BIOMETRY

Fall 2024

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All evolutionary biologists know that variation itself is nature's only irreducible essence.

— Stephen Jay Gould (1991, "The median isn't the message", *Bully for Brontosaurus*)

Biology is a field defined by variation. Biologists catalog different forms of life; molecular, cellular, and tissue structures; and organisms — and we are especially interested in understanding *why* living things differ, and *how* those differences arise in the processes of individuals' development and populations' evolution. Variation has many sources, though. When we set out to answer a question in biology — Does this protein play a role in cell death? Is this moth an important pollinator for the flowers it visits? Does this gene help determine the color of lizards' skin? — we want to separate some specific causal factor from the many other sources of variation that may be at play.

Separating a particular causal factor from other possibilities requires careful design of experiments and selection of observations, and an understanding of statistical methods that help us interpret their results. The two are closely intertwined, because identifying the statistical test that can answer your research question is really the first step to planning what data you will collect. *To be a good biologist, you must understand statistics!*

Many biologists never take a formal class in experimental design and statistics, but most also say they wish that they had more training in these critical topics. Our goal this semester, then, will be to prepare you to **frame your research questions in terms of statistical tests and experimental designs that can answer them**. By the end of the course, you will understand statistical analyses well enough to:

- Design your own experiments and analyze the data you gather (e.g., your lab project, your thesis research, or data you collect in the future).
- Evaluate whether other published studies were analyzed correctly, making you a better reader of the scientific literature.

Catalog Descriptions — BIOL 502, Biometry (3) and BIOL 502L, Biometry lab (1)

Application of quantitative methods to variation patterns in biological systems, their analysis and interpretation. Lecture, 3 hours.

Corequisite: BIOL 502. Students have supervised time to work problem sets. Lab, 3 hours.

ELEMENTS OF THE COURSE

Computing needs

We'll use Canvas as a central organizing platform for all course activities, and we will frequently use the course Canvas site or other online resources during class meetings. On Canvas, the course will be organized in *modules* for each class meeting, where I'll post lecture slides, data sets, and R code.

To access Canvas and complete class activities, you will need access to a laptop with a solid Internet connection, a spreadsheet program (Excel, Numbers, and Google Sheets will all work), and R/RStudio.

Reading

To get the most out of class meetings, you should plan to keep up with reading assignments; there will usually be a new one for each module.

Our textbook for the semester is *Experimental Design and Data Analysis for Biologists* by Gerry P. Quinn and Michael Keough. For your convenience, this class is participating in the *myCSUNDigitalAccess* textbook program this semester. This program provides a digital copy of the textbook on BryteWave, with your CSUN login: brytewave.redshelf.com/app/ecom/shelf/course-section/7409546

The *myCSUNDigitalAccess* program *automatically* provides this digital textbook to everyone in the class at a discounted price. The cost will be charged to your student account unless you opt out of the program by **Friday, September 20**. You may find a cheaper option to access the textbook, and if you do, you can opt out of the program to avoid the charge — but if you opt out, you will lose access to the digital textbook, and you cannot opt out after September 20. *After the opt-out deadline the charge for the digital textbook is not reversible*.

More details are at bkstr.com/csunorthridgestore/help-faq/textbook-faqs1

We will also have smaller-scale reading assignments as examples of specific statistical analysis and broader topics in the course. All reading assignments are listed in the semester schedule (below) and assignments outside the textbook will be available for download from Canvas.

Some other texts that may be helpful, but are not required or assigned readings, are

- *Biometry: The Principles and Practices of Statistics in Biological Research* by Robert R. Sokal and F. James Rohlf
- *The Analysis of Biological Data* by Michael Whitlock and Dolph Schluter
- *Ecological Statistics* by Gordon A. Fox, Simoneta Negrete-Yankelevich, and Vinicio J. Sosa
- *A Primer of Ecological Statistics* by Nicholas J. Gotelli and Aaron M. Ellison
- *Mixed Effects Models and Extensions in Ecology with R* by Alain F. Zuur and Elene N. Ieno, Neil J. Walker, Anatoly A. Saveliev, and Graham M. Smith
- *Ecological Models and Data in R* by Benjamin M. Bolker

GRADING

The elements of the course combine for the final grade following this breakdown:

1. Quizzes — 5%
2. Problem sets — 35%
3. A paper review — 10%
4. Midterm exams — 15% each
5. Final exam — 20%

Grades follow a 90/80/70/60 A/B/C/D scheme with plusses and minuses. I may "curve" exam or assignment grades by adjusting scores upward until at least half the class has a 75% or better. Grad students, keep in mind that you must finish with a B or better to get credit for the course.

Quizzes — Intermittently (roughly once a week) we'll have short review quizzes during class. These are intended to be low stakes assessments to make sure we're all on the same page as we move through material.

Problem sets — A major portion of the grade will be "problem set" assignments, in which you analyze data to practice statistical analyses we have covered in class. *I encourage you to talk to each other and collaborate on these problem sets*. In fact, these are often difficult to do on your own! However, it's important that you each create your own R script and provide your own answers to each question. *Everybody must turn in their own individual assignment.*

Talking about how to solve the problems is good, but ultimately you need to do it yourself to learn it. Problem sets are due *by the beginning of class on the due date* (see our schedule below). Late assignments will be accepted (see policies below), but I will generally post answers to the problem sets a week after the due date — and once the answers are posted, I won't be able to accept late assignments.

Paper review — Part of understanding statistical methods is not just planning and analyzing your own experiments, but interpreting and evaluating the quality of statistics in published scientific papers. For this assignment, you will choose a paper in your field and present it to the class, discussing what statistical methods were used, what you do and don't understand about them, and your best understanding of how correct the authors were in their choices of analysis.

Exams — We will have two midterm exams and a cumulative final. Each of these exams will have a written component and a practical, "take home" component, which will require you to use R and will be similar to the problem sets. Take-home exams will generally be posted a week before the corresponding in-class exam, and will be due before the start of class on the day of that exam.

POLICIES

Please do your best to be kind and respectful as we work together in class meetings. A reminder of some best practices for in-person classes:

- You should arrive to class on time and prepared for the topic on the schedule, and you should be ready to work with other students to complete in-class questions and activities.
- If you do arrive late, please take a seat quietly. Plan to get notes on anything you missed from a classmate, and to review the class lecture-capture video.
- When you have a question, or if you're volunteering an answer to a question asked by the professor, please raise your hand and wait to be called on before you speak.

Making up missed work

The plans for making up missed work vary with the kind of work in question:

- ***Quizzes* —** There will be *no way to make up quizzes*; they're a low-stakes check-in, and a small enough part of the overall grade that you can afford to miss a couple.
- ***Problem sets* —** I'll accept problem sets after the deadline, but I will deduct 10% of the maximum grade per full day late, down to a minimum value of 50%. I will generally post answers to the problem sets a week after the due date, and once the answers are posted, I won't be able to accept late assignments.
- ***Exams* —** I will arrange make-up exams *within one week of the exam date* — later is only possible in extreme circumstances.
- ***Other assignments* —** Except when missing the due date makes completion of an assignment impossible, I will penalize the grades of all other assignments 10% for each day they are late, up to a 50% total penalty.

Academic honesty

Do your own work, and cite your sources. Cheating, fabrication, and plagiarism — presenting text that you did not write as if it is your original work — violate the CSUN student conduct code. (These forms of academic dishonesty are defined in detail in the online Course Catalog, at https://catalog.csun.edu/policies/academic-dishonesty). *I will penalize all cases of academic dishonesty with a zero grade upon first offense*, and university policy requires me to report academic dishonesty to the Office of Student Affairs.

Dropping

Do not overload yourself. If you are going to drop, you must do so *in the first three weeks of class* unless you have an unforeseeable, serious, compelling, verifiable justification.

Campus emergencies

If a campus emergency prevents us from completing any class activity, I will remove that activity from the grade book and assign final grades based on all other work completed.

RESOURCES

This is a 500-level course aimed at graduate students, and it requires coursework appropriate to that level. That doesn't mean I expect it to be easy for you! Everyone needs help sometimes — in fact, if you don't need help at some point in a university course, you may not be learning much from it. CSUN provides an array of resources to draw on when things get challenging.

General assistance

CSUN provides access to laptops and internet connections via the campus device loaner program: csun.edu/it/device-loaner-program

The Learning Resource Center, on the third floor of the CSUN Library, provides tutoring and general support for any students who need it. Stop by the LRC or visit csun.edu/lrc for details.

The Biology Department also offers subject-specific tutoring. The tutoring schedule will be posted to the department website, at csun.edu/science-mathematics/biology/students.

The Peer Learning sessions for the course (see above) are another venue for help, specifically provided as a time when you can ask questions and work together on your study guides.

Research and writing

The campus library provides guidance and planning tools for research projects such as the paper you will write for this class — find it online at libguides.csun.edu/research-strategies

The University Writing Center in the Learning Resource Center is staffed with Part Time Faculty and Masters Candidates at CSUN, who can help with any step of the writing process from conception to completion, either in one-on-one meetings, group sessions, or via an "online writing lab." Details are at the LRC website, csun.edu/lrc; you can also make an appointment by calling 818-677-2033, or in person at the CSUN Library, room 300.

Disability accommodations

If you need accommodations for any specific physical, psychiatric, or learning disabilities, please let me know as soon as possible so that your learning needs may be appropriately met. If you haven't previously, you should also consult the Disability Resources and Educational Services (DRES) office or the NCOD: Deaf and Hard of Hearing Services Department.

The DRES office is located in Bayramian Hall 110 and can be reached at 818-677-2684; you can find online services at csun.edu/dres.

NCOD: Deaf and Hard of Hearing Services is located on Bertrand Street in Jeanne Chisholm Hall and can be reached at 818-677-2611; online services are at csun.edu/ncod.

SEMESTER SCHEDULE

Regular meetings Monday and Wednesday from 2:30-5:15pm, in Chaparral Hall 5332.

Date	Topic(s) — reading	Due
08/26	Why biologists need statistics; Excel and R — Quinn & Keough, ch. 1; Abrahams & Townsend (1993)	
08/28	Probability distributions, descriptive statistics — QK2	
09/02	*Labor Day holiday; no class meeting*	
09/04	Visual exploration of data — QK4, 19	
09/09	Experimental design; replication, and pseudoreplication — QK7, Hurlbert (1984)	
09/11	Null hypothesis testing and confidence limits — QK3	PS1
09/16	The t-test — QK3	
09/18	Correlations — QK5	
09/23	General linear models; regression — QK5	
09/25	Multiple regression — QK6; **take-home 1**	PS2
09/30	**Midterm 1**	Take-home 1
10/02	More general linear models; analysis of variance — QK8	
10/07	Pairwise comparison; planned contrasts — QK 12.6	
10/09	Nested ANOVA; 2-way ANOVA — QK9	
10/14	Fixed and random effects; partitioning variance; variance components — QK8, 9, Harrison *et al.* (2018)	PS3
10/16	Model selection; repeated measures ANOVA — QK10, 11	
10/21	Analysis of covariance — QK12	
10/23	Power analysis — QK7; **take-home 2**	PS4
10/28	**Midterm 2**	Take-home 2
10/30	Generalized linear mixed models — QK13; paper reports 1, 2	
11/04	Simple GLMs, logistic regression — QK13; PRs 3, 4	
11/06	Models with frequencies — QK14; PRs 5, 6	
11/11	*Veterans' Day — campus closed*	
11/13	Exploring multidimensional space; ordination plots; principal components analysis — QK 15, 17; PRs 7, 8	PS5
11/18	MANOVA; discriminant function analysis — QK16; PRs 9, 10	
11/20	Non-metric multidimensional scaling — QK18; PRs 11, 12	
11/25	Time-series analysis; zero-inflated distributions; PRs 13, 14	PS6
11/27	*Thanksgiving holiday; no class meeting*	
12/02	Machine learning methods	
12/04	Data potluck, semester wrap-up and debrief; **take-home final**	
12/16	**Final Exam,** 3-5pm	Take-home final