

BIOLOGICAL RESEARCH METHODS + DESIGN

BSC 3930C

3 credits, Spring 2018

Course Instructor

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Course Description

An introduction to research methods in biology, with specific focus on critical thinking, scientific skepticism, experimental design, and working with data relevant to biological questions. Students will develop an understanding of the logical and philosophical underpinnings of the scientific method, learn how biological research is commonly conducted and disseminated, and develop a skillset of data analysis techniques in relation to experimental questions and hypotheses in biology. Course format will consist of lectures and accompanying hands-on breakout sessions where students will perform data analysis and examine published science.

Course Goals and Learning Objectives

Upon completion of the course, students will be able to:

- Understand methodological naturalism and the general conceptual process of scientific inquiry.
- Identify and judge key cognitive biases and logical fallacies.
- Think critically about biological questions and evidence.
- Design appropriate experiments to address biological questions.
- Identify common data types and inspect biological data.
- Select appropriate analyses to answer biological questions.
- Confidently perform the most common and useful analyses used in biology.
- Interpret results of statistical tests in biologically relevant terms.
- Evaluate the validity of experiments and data analysis in the scientific literature.
- Understand basic research ethics and how findings are disseminated.
- Learn how to synthesize research on a particular question to determine the limits of knowledge.

Prerequisites

A grade of "C" or better in both BSC 2011C and STA 2023, and a grade of "C" or better in either PCB 3044 or PCB 3063, or permission of course instructor.

Class Meetings

Lab - Tuesday 4:30-6:20pm

Lecture – Thursday 4:30-5:50pm

Webcourses Site

There is a course website available through Webcourses (<https://webcourses.ucf.edu>) that will be used to post materials for the course, including the syllabus, lecture slides, reading materials, and grades.

Course Texts, Software, and Equipment

This course will use three texts:

- “*Essential Biostatistics: A nonmathematical approach*” by Harvey Motulsky (ISBN 0199365067)
“*How to Lie with Statistics*” by Darrell Huff (ISBN 0393310728)
“*The Demon-Haunted World: Science as a Candle in the Dark*” by Carl Sagan (ISBN 0345409469)

Additional supplementary reading materials (e.g. journal articles, videos, etc) will be provided by the instructor through Webcourses.

The course will also use the software package JMP, which is site-licensed by UCF and freely available to students via UCF Web Apps <http://apps.ucf.edu/>.

Students are required to bring a laptop computer or other similar device capable of running JMP via UCF Web Apps and handling standard data files (e.g. Excel, CSV, etc) to breakout sessions when indicated. If you do not have such a device available to you, the Biology Department has a number of laptops that can be checked out.

Methods of Evaluation and Grading System

Grades will be assigned on the following scale without rounding or the use of plus/minus grades:

A: 90-100% B: 80-89% C: 70-79% D: 60-69% F<60%

The grade for this course will be based on the following components:

- (1) One **essay** reviewing Carl Sagan’s *The Demon Haunted World* as it relates to today’s world two decades later (10% total).
- (2) Six **in-class/homework assignments** (5% each, 30% total) demonstrating completion of data analysis exercises and interpretation. Assignments are due in class (breakout session) the week after the breakout session in which they were assigned.
- (3) One **team literature review project** synthesizing existing research on a question of interest, generating a quantitative and narrative review and making informed suggestions for further research (5% proposal, 20% final written report, 10% final presentation; 35% total). This project is graded using the group scores as a baseline, adjusted by individual contributions if needed.
- (4) A **research reflection** assesses how your team project went, what you learned, and what you would do differently with a new experience based on what you have learned (3% total).
- (4) One **practical final exam**, given in class on the date indicated on the schedule (12% total). This open-book, open-note exam will consist of a series of data analysis questions using JMP.
- (6) **Participation** in class discussions and group activities (10% total).

Course Policies

1. Attendance is vital in this course. A large portion of the course grade will be based on participation, homework assignments using skills demonstrated in breakout sessions, and exams will cover material not available outside of class.
2. Make-ups for in-class participation cannot be provided.
3. Assigned readings are very important to this course, and all assigned readings should be completed before attending class!
4. This course may occasionally cover politically or socially controversial topics where they intersect with science and scientific evidence. Students are expected to behave professionally and treat other students and the instructor in a civil manner in the interest of scholarly discourse.
5. Written communication with the instructor should be sent via Webcourses or UCF email. Note that I will not be able to respond to course inquiries sent from third-party email addresses (e.g. Gmail) where student identity cannot be confirmed, in order to comply with FERPA regulations.
6. This course will use technology in class – it is the student’s responsibility to be respectful of others by remaining on-topic and not distracting others.
7. This course will involve a long-term group project. Students will need to communicate and work with one another outside of class to complete it. Groups will be self-selected and based on shared research interests, as is typical for research collaborations in science. Students will need to resolve conflict among group members as much as possible, but the instructor will mediate any major conflicts.
8. Academic dishonesty (e.g. plagiarism or cheating) is governed by the UCF Golden Rule. Students found to have committed academic dishonesty will receive a minimum of an “F” for the assignment in question, and at the instructor’s discretion based on severity of the violation, an “F” for the entire course with referral to the Office of Student Conduct.
9. Students are highly encouraged to discuss any and all portions of this course with me. If you are struggling, please do not wait until you fall behind to meet with me. I am available during my weekly office hours or by appointment and will always be happy to discuss the course.

Resources for Success

University Writing Center

The University Writing Center (UWC) offers writing support to UCF students from first-year to graduate in every discipline. Trained peer consultants provide help at every stage of the writing process, including understanding assignments, researching, drafting, revising, incorporating sources, and learning to proofread and edit. The UWC’s purpose is not merely to fix papers or to make better writers, but to teach writers strategies to navigate complex situations for writing, both in and outside the University. Consultations are available for individuals and small groups. <https://uwc.cah.ucf.edu/>

Student Accessibility Services

It is my goal that this class be an accessible and welcoming experience for all students, including those with disabilities that may impact learning in this class. If anyone believes the design of this course poses barriers to effectively participating and/or demonstrating learning in this course, please meet with me to discuss reasonable options or adjustments. You may also contact SAS (Ferrell Commons 185; 407-823-2371; sas@ucf.edu) to talk about academic accommodations. <http://sas.sdes.ucf.edu/>

Counseling and Psychological Services

Counseling and Psychological Services (CAPS) is a campus agency designated to provide psychological services to currently enrolled students free of charge. CAPS provides a variety of services from career assessment and stress management to crisis intervention. The office is located in Counseling Center 101, which is next to the UCF Health Center. <http://caps.sdes.ucf.edu/>

Career Services

Career Services offers a range of services to help UCF students of any major reach their academic and career goals. Career-planning services include: choosing and confirming educational and career choices, gaining career-related experience, developing effective job search skills and searching for full-time employment. Career Services is located in Building 140 on Memory Mall. <http://career.ucf.edu/>

Course Schedule

Course schedule is an approximation and will be updated throughout the semester. Please bring a laptop on days marked with an 'L'.

Week	Day	Topics	In-Class Activity	L?	Readings before Class
1	Jan 9 (2 hrs)	Introduction, What is Science? History of Science Science Versus Pseudoscience	Lecture		<ul style="list-style-type: none"> Naomi Oreskes' TED Talk Science vs. Pseudoscience: Where is the Difference?
	Jan 11 (1.5 hr)	Science Versus Pseudoscience	Discussion: Demarcation Problem		<ul style="list-style-type: none"> "The Demarcation Problem" - Massimo Pigliucci Take Demonstration Quiz
2	Jan 16 (2 hrs)	Cognitive Bias and Logical Fallacies The Dunning-Kruger Effect and Confirmation Bias	Lecture + Activity		<ul style="list-style-type: none"> Cognitive Bias List Logical Fallacy List Kruger and Dunning, 1999
	Jan 18 (1.5 hr)	Baloney Detection Methods	Discussion: Carl Sagan then and now		<ul style="list-style-type: none"> Finish reading <i>Demon-Haunted World</i>, re-read Ch 12: "The Fine Art of Baloney Detection" 20 Tips for Interpreting Claims
3	Jan 23 (2 hrs)	Decoding a Published Study Common Observational + Manipulative Approaches The Importance of Controls The Peer Review Process	Lecture, Discussion Sagan Essay Due		<ul style="list-style-type: none"> Motulsky Ch 25 How to Read a Scientific Paper How to (Seriously) Read a Scientific Paper Guide to Peer Review
	Jan 25 (1.5 hr)	Researcher Degrees of Freedom, P-hacking Method Reliability/Validity Publication Bias + Research Ethics	Lecture, Discussion		<ul style="list-style-type: none"> Statistics Done Wrong – Researcher Degrees of Freedom, Everybody Makes Mistakes, Hiding the Data Radiolab – "Stereothreat" Ben Goldacre's TED Talk Simmons et al. 2011 (Researcher DF)
4	Jan 30 (2 hrs)	Systematic Reviews and Meta-Analysis	Lecture Team Literature Review Project Planning		<ul style="list-style-type: none"> Cochrane Guide to SRs Sambunjak et al. 2011 (Flossing) Whitehead et al. 2017 (Crops) Schoenfeld and Ioannidis 2013 (Cancer) Project Rubrics for Draft + Final

	Feb 1 (1.5 hr)	Library Skills and Citation	Activity: Web of Science vs. Google Scholar	L	<ul style="list-style-type: none"> Beckmann and Von Wehrden 2012
5	Feb 6 (2 hrs)	Intuition, Statistics, and Probability Theory	Lecture, FlexStats Demonstration		<ul style="list-style-type: none"> Motulsky Ch 1-3 Statistics Done Wrong – P-values
	Feb 8 (1.5 hr)	Statistical Significance vs. Effect Size The Base Rate Fallacy	Lecture Discussion of Paper		<ul style="list-style-type: none"> Motulsky Ch 4, 18 Miller et al. 2000 (Whale Song) Klein et al. 2011 (SELECT) Carlson et al. 2015 (Telomeres)
6	Feb 13 (2 hrs)	Replication and Pseudoreplication Sample Size and Power, Bayesian Thinking	Lecture Discussion of Paper		<ul style="list-style-type: none"> Statistics Done Wrong- Statistical Power, Pseudoreplication, Regression to the Mean Hurlbert 1984 Davies and Gray 2015 Steidl et al 1997
	Feb 15 (1.5 hr)	Replication and Pseudoreplication Sample Size and Power, Bayesian Thinking	Data Workshop 1: Design and Power Analysis	L	
7	Feb 20 (2 hrs)	Data types and Distributions, Describing Variation	Lecture, Data Workshop 2: Data Visualization + Descriptive Statistics ASSIGNMENT 1 DUE	L	<ul style="list-style-type: none"> Motulsky Ch 5-11, 21
	Feb 22 (1.5 hr)	Best Practices for Figures	Activity: Figure Critique TEAM LITERATURE REVIEW PROPOSALS DUE		<ul style="list-style-type: none"> “How To Lie With Statistics” – Darrell Huff
8	Feb 27 (2 hrs)	Peer Review of Proposals	Peer Review of Proposals ASSIGNMENT 2 DUE		<ul style="list-style-type: none"> Rubric (each group review two other proposals, each proposal receives two reviews)

	Mar 1 (1.5 hr)	Hypothesis Testing and Significance Differences among Groups/Treatments	Lecture, Discussion		<ul style="list-style-type: none"> • Motulsky Ch 12-15, 19 • TBD
9	Mar 6 (2 hrs)	Hypothesis Testing and Significance Differences among Groups/Treatments	Data Workshop 3: Chi-Square, T-test, ANOVA	L	
	Mar 8 (1.5 hr)	Correlation and Regression Multiple and Logistic Regression	Lecture, Discussion		<ul style="list-style-type: none"> • Motulsky Ch 22-24 • TBD
10	--	Spring Break, No Class	--		--
11	Mar 20 (2 hrs)	Correlation and Regression Multiple and Logistic Regression	Data Workshop 4: Correlation Approaches ASSIGNMENT 3 DUE	L	
	Mar 22 (1.5 hr)	Factorial Designs, Split-Plot Designs Blocking and Block Designs	Lecture, Discussion		<ul style="list-style-type: none"> • TBD
12	Mar 27 (2 hrs)	Factorial Designs, Split-Plot Designs Blocking and Block Designs	Data Workshop 5: Two-way + Block designs ASSIGNMENT 4 DUE	L	
	Mar 29 (1.5 hr)	Repeated Measures/Time Series Data Analysis of Covariance	Lecture, Discussion		<ul style="list-style-type: none"> • TBD
13	April 3 (2 hrs)	Repeated Measures/Time Series Data Analysis of Covariance	Data Workshop 6: Time Series and ANCOVA ASSIGNMENT 5 DUE	L	
	April 5 (1.5 hr)	Multiple Comparisons and Type I Error Data Mining	Lecture, Discussion		<ul style="list-style-type: none"> • Motulsky 16-17, 25 • Statistics Done Wrong – Wrought? • Leung et al. 2014 and Slate Article • TBD
14	April 10 (2 hrs)	Science, the Media, and the Law	Discussion on Paper and Myriad Genetics ASSIGNMENT 6 DUE		<ul style="list-style-type: none"> • On the Media Consumer Handbooks • TBD

	April 12 (1.5 hr)	<u>Advanced Topics:</u> Principal Components Analysis Path Analysis <i>or others as requested</i>	Lecture		
15	April 17 (2 hrs)	Team Research Project Presentations	15 minutes each		<ul style="list-style-type: none"> • Final Team Research Projects Due • Research Reflections
	April 19 (1.5 hr)	Team Research Project Presentations	15 minutes each		