Experimental Design and Data Analysis in Biology **BSC 494**

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3 credit hours
Prerequisite: PSY 360, CSS 211, or permission of instructor.

Overview of Course:
This course is intended to familiarize students in biological sciences with the role of experiments in scientific discovery, and with basic concepts and tools of experimental design and statistical analysis in biological research. Students will learn how to design and execute an experiment, and how to use various statistical tools to estimate data parameters and test hypotheses. Upon completion of this course, students should be able to formulate a refutable hypothesis from biological theory, design an experiment to test this hypothesis, carry out this experiment, use an appropriate statistical analysis to test the hypothesis, interpret the results of this analysis in terms of the biological question(s) of interest, and communicate their findings to others. The primary objective of this course is to help students develop the logical, statistical, and critical thinking skills needed to undertake biological research, and to understand and evaluate others' research as published in the biological literature.

Coverage of various statistical tests will focus on when each test is appropriate or inappropriate, how to apply each test, and how to interpret the results of the analysis. The course will include many homework and class exercises, to give students practical experience at collecting data, handling data, conducting analyses, and generating tabular and graphical output from these analyses. The computational mechanics of individual analysis tools will be covered in lectures, to give students an understanding of how each test works, but laborious hand calculation will be kept to a minimum. Instead, students will use one of the many available statistical software packages to complete course assignments.

Required Textbook:
Zar, Jerrold H. 1999. *Biostatistical Analysis*. Fourth edition. Prentice-Hall, Upper Saddle River, New Jersey. 663 pp. ISBN: 0-13-081542-X.

Course Responsibilities:
1) Students will have assignments to be completed each week.
2) There will be one midterm and one final exam, where students will be required to answer questions about material covered in lectures, apply design and analysis concepts to novel situations, and critically evaluate experimental designs and analysis.

3) Students will be required to read and discuss several assigned papers from the statistical and biological literature. This will include classroom discussion of papers on statistical methodology, classroom critique of experimental design and analysis in published research papers, and classroom critique of graduate student presentations.
4) Students will also have to hand in one or more (depending on class size) written critiques of an empirical reseach paper from the peer-reviewed biological literature.
5) All students will have to complete and turn in a written research project, written in the style of a journal publication, with an Introduction, Materials and Methods, Results, and Discussion sections. These assignments may use real or hypothetical experiments and data, but all will require students to develop and explain one or more hypotheses to be tested, design and implement an experiment to test these hypotheses, conduct the experiment (collect data), analyze their data to test the hypotheses, interpret the results of their experiments, and discuss the meaning of their findings.

Grading:
The final grade for this course will be based on each student's scores on all exams, graded assignments, and projects, as detailed below.

Midterm exam	30%
Final exam	30%
Weekly Assignments	20%
Written critiques	10%
Research project	10%
Final Score	100%

All grades will be on a scale of 0 to 100 points. Letter grades will be assigned as follows:

90 to 100 = A
80 to 89 = B
70 to 79 = C
60 to 69 = D
Below 60 = F

Attendance:
There is no formal attendance requirement for this course. You are strongly encouraged to attend all classes, but it is your responsibility to make the most of your educational opportunities. You should note that this is a challenging course, and we will cover a great deal of complex material, much of which will only be explained during class. No special arrangements will be made to cover material you missed because of an absence. If you do not attend class, you will simply miss the material covered that day, and it will be very difficult to catch up if you fall behind. Do not expect to get by copying others' notes from class; it will not work.

If you miss an examination or practical because of absence, you will not automatically be allowed to take a make-up exam. If you are unable to take an exam at the scheduled time, you must contact me as soon as possible before the exam. If you have a valid reason that you can not make the exam time, I may make arrangements for you to take the exam at another time. Do not count on being allowed to take an exam at an alternate time; there are very few circumstances that I consider valid for this purpose. If you have not made prior arrangements with me, you will receive a score of zero on any exam that you miss. In the event of a last minute emergency, you should contact me as soon as possible, by telephone (leave a message if I am not in the office) or by e-mail. As a last resort, you can get a message to me by phoning the Department of Biological Sciences office (266-4748).

Cheating and Plagiarism:
Cheating and plagiarism are violations of the Code of Student Conduct (in your Student Handbook) and will not be tolerated. Anyone caught cheating will be penalized as proscribed by University Policy. The minimum academic penalty for any infractions will be a grade of zero on the assignment or exam associated with the violation.

Questions and Problems:
Students are encouraged to actively participate in class activities and to ask questions during class. If you do not understand something, ask a question. If the issue can not be clarified during class, make arrangements with the instructor to discuss the material later. I am here to help you learn, and will do my best to help resolve any difficulties you have with the course material. However, I can not help if I do not know that a problem exists.

Classroom Conduct:
While interaction with the instructor and with your fellow students is a valuable part of the learning process, disruptive behavior in the classroom is not acceptable. Show respect for your fellow students, and do not hinder their ability to participate and learn. The use of cellular phones, pagers, or other electronic devices during class is not allowed.

Students With Disabilities:
If a student has a disability that qualifies under the Americans with Disabilities Act and requires accommodations, he/she should contact the Office for Disability Accomodations for information on the appropriate policies and procedures. USM Box 8586; Tel: 266-5024; TTY: 266-6837; Fax: 266-6035.

Lecture Topics:

Role of experiments in biological research
- Hypothetico-deductive reasoning

Nature and types of biological data
- Variability and noise
- Continuous versus nominal variables

Descriptive statistics and data distributions

Sampling
- Independence of data
- Random versus representative sampling

Logical design of experiments
- Treatments and controls
- Replication and pseudoreplication

Hypothesis testing and probability
- Basis for the magical *P* value

Analysis of nominal data – contingency tables

Parametric versus nonparametric statistical tests
- Utility, power, and requisite assumptions

One sample and two sample tests

Analysis of variance
- One way, multi-way, nested, repeated measures

Correlation and regression

Analysis of covariance

Nonparametric statistical tests
- Mann-Whitney, Wilcoxon, Kruskal-Wallis

Multivariate analyses
- Multiple regression
- MANOVA
- Principle components analysis

Summarizing and presenting data and analysis results