exams (including final). The first two exams will each count for 20% of the grade and the final will be 30% of the grade. We will not have lab exams, but a short report will be required for each weekly project. The total lab report contribution to the grade will be 30%. The final exam (unlike the first two exams) will be somewhat comprehensive in that it will concentrate on the material from the last third of the course but will include some general concepts from earlier parts of the course. There will be a small number of "low-impact" computer programming quizzes (only a few points) during the semester. Graduate students (BIO 680) will conduct an additional project (10% of the grade).

Class attendance: The course covers a lot of material and much of it will be new to you. There will be readings and handouts, but a lot of information is only presented and explained during lectures. The projects (not to mention the exams!) will be difficult to complete if you do not make every effort attend all of the lectures.

Project reports: These reports need not be very long (a few pages), but should include three main sections: (1) an Introduction with a brief description of the model(s) being studied that week, (2) a Results section with numerical data or graphs, and (3) a Conclusions section summarizing what was learned from the model about that particular biological system or process. For the projects where you write your own programs, a listing of the program should be included as an Appendix. Reports must be typed. These reports will be due at the end of the week following the lab; 1 point will be deducted for each week they are late.

Computer programming: For several of our exercises, we will write our own programs using the computer programming language C. Here are a few rules and suggestions for these activities:

- It is ok and sometimes useful to work with other students in the development of your programs. BUT, you must turn in your own program and project reports based on your own results and not some kind of shared copy of program, results, and/or report.
- Reviewing the programs of other students along with the sample programs available on the course web page can help you to learn programming and to develop the programs for our projects, but it will be essential that you understand the programs in terms of how they work and what each statement means - if you just copy and paste parts of sample programs or those of other students without understanding how it works and why, you will not learn programming!
- Sometimes students are tempted to get other people to write their programs for them – this is generally a bad idea, because you will not end up learning anything about writing programs yourself and you will not understand the ones you see in class or are asked about on an exam.

Academic Misconduct: Academic integrity is a legitimate concern for every member of the campus community; all share in upholding the fundamental values of honesty, trust, respect, fairness, responsibility and professionalism. By choosing to join the UNLV community, students accept the expectations of the Academic Misconduct Policy and are encouraged when faced with choices to always take the ethical path. Students enrolling in UNLV assume the obligation to conduct themselves in a manner compatible with UNLV's function as an educational institution.

An example of academic misconduct is plagiarism. Plagiarism is using the words or ideas of another, from the Internet or any source, without proper citation of the sources. See the *Student Academic Misconduct Policy* (approved December 9, 2005) located at: http://www.unlv.edu/studentconduct/misconduct/.

Copyright: The University requires all members of the University Community to familiarize themselves with and to follow copyright and fair use requirements. You are individually and solely responsible for violations of copyright and fair use laws. the university will neither protect nor defend you nor assume any responsibility for employee or student violations of fair use laws. The university will neither protect nor defend you nor assume any responsibility for employee or student violations of fair use laws. Violations of copyright laws could subject you to federal and state civil penalties and criminal liability, as well as disciplinary action under University policies. To familiarize yourself with copyright and fair use policies, you are encouraged to visit the following website: https://www.unlv.edu/provost/copyright.

Disability Resource Center (DRC)**:** The Disability Resource Center (DRC) coordinates all academic accommodations for students with documented disabilities. The DRC is the official office to review and house disability documentation for students, and to provide them with an official Academic Accommodation Plan to present to the faculty if an accommodation is warranted. Faculty should not provide students accommodations without being in receipt of this plan. UNLV complies with the provisions set forth in Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990, offering reasonable accommodations to qualified students with documented disabilities. If you have a documented disability that may require accommodations, you will need to contact the DRC for the coordination of services. The DRC is located in the Student Services Complex (SSC), Room 137, and the contact numbers are: Voice (702) 895-0866, TDD (702) 895-0652, fax (702) 895-0651. For additional information, please visit: http://drc.unlv.edu/.

Outline of Topics

Week	Topic
1	Introduction. What is a model? Why are models useful? Modeling approaches and pitfalls. (Haefner, Ch 1)
2	Programming for modeling (Intro to C language) Lab 1: Computers & programming intro. (Simple population model).
3	The modeling process (Haefner Ch 2) Lab 2: Logistic equation population growth.
4	Model development I - qualitative (Haefner Ch 3) Lab 3: Two-species interactions – Predator-Prey model.
5	**Exam I – 13 February.** Model development II - quantitative
6	Model development II - quantitative cont'd (Haefner Ch 4) Lab 4: Berkeley-Madonna program introduction
7	Compartment models Lab 5: Aquatic system model
8	Numerical methods I (Haefner Ch 6) Lab 6: Euler's method.
9	Numerical methods II (Haefner Ch 6) Lab 7: Root-finding methods.
10	Organism – Environment interactions Lab 8: Lizard energy budget.
	Spring break: 27 – 30 March
11	**Exam II – 03 April.** Stochastic models – random numbers (Haefner Ch 10) Lab 9: Computers and generating random numbers
12	Stochastic models cont'd (Haefner Ch 10) Lab 10: Random processes and population dynamics.
13	Chaotic systems in biology (Haefner Ch 18) Lab 11: Chaotic systems.
14	Computational genomics & proteomics (Haefner Ch 20)

Lab 12: Sequence alignment methods.

15 Artificial life simulations
Lab 13: Avida program.

Final exam – Tuesday 08 May, 6 – 8 PM (Graduate student project due)