

# BIO180: Mathematical Modeling for Biology (4 units) – Online Syllabus

## Instructors:

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Teaching Assistant: TBA

## BIO 180 as an online course:

This version of BIO180 is entirely online. There are many benefits to this online format that many students like, including being able to watch the lectures whenever you want and to pause or review the lectures as needed. However, this format puts a lot of responsibility on you the student to keep up with the lecture material and to contact the instructors with any questions or problems you are having with the course. Each week will involve working through “Modules” on specific topics. Each of these modules will involve about 2-6 video lecture segments totaling 30-60 minutes, where many of the segments will be followed by an online quiz or computer activity. All of these lectures and activities will be posted to the Canvas CatCourses site for the class. About 13 homework assignments will be posted throughout the semester that you will complete on your own computer and then submit through CatCourses.

## Textbooks:

The two required textbooks for the course are:

*Modern Statistics for the Life Sciences*, by Grafen & Hails, Oxford (2002). [“GH”]

*Mathematical Models in Biology*, by Allman & Rhodes, Cambridge Univ. Press (2004) [“AR”]

The following book is also recommended (not required for the course):

*Statistisc: An Introduction using R*, by M. J. Crawley, John Wiley & Sons (2014)

## Contacting instructors and getting help with the class:

There are a variety of ways to contact the instructors for help in the class. There will be weekly “virtual” discussion sessions during which the instructors will provide guidance on each week’s homework and provide real-time answers to any student questions. There will also be office hours (schedule to be posted on the "Contacting the Instructors" CatCourses page). Finally, you can email the instructors at any time and they will do their best to answer your questions in a timely manner. If you send your email to [bio180@lists.ucmerced.edu](mailto:bio180@lists.ucmerced.edu) your email will be automatically forwarded to both instructors and the teaching assistant for the course. We try our best to reply to emails as quickly as possible throughout the week.

## Course Goals and Objectives:

The analysis of quantitative data is at the heart of modern biology. Therefore, this course is designed to provide basic statistical analysis capabilities and mathematical modeling skills for 21<sup>st</sup>-century life scientists. Emphasis will be placed on:

- the practical application of modern statistical tools for complex, real-world data sets
- the use of difference equations to predict the growth of animal, cell, and plant populations
- the mutualistic or competitive interactions between species
- demographic change
- the spread and control of epidemics.

The “R” statistical language (a very powerful and freely available software tool) will be implemented throughout the course.

## Homeworks:

Homework assignments based on the content of particular modules will be posted to CatCourses. You will work on them independently following completion of the relevant modules. The homework assignments are essential to mastering the material in BIO 180. Homeworks are to be performed individually—see section below on Academic Integrity. Note that in many cases, every student will get an individualized version of the homework data sets, so it will be immediately apparent if you don’t do your own calculations.

Note that late assignments will generally not be accepted unless there is a documented emergency (such as those listed in the **Exams** section below).

## Exams:

No Make-ups: There will be two midterm exams and a cumulative final exam. Make-up exams will **not** be offered if a student misses an exam without an extenuating circumstance\*\*, so it is important to take every exam at the regularly scheduled time. In the case of a documented emergency\*\* the course instructor may excuse the student from taking the exam, in which case the student’s other assignments in the course will be weighted more heavily in final grade determinations.

### \*\*Examples of documented emergencies:

-An incapacitating illness or accident (requires a physician’s note, from a physician who is not a family member).

-Death or serious illness of an immediate family member (also requires proper medical documentation).

Students who miss the final exam will receive a failing grade for the course unless an acceptable excuse is provided (see above), and the student was achieving a passing grade up until the final exam.

Exam Rescheduling: Students who have a religious observance or other necessary scheduling conflict (e.g. graduate school interview) should contact Dr. Reed by email as early as possible,

ideally during the first week of classes. In some cases, it may be possible to arrange an alternative time for the student to take the exam or the student might be excused from taking the exam altogether, at the discretion of the instructor. Students who are granted permission to take an exam at an alternative time may not discuss any aspect of the exam with other students in the class; to do so is a serious breach of academic integrity.

**Exam Regrading:** A student may request that their exam be regraded if the student believes that errors were made in the grading. Requests for regrading must be made within a week of the original grade assignment. Exams submitted for regrading will be completely regraded, so that the resulting grade may be higher or lower than the original grade. The final exam will not be returned to the students, but a student may request to examine the graded final in the presence of the instructor after the end of the term.

**Grading Scale:**

Activity	Number	% Final Grade
Online Quizzes	~60	10%
Discussion	~13	5%
Homeworks	~13	25%
Midterms	2	35%
Final	1	25%
Total		100%

Overall grades will be assigned using the following *approximate* scale. Plusses and minuses will be assigned at the end of the term, and generally encompass the top and bottom 2% within each grade bracket (subject to modification by the instructor):

Letter grade	Overall percentage
A's	90 – 100 %
B's	80 – 90 %
C's	70 – 80 %
D's	60 – 70 %
F's	< 60 %

**Special Accommodations:**

UC Merced is committed to making our courses accessible to all students, including students with limited mobility, impaired hearing or vision, and learning disabilities. The American with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact Student Accessibility Services at (209) 228-6996, Email: [disabilityservices@ucmerced.edu](mailto:disabilityservices@ucmerced.edu), or visit <http://disability.ucmerced.edu/>

### Course Student Learning Outcomes:

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

- I. Use the *General Linear Model* statistics framework to analyze datasets including multiple continuous or categorical explanatory variables.
- II. Design experiments according to optimal statistical design criteria.
- III. Build and analyze population-based models of many different biological phenomena.
- IV. Use the freely available **R** statistical modeling language to graph data sets and build statistical models.
- V. Write basic population modeling programs in the **R** statistical modeling language.
- VI. Understand and apply the principles of modeling human epidemics and disease spread.

These learning outcomes are mapped onto the schedule below.

### Schedule:

(Note: Schedule may be subject to modification by instructors)

Module (Learning Outcomes)	Concepts	Readings	Finish Date
Preliminaries (I.)	Course overview and logistics, R tutorials		1/21/22
Module 1 (I., IV.)	Descriptive Statistics	GH Revision Section	1/28/22
Module 2 (I.)	Measures of variability in data	GH Revision Section	1/28/22
Module 3 (I., IV.)	Analysis of variance	GH §1	2/4/22
Module 4 (I., II.)	Linear Regression	GH §2	2/4/22
Module 5 (I.)	Unifying framework: General Linear Models	GH §3	2/11/22
Module 6 (I., IV.)	Multiple explanatory variables	GH §4	2/11/22
Module 7 (I., II.)	Designing experiments	GH §5	2/18/22
Module 8 (I., III.)	Mixing continuous and categorical variables	GH §6	2/18/22
Module 9 (I., II.)	Factorial experiments	GH §7	2/25/22
Module 10 (I.)	Testing for independence	GH §8	3/4/22
Module 11 (I., IV.)	Testing for homogeneity, additivity and normality	GH §9	3/4/22
	Midterm Exam 1		TBA

Module 12 (I., II., IV.)	Model selection for designed experiments	GH §10	3/11/22
Module 13 (I., IV.)	Model selection for observational data sets	GH §11	3/11/22
Module 14 (I., IV.)	Random effects and nested data	GH §12	3/18/22
Module 15 (III.)	Introduction to biological population modeling	AR §1	3/25/22
Module 16 (V.)	Programming in R	Handout	3/25/22
Module 17 (III., V.)	Difference and differential equations	AR §1	4/1/22
Module 18 (III., V.)	Linear Population Models	AR §2	4/1/22
Module 19 (III., V.)	Stratified Population Models	AR §2	4/8/22
	Midterm Exam 2		TBA
Module 20 (III., V.)	Non-linear Models of Interactions	AR §3	4/15/22
Module 21 (III.)	Stability in Nonlinear Population models with interactions	AR §3	4/15/22
Module 22 (VI.)	Epidemic modeling: History and General Principles	AR §7	4/22/22
Module 23 (V., VI.)	Epidemic modeling—S.I.R. Models	AR §7	4/22/22
Module 24 (V., VI.)	Epidemic modeling—S.I. and S.I.S. Models	AR §7	4/29/22
Module 25 (V., VI.)	Epidemic modeling—Advanced models	AR §7	5/6/22
Module 26 (III., V., VI.)	Themes and strategies in population modeling	AR §1-3, 7	5/6/22
	Final Exam—Wednesday-11:30am – 2:30pm	Cumulative	5/11/22

### Final Thoughts:

Your instructors want you to succeed in BIO 180! A few thoughts to help you get the most out of the course:

Be prepared to spend 1-2 hours studying for every 1 hour spent watching the online lecture materials. (If you can't commit the study time, consider taking this course a different semester).

Do the assigned readings before watching the online lectures.

Do print out the lecture slides and take notes as you watch the lectures.

Do attend office hours to get help.

Install the **R** software package on your own personal computer and do all of the **R** examples shown in the videos on your own computer and try to use **R** in your other classes whenever possible.

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