NC STATE UNIVERSITY

Biology 310 Course Syllabus

Quantitative Approaches to Biological Problems

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INSTRUCTOR INFORMATION

Name	Office Phone	Mobile Phone	Email	Office Location
Dr. Gavin Conant, *he/him/his*	NA	573-489-1252	gconant@ncsu.edu	356 Ricks Hall OR Virtual

COURSE INFORMATION

Course Website: conantlab.org
Course Credit Hours: 3
Tues/Thurs 10:15-11:30, COX 105 (Contingency: Synchronous Virtual)

Course Description
This course serves as an introduction to the use of mathematical, statistical and computational models and tools for understanding biology at the molecular, population, ecological and evolutionary scales. We will use discrete and continuous mathematics to model disease spread, ecological competition and biochemical systems. We explore the effect of random events in biochemistry and learn how to model such randomness in a statistical framework. We will also use computation tools to analyze genetic data and write a short computer program that simulates the change in allele frequencies in a population in time due to random effects. All course topics will involve hands-on computational exercises, but no prior experience in these tools and methods is expected.

Prerequisites/Corequisites

BIO 181 and either MA 131 or MA 141 (or equivalents).

General Education Program (GEP) Information
None

GEP Category Fulfilled
None

GEP Corequisites
None

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HEALTH AND WELL-BEING

Health and Participation in Class

We are very concerned about your health and the health of your classmates and instructors/TAs.

- If you test positive for COVID-19, or are told by a healthcare provider that you are presumed positive for the virus, **do not come to class.** Please work with your instructor on health accommodations.
- If you feel unwell please **do not come to class**. Please work with your instructor on health accommodations.
- If you need to make a request for an academic consideration related to COVID-19, such as a discussion about possible options for remote learning, please talk with your instructor for the appropriate process to make a COVID-19 request.

Health and Well-Being Resources

These are difficult times, and academic and personal stress is a natural result. Everyone is encouraged to take care of themselves and their peers. If you need additional support, there are many resources on campus to help you:

- Counseling Center (https://counseling.dasa.ncsu.edu/)
- Health Center (https://healthypack.dasa.ncsu.edu/)
- If the personal behavior of a classmate concerns or worries you, either for the classmate's well-being or yours, we encourage you to report this behavior to the NC State CARES team: (https://advising.dasa.ncsu.edu/resources-for-advisors/advisors-toolkit/cares/)
- If you or someone you know are experiencing food, housing or financial insecurity, please see the Pack Essentials Program (https://dasa.ncsu.edu/pack-essentials/).

Course Expectations

- Course Attendance: NC State attendance policies can be found at: https://policies.ncsu.edu/regulation/reg-02-20-03-attendance-regulations/ . Please refer to this course's attendance, absence, and deadline policies for additional details.
- Course Meeting Schedule: Our course will have *required* in-person meetings, with graded in-class exercises conducted during those meetings. The lectures will not be recorded unless you make special arrangements with me in advance. If you cannot attend class, please be contact with the instructor to be sure that all class assignments are handed in at the appropriate time. Be sure to pay attention to any updates to the course schedule as the information in this syllabus may have changed. Please discuss any questions you have with the instructor.
- Technology Requirements: All computational work for this class will be conducted in-class with the laptops provided. You may be required to compose short lab reports out-of-

class, using Word or other online document editing programs. If you need access to additional technological support, please contact the Libraries' Technology Lending Service: https://www.lib.ncsu.edu/devices.

COURSE DELIVERY AND STRUCTURE

The course consists of a mix of lectures, in-class discussions and in-class computational assignments/analyses. We will introduce and discuss a topic first, and then use the computational assignments to explore it in more depth.

- Lecture materials, video lectures, exercise components and reading assignments (including optional textbook chapters) are provided via **Moodle.**
- I will likely assign some short video lectures to supplement the class meetings—these will be announced in advance and posted to Moodle.
- Students will submit assignments using Moodle.
- I will make use of a whiteboard to derive equations/diagram models etc.
- Most class meetings will involve an in-class exercise/assignment. These exercises will use either the computers in Cox 105 or tools install on the campus Virtual Computing Laboratory. I will demonstrate how to connect to VCL and help support your use of the VCL throughout the semester. Prior experience with the VCL and the LINUX operating system *is not an expectation for this course*.
- Example exercises include:
    - Using R to model the spread of an infectious disease
    - Using Excel or a similar product like Google Sheets to approximate a definite integral
    - Using CoPASI to simulate biochemical reactions
    - Using R to conduct statistical analyses
    - Using Python to write a computer program simulating genetic drift
    - Using a LINUX command line to infer an evolutionary tree

COMMUNICATION

Outside of class time, it is most efficient to contact me by email.

In an effort to affirm and respect the identities of transgender students in the classroom and beyond, please contact me if you wish to be referred to using a name and/or pronouns other than what is listed in the student directory.

Announcements
I will periodically send email announcements thorough Moodle: please check your email at least daily for these updates.

Response Time

I will answer emails within one business day (e.g., I do not generally respond in the evening or on weekends.)

Assignments and exams will be graded within 4 class meetings (generally less).

Office Hours
By appointment.

COURSE LEARNING OUTCOMES

By the end of this course, you will be able to:

1. Describe at least four uses of models in science, give examples of such models and describe their mathematical or computational form.
2. Recognize the use of common mathematical frameworks to model very different biological systems (e.g., SIR, Lotka-Volterra and Michaelis and Menton models).
3. Describe a simple biological system (like population growth) as a differential equation
4. Derive a steady state from a set of differential equations that describe a system that possesses such a steady state.
5. Reduce the complexity of a model of a biochemical reaction by employing a steady-state approximation to one of its components
6. Use mathematical models to illustrate emergent properties in biological systems (metabolic robustness, herd immunity)
7. Give examples of biological systems where models accounting for stochasticity may be necessary for meaningful predictions.
8. Test a simple biological hypothesis in terms of null and alternative statistical hypotheses
9. Explain the principle of using maximum likelihood to infer the unknown parameters of a statistical model from experimental data.
10. Use computers and software for the analysis of biological data, including:
    a. Excel
    b. Perl
    c. CoPASI
    d. R
    e. Linux

COURSE SCHEDULE

Week	Date Range	Topic	Readings	Activities [Assignments, quizzes, tests, etc.]	Due Date

Week 1	Jan 9&11	Course Intro/ Modeling the spread of an infectious disease: introduction to differential equations	None	Assignment #1, Approximating a function with its derivative	Jan 16
Week 2	Jan 16&18	SIR models of infectious diseases	Ebola paper in NJM	Assignment #2: Exploring the R0 parameter of the SIR model with R	Jan. 23
Week 3	Jan 23&25	Biological modeling/ species interactions/ population growth	None	Assignment #3: Modeling exponential growth with Excel	Jan 30
Week 4	Jan 30 & Feb 1	Lotka Volterra models of species interactions	None	Assignment #4: Lotka-Volterra model: Phase plane results Assignment	Feb 6
Week 5	Feb 6&8	Differential equation models of biochemical reactions	Moodle reading: Pielak, PNAS 2005	None	None
Week 6	Feb 15	Week 5, continued	Moodle reading: Kacser & Burns 1981	**Feb. 13th: WELLNESS DAY: No class** Assignment #5: Robustness from biochemistry: Kacser & Burns Assignment	Feb 22
Week 7	Feb 20&22	Biochemical robustness, emergent properties	None	**EXAM #1, Feb. 20th** Assignment #6: Flux-balance analysis and robustness	**EXAM #1, Feb. 20th** Feb. 27
Week 8	Feb 27 & 29	Biochemical noise/ Introduction to randomness	None	Assignment #7: Simulations of noisy gene expression	Mar 5
Week 9	Mar 5&7	Introduction to statistical distributions/	None	Assignment #8: Simulation of the sum of a number of random variables	**Mar 7 (Completed in-class)**

		Central limit theorem			
SPRING BREAK	Mar 11-15	NONE!	NONE!	NONE!	NONE!
Week 10	Mar 19&21	Intro to programming/ Hypothesis testing with statistics	None	Assignment #9: Python program simulating the CLT	Mar 26
Week 11	Mar 26 & 28	Agent-based approaches to statistical modeling—genetic drift	None	Assignment #10: Two-sample *t*-test **EXAM #2, March 28th**	Apr 3 **EXAM #2, March 28th**
Week 12	Apr 2&4	Week 11 cont/ Bioinformatics; sequence alignment	None	Assignment #11: Python script simulating genetic drift	Apr. 9
Week 13	Apr 9&11	Modeling evolution/ Phylogenetics/ Start networks	Moodle reading: Perils of tree-thinking	Assignment #12: Are whales fish?	Apr 16
Week 14	Apr 16&18	Network models & Metabolic scaling/ fractals	Moodle reading: Small world networks	Assignment #13: Kevin Bacon game	Apr. 23 (Nominal)
Week 15	Apr 23	Topics arising	Topics arising	None	
Final Exam Weeks				**NON-CUMULATIVE FINAL (Exam #3): April 30: 8:30-11am**	**EXAM #3: Tues, April 30: 8:30-11am**

Please note: course schedule is subject to change, ***but the exam dates will not change***.

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COURSE MATERIALS

Required Textbook and/or Software
There is no course textbook: course readings are posted on Moodle and will be announced in class.

As additional material, I am providing PDF drafts of textbook chapters on Moodle to the extent I have such chapters written (generally the first 12 weeks of the course). These chapters are optional material for review or further background: no exam material will come from them unless that material is also covered in class in the slides.

Optional Materials
See above.

TECHNOLOGY REQUIREMENTS

Hardware
NC State's Online and Distance Education provides **technology requirements and recommendations** for computer hardware.

Software
Most required analysis software is pre-installed on the Cox 105 computers or with VCL instances we will use in class. The out-of-class assignments will require only a web browser (access to Moodle and other sites), PDF viewer (Preview or Adobe Reader), Powerpoint or similar (for downloading class slides) and text editor (e.g., Word or similar).

Minimum Technology Skills

- The course will require an internet connection
- Some typing (MS Word, text editors, Google Docs) will be required to complete some assignments (generally less than 1 page of text)
- Reading emailed class updates
- Interaction with Moodle
- The course will make extensive use of computers, however, the instructor will demonstrate all of these tools in-class and provide immediate assistance. Students should nonetheless feel comfortable learning new skills on computers
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ONLINE LEARNING EXPECTATIONS

This course will require between 3-6 hours of out-of-class work per week, consisting of:

- Reviewing slides before and after class

- Performing assigned readings
- Completing course assignments

NETIQUETTE

Netiquette is the term used to describe the special set of rules for online communication.

Students should be aware that their behavior impacts other people, even online. I hope that we will all strive to develop a positive and supportive environment and will be courteous to fellow students and your instructor. Due to the nature of the online environment, there are some things to remember.

Tips for Success:

> **Do**: Follow the same standards of behavior that you subscribe to offline. Keep in mind that all online communication is documented and therefore permanent.
> **Don't**: Flame others in discussion forums. Flaming is the act of responding in a highly critical, sarcastic, or ridiculing manner – especially if done on a personal level. Remember that these discussions are meant for constructive exchanges and learning!

> **Do**: Ensure you are responding to forums by the due date, in order to leave time for peers to comment on your response.
> **Don't**: Go for long periods of time without communicating to your instructors or classmates. It is important to stay a part of the online community!

> **Do**: Remember to read over your posts before selecting "Submit."
> **Don't**: Use slang, poor grammar, and other informal language in discussion forums or email messages to instructors or classmates.

Additional resources

> **Netiquette – Ethics in Computing**
> **How to Teach Netiquette** on the **DELTA Knowledge Base**

COURSE POLICIES

Grading Policy

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

- Exams (45%) – three exams, 15% each
- Weekly assignments (55%) – 1 per week (13 total), 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 (45%)

There will be three exams, equally weighted at 15% each. The exams will not be cumulative. The exams will be conducted with Moodle in class on the dates given in the course schedule. You **must** take the exams in-person unless you have prior email permission from me. **The third exam will occur at the scheduled final exam time for this class (Tues. April 30), but will be non-cumulative and of the same length and weight as the first two exams.**

Assignments (55%)

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, R, programming, statistical). You will submit your results electronically via Moodle. To facilitate students following the class asynchronously, these assignments will be due the week following the one in which I discuss them. No makeups will be given: instead you may drop your two assignments with the lowest scores (13 assignments, 11 counted, 5% each).

Grading Scale
This course uses this grading scale:

Low	Letter	High
97 ≤	A+	≤ 100
92 ≤	A	< 97
90 ≤	A-	< 92
87 ≤	B+	< 90
82 ≤	B	< 87
80 ≤	B-	< 82
77 ≤	C+	< 80

72 ≤	C	< 77
70 ≤	C-	< 71
67 ≤	D+	< 70
61 ≤	D	< 67
60 ≤	D-	< 61
0 ≤	F	< 60

Late Assignments

Note that either this syllabus or my in-class statements are definitive with respect to due dates. Moodle due dates may be incorrect. If I do not announce an extension to an assignment due date, it is due at the time listed above. I **will not** move assignment due dates **forward** relative to this syllabus.

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 (without excuse) will require you to meet with the instructor to develop an action plan for replacement (likely a term paper).

Incomplete Grades

Assignments submitted more than 1 week late will receive a score of 0 (15%/day over 7 days is 105% penalty). There are no incomplete assignment grades. Missed exams are subject to the policy above. Students finding themselves unable to complete the coursework due to significant personal circumstances will be afforded the opportunity to drop the course with a passing grade subject to the instructor's approval.

Attendance and Participation

I will not take attendance in class. Because it will not generally be possible to repeat missed exercises, you will be able to drop the lowest two assignment grades (out of the total of 13):

Academic Integrity and Honesty

Students are required to comply with the university policy on academic integrity found in the **Code of Student Conduct**. Therefore, students are required to uphold the university pledge of honor and exercise honesty in completing any assignment.

All exams are to be completed individually without any contact with other students, unless otherwise stated in writing. You are also expected to complete the exams without using external resourses such as web searches. A calculator is allowed but unnecessary. 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. In addition, such behavior will, at a minimum, result in a 0 grade for the exam or assignment in question.
You are encouraged to collaborate on the analysis portions of your in-class assignments, but each student must submit her or his own unique version of any written portion of each assignment (where applicable) to receive credit. Use of automated writing tools such as ChatGPT is not allowed and grounds for receiving a 0 on that assignment.

Please refer to the **Academic Integrity** web page for a detailed explanation of the University's policies on academic integrity and some of the common understandings related to those policies.

Inclusion
It is the policy of the State of North Carolina to provide equality of opportunity in education and employment for all students and employees. Educational and employment decisions should be based on factors that are germane to academic abilities or job performance. North Carolina State University ("NC State") strives to build and maintain an environment that supports and rewards individuals on the basis of relevant factors such as ability, merit and performance. Accordingly, NC State engages in equal opportunity and affirmative action efforts, and prohibits discrimination, harassment, and retaliation, as defined by this policy.

Our class will include many opportunities for in-class collaborations. Recall that each of you comes to the class with different backgrounds and expertise: be willing to learn from others when they have background you do not and to share your insights in return. Successfully collaborative science requires *listening*: no one is so brilliant that they will not learn something new if they listen.

Supporting Fellow Students in Distress
As members of the NC State Wolfpack community, we each share a personal responsibility to express concern for one another and to ensure that this classroom and the campus as a whole remains a safe environment for learning. Occasionally, you may come across a fellow classmate whose personal behavior concerns or worries you. Anytime you are concerned about **any** member of the Wolfpack community, I would encourage you to report this behavior to the NC State Students of Concern website. Although you can report anonymously, it is preferred that you share your contact information so they can follow-up with you personally.

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STUDENT SERVICES

- **Academic Advising**
- **Registering for Classes**
- **Financial Aid**
- **Accessibility Support**
- **Online and Distance Education website**
- **Student Ombuds Services**
- **Pack Essentials:** food pantry, emergency financial assistance, housing resources.
- **Supplemental Nutrition Assistance Program (SNAP):** college students **can** qualify for assistance with food expenses through SNAP. No social security number is required.
- **More in My Basket:** NC State office that assists with completing SNAP applications.
- **Wolfpack Styled Professional Clothing Closet**

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TECHNICAL SUPPORT

NC State University HELP Desk:

- Website: https://help.oit.ncsu.edu/
- Email: help@ncsu.edu
- Phone: 919.515.HELP
- Walk-in Support

Hours:

Semester	Monday-Friday	Saturday
Fall and Spring	8 a.m. to 7 p.m. After 5 p.m., please ring doorbell.	Noon to 5 p.m. Please ring doorbell.
Summer	8 a.m. to 5 p.m.	Noon to 5 p.m. Please ring doorbell.

Students can receive computer support in these areas:

- **Operating system**
  Including virus and spyware removal
- **Software**
  Most software packages are easy to install, but if you encounter difficulty, Walk-in Center staff are happy to help.
- **Network connectivity**
  ResNet and the campus wireless network
- **Warranty and hardware repair**
  For computers and warranties purchased through the NC State Bookstore
- **Unity account**
  Including password resets, disabled accounts
- **2SV support**
  Duo and Google two-step verification support

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ELECTRONIC COURSE COMPONENTS

This course uses Moodle and the NCSU Virtual Computing Laboratory (VCL). Some of the material on Moodle and the VCL is copyright-protected. Hence, please ask me before redistributing any course material to anyone not in our class. Note that despite the language below, our class does not *require* any online communication between students (though it is encouraged). Nor will I post any personally identifiable information from any students on the course Moodle page.

For use in courses with online exchanges among students and the instructor, but NOT persons outside the course:
Students may be required to disclose personally identifiable information to other students in the course, via electronic tools like email or web-postings, where relevant to the course. Examples include online discussions of class topics, and posting of student coursework. All students are expected to respect the privacy of each other by not sharing or using such information outside the course.

Students are responsible for reviewing the NC State University PRR's which pertains to their course rights and responsibilities:

- **Equal Opportunity and Non-Discrimination Policy Statement** and **additional references**
- **Code of Student Conduct**
- **Grades and Grade Point Average**
- **Credit-Only Courses**
- **Audits**

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 the **Disability Resource Office** at Holmes Hall, Suite 304, Campus Box 7509, 919-515-7653. For more information on NC State's policy on working with students with disabilities, please see the **Academic Accommodations for Students with Disabilities Regulation (REG02.20.01)**

COURSE EVALUATIONS

ClassEval is the end-of-semester survey for students to evaluate instruction of all university classes. The current survey is administered online and includes 12 closed-ended questions and

3 open-ended questions. Deans, department heads, and instructors may add a limited number of their own questions to these 15 common-core questions.

Each semester students' responses are compiled into a ClassEval report for every instructor and class. Instructors use the evaluations to improve instruction and include them in their promotion and tenure dossiers, while department heads use them in annual reviews. The reports are included in instructors' personnel files and are considered confidential.

Online class evaluations will be available for students to complete during the last two weeks of the semester for full semester courses and the last week of shorter sessions. Students will receive an email directing them to a website to complete class evaluations. These become unavailable at 8am on the first day of finals.

- Contact ClassEval Help Desk: **classeval@ncsu.edu**
- **ClassEval website**
- **More information about ClassEval**

SYLLABUS MODIFICATION STATEMENT

The schedule of topics is necessarily flexible: Dates for assignments represent the earliest possible time they would be due: changes will always be announced in class and posted on Moodle. **EXAM DATES WILL NOT CHANGE:** exams will include only the material covered to that point, regardless of the schedule above.