Biological Sciences 295:
Quantitative Approaches to Biological Problems

NC State University
Spring 2018
Tuesdays and Thursdays 10:15-11:30
Location: 110 Cox Hall

Course Syllabus

INSTRUCTOR	OFFICE HRS
Dr. Gavin Conant (gconant@ncsu.edu) Assoc. Prof.; Biological Sciences 356 Ricks Hall	By appointment

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Course Content

This course serves as an introduction to the use of mathematical, statistical and computational models for understanding biology at the molecular, population, ecological and evolutionary scales. By the end of this course, you will be able to:

- Describe at least four uses of models in science:
- Give four examples of biological models and describe their mathematical form:
- Recognize the use of common mathematical frameworks to model very different biological systems.
- Give examples where accounting for stochasticity may be necessary for biologically meaningful predictions.
- Understand the idea of a model with unknown parameters that are inferred from experimental data
- Use computers and software for the analysis of biological data, including:
    - Excel
    - Perl
    - Mathematica
    - R/SAS
    - Linux
- Describe a simple biological system (like population growth) as a differential equation
- Test a simple biological hypothesis in terms of null and alternative statistical hypotheses
- Use Excel to computationally model and visually explore datasets

Course structure: The course mixes lectures/discussions with computer lab assignments/analyses. We will introduce and discuss a topic first, and then use the computational assignments to explore it in more depth.

Prerequisites

BIO 181 and MA 131 or equivalents.

Assignments and Grading

Your grade will be determined by your performance on two exams and on in-class/take-home assignments, broken down as follows:

- Exams (40%) – two exams, 20% each
- Weekly assignments (60%) – 1 per week, 5% each, with the lowest two dropped

I will not formally take attendance. However, you will not be able to complete the weekly assignments without attending class.

Exams (36%)

There will be three in-class exams, equally weighted at 12% each. The dates are listed in the syllabus. They will not be cumulative.

Assignments (60%)

Each week we will have a hands-on exploration of some aspect of modeling/computation/data analysis in biology. These assignments will have a range of formats (Excel, Mathematica, programming, statistical). You will submit your results electronically via Moodle. Some assignments will be due immediately at the end of lab, while others will be due the following week. No makeups will be given: instead you may drop your two assignments with the lowest scores (14 assignments, 12 counted, 5% each).

Course Grade

The total course grade is a weighted average, with the weights described above:

- 97-100: A+
- 92-96: A
- 90-91: A-/
- 87-89: B+
- 82-86: B
- 80-81: B-

- 77-79: C+
- 70-76: C
- 67-70: C-
- 60-67: D
- Below 60: F

Class Policies

Computer Resources

Course Moodle page: https://wolfware.ncsu.edu

We will meet in Cox Hall, room 110, which is equipped with laptop computers. I have also created a virtual machine image with the NCSU **Virtual Computing Laboratory** (VCL) for several course assignments. We will cover using this system in class.

Late Assignments/Makeup Work

You may submit late assignments, but they will be penalized 15% for every 24 hours they are late. Hence, an assignment due at 5:00PM on Thursday would have a maximum grade of 85% if received at 5:01PM. In the case of a university-excused absence, you will not be penalized for the period of that absence.

A missed exam can only be made up in the case of a university-excused absence.

Office Hours

My office is Ricks Hall 356. Rather than have fixed office hours, please email me for an appointment.

Academic Integrity

All exams are individual assignments, unless otherwise stated in writing. Evidence of cheating, plagiarism, or other violations of the Code of Student Conduct will be investigated and, if appropriate, referred to the Office of Student Conduct for disciplinary review. You are free to collaborate on your in-class assignments, but each student must submit her or his own unique version for credit.

The Code of Student Conduct can be found at:
http://www.ncsu.edu/policies/student_services/student_discipline/POL11.35.1.php

Information about policies and procedures of the Office of Student Conduct can be found at:
http://www2.ncsu.edu/student_affairs/osc/

Inclement Weather

The class will follow the University's closure policy. If classes are not cancelled, I will make every effort to be in class on time, and so should you. Please do not send me email

asking whether class is going to meet. Instead, check the University website or the weather hotline (513-8888).

Students with Disabilities

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with Disability Services for Students at 1900 Student Health Center , Campus Box 7509, 515-7653. http://www.ncsu.edu/provost/offices/affirm_action/dss/

For more information on NC State's policy on working with students with disabilities, please see: http://www.ncsu.edu/provost/hat/current/appendix/appen_k.html

Schedule of Topics

Week 1	Modeling the spread of an infectious disease: introduction to differential equations
Assignment	Excel sheet: Approximating a function with its derivative
Week 2	SIR models of infectious diseases
Assignment	Mathematica plots of infection dynamics for $R_0 \approx 1$
Week 3	Biological modeling/species interactions/population growth
Assignment	Excel models of bacterial/human population growth
Week 4	Lotka Volterra models of species interactions
Assignment	Mathematica plots of predator/prey dynamics near and far from steady state
Week 5	Differential equation models of biochemical reactions
Assignment	Mathematica plots of system with and without assumption of enzyme steady state
Week 6	**EXAM 1** Implications of biochemical models, robustness COPASI simulations of a biochemical pathway with enzyme concentration changes (Kacser & Burns)
Assignment	None
Week 7	Biochemical noise/Introduction to randomness
Assignment	COPASI simulations of noisy gene expression
Week 8	Introduction to statistical distributions
Assignment	Demonstration of the central limit theorem
Week 9	Hypothesis testing with statistics
Assignment	Excel exercise on multiple hypothesis testing
Week 10	Agent-based approaches to statistical modeling—genetic drift
Assignment	Initial Perl/Python script simulating drift
Week 11	**EXAM 2**
Assignment	None
Week 12	Bioinformatics –Algorithms versus models; sequence alignment
Assignment	LINUX BLAST search results

Week 13	Modeling evolution/Phylogenetics
Assignment	Are whales fish? PhyML trees
Week 14	Network models
Assignment	Kevin Bacon program results
Week 15	Topics to be selected
Assignment	TBD
Finals Week	**EXAM 3** (As scheduled by the university)