

Advanced Biomedical Research Methods RSCH 496A

I. General Information:

- A. Course Number: ENGR 496 and NSCI 496 (Cross Listed)
- B. Title: Advanced Biomedical Research Methods
- C. Units: 3
- D. Prerequisites: Upper Division standing, completion of the GE Foundation, one or more Explorations courses and HHS361 or CLA361 or ENGR361 or NSCI361.
- F. Responsible Faculty: Various
- G. SCO Prepared by: Sorin, Eric (CNSM)
- H. Date Prepared / Revised: Spring 2015 / Fall 2015 / Spring 2016

II. Catalog Description

Advanced Biomedical Research Methods (3)

Prerequisite: Upper Division standing, completion of the GE Foundation, one or more Explorations courses and HHS361 or CLA361 or ENGR361 or NSCI361.

An advanced study of the theoretical and practical aspects of conducting biomedical research including hypothesis formulation, experimental design, assessment of error within empirical data, and the preparation of sound and fundable grant proposals.

III. Curriculum Justification

Currently, the majority of students in STEM fields do not receive formal training in the pursuit of scientific research. Advanced Biomedical Research Methods will build on the STEM training that our majors receive by giving them formal instruction in data analysis and interpretation, hypothesis generation, experimental design, communication of experimental observations, and the process of formulating compelling funding applications. The course will be open and accessible to a diverse student populace including majors from the CNSM, COE, CHHS (Health Sciences), and CLA (neuroscience). Students enrolling in this course will have identified scientific research as a long-term career goal; completed the GE Foundation, including a course in scientific and/or technical communication; and initiated their pursuit of scientific research in a local academic laboratory.

The requested GE Category is F: Advanced Skills (Research and Advanced Methods). Advanced Biomedical Research Methods will provide formal instruction in skills that are fundamental to pursuing graduate studies and a career in the biomedical sciences including Inquiry and Analysis, Quantitative Reasoning, and Written Communication. Students will learn to properly conduct statistical analysis of empirical data, as well as assessing the causes and numerical significance of errors within such data sets and the limitations of various empirical approaches. These skills will be applied to analyzing published data and data resulting from their own research projects, which will be followed by in-class presentation of their analytical efforts. Students will then undertake the complex process of identifying a research topic, investigating current knowledge of their topic of choice, developing and rationalizing hypotheses to be tested, and designing experiments to test those hypotheses. Although technical writing and oral communication will be a touchstone of this course from the first week forward, the course will culminate in the production of a high-caliber grant proposal centered on the students' topics of interest, in both written and oral forms, which will serve to significantly refine their scientific communication skills. Students will then garner advanced understanding of the peer-review process, which they will then put into practice by evaluating their peers' written and oral

proposals. Stress- and time-management skills will be integrated in to all of the activities and practiced to promote a life-long healthy lifestyle.

The CSULB Research Infused Curriculum:

Among the selling points in pursuing a college education is the idea that graduates will have the skills to discover new solutions to the community's challenges and lay the groundwork for the industries of the future. Much of this promise is directly supported when students are prepared to become research professionals in their respective fields.

CSULB will support the preparation of its graduates to pursue further research training in graduate programs and entry into research careers through its proposed "Research Infused Curriculum." In this integrated and research career focused curriculum, each course's content supports the other courses and provides the skills necessary to identify long-term research projects, design and implement research plans, prepare fundable research proposals, and communicate the findings of research to experts and the general population.

While individual programs may have courses that fit pieces of the curriculum, many programs don't have a large enough pool of research career focused students to offer discipline specific courses of this type. Through the "Research Infused Curriculum" such training will be made available to the larger population of CSULB students. To address degree unit caps, the proposed courses have been designed to meet general education certification.

The existence of these courses will not preclude programs from running or developing their own more discipline specific courses, and will give course options for those programs wishing to serve their majors desiring to pursue research careers. The curriculum will also help underscore the position of scholarly activity within the training CSULB students receive.

The four courses making up the "Research Infused Curriculum" includes:

Introduction to Research Methods – This sophomore level course begins the training of students to become productive researchers. Although the courses share common elements, two courses have been created to address differences in the Biomedical (ENGR296 & NSCI 296) and Behavioral (CLA 296 & HHS 296) discipline needs in an introductory research methods course.

Introduction to Health Disparities – This interdisciplinary course (HHS 207) is designed to provide a showcase for the ways differing disciplines address health challenges faced by subsets of the community and/or the community at large.

Research Communication – This cross-listed (CLA 361, ENGR 361, HHS 361, NSCI 361) junior level course focuses on the dissemination of research findings and the development of fundable research proposals.

Advanced Research Methods – This senior level course emphasizing the development of a program of research, including proposal development and funding. Although the courses share common elements, two courses have been created to address differences in the Biomedical (ENGR 496 & NSCI 496) and Behavioral (CLA 496 & HHS 496) discipline needs in an advance research methods course.

IV. Measurable Student Learning Outcomes (SLO), Evaluation Instruments, and

Instructional Strategies for Skill Development

This course can be categorized as an Advanced Skills general capstone F in the GE categories. The Essential Primary Skills of GE that can be developed by this course is 'Inquiry and Analysis' and the secondary GE skills is 'written communication.' The Student Learning Outcomes (SLOs), instructional strategies, and evaluation instruments are:

Course Outcomes: After taking this course, students will be able to:

- Investigate, hypothesize about, and design experiments to probe specific scientific problems.
- Perform statistical and error analyses on empirical data sets
- Present convincing scientific arguments in written and oral formats
- Prepare high-caliber scientific funding proposals
- Objectively evaluate (peer-review) scientific arguments and funding applications

GE Learning Outcomes:

- Inquiry and Analysis
 - Topic Selection, Existing Knowledge, Research, and/or Views
 - Design Process, Analysis, and Conclusions
 - Limitations and Implications
- Quantitative Reasoning
 - Interpretation, Representation, and Assumptions (Limitations)
 - Calculation and Application/Analysis
 - Communication (Expression of quantitative evidence)
- Written Communication
 - Context of and Purpose for Writing
 - Content Development
 - Sources and Evidence

The preceding learning outcomes should appear on all course syllabi.

V. Outline of Subject Matter

The primary topics to be covered in Advanced Biomedical Research Methods are designated below as A-D. Each primary topic is followed by a list of relevant Student Learning Outcomes. Instructors are expected to cover some or all of the listed subject matter for each primary topic. This course is intended to be activity-driven so that students are engaged with guided-discovery and improvement of their own strengths and weaknesses as young scientists.

The course is designed around the premise that students who are actively engaged in directing their own academic and career trajectories are more likely to stay on task and realize their planned objectives. Thus, while an aspect of this course is designed to inform students of standard scientific conventions and methods, its principal goal is to motivate the students to plan and achieve a life-long academic career focused upon innovative research.

(A) Appreciate hypothesis-driven and curiosity-driven approaches to designing experiments and the processes of publishing and presenting one's results.

- SLO: Distinguish between basic, applied, translational, and clinical research approaches and paradigms.
- SLO: Apply the scientific method to design and critically assess experimental procedures and the conclusions drawn from empirical data.

- SLO: Appreciate the complementary nature of experimental, theoretical, and computation/modeling approaches in scientific inquiry.
- SLO: Compare and contrast the various types of scientific publications, and identify and assess metrics commonly used to judge the quality of scientific publications.
- SLO: Discuss, practice, and assess the manuscript preparation and peer-review processes.
- SLO: Weigh the importance and severity of experimental mistakes, errata, and fraudulent reporting.

(B) Understand population versus sample statistics and the identification and quantification of experimental error inherent to data collection and interpretation.

- SLO: Identify sources and types of errors in experimental procedures and weigh their significance.
- SLO: Conduct statistical characterization of collected data, assess confidence intervals, and identify outliers.
- SLO: Propagate quantitative errors associated with multiple values within a numerical analysis; visualize and interpret data with error bars.
- SLO: Fit quantitative data, with errors, to analytical models and assess the quality of such fits.
- SLO: Apply basic computer programming to perform data analysis and statistical characterization using common scientific software (Mathematica, MatLab).

(C) Learn to interpret and assess unfamiliar experimental methods, techniques used in post-processing data analysis, and the conclusions that result.

- SLO: Critically analyze, and identify the limitations within, past studies.
- SLO: Investigate and assess unfamiliar experimental techniques and methods of analyzing data, including both fundamental and cutting-edge methods.
- SLO: Define resolution and the resulting experimental constraints needed to probe questions of interest.
- SLO: Draw connections between new and previously applied methods, and assess contradictory results stemming from varying approaches.

(D) Understand the processes of project planning and the preparation of funding applications.

- SLO: Analyze and interpret the results of preliminary data with the mindset of planning a complete experiment.
- SLO: Define a research project: based on the scientific literature, develop a list of research questions to be addressed and hypotheses to be tested, including rationales for each hypothesis, and design a series of experiments to undertake the project.
- SLO: Identify appropriate funding agencies and programs that could fund the project of interest.
- SLO: After reviewing the most recent literature relevant to the project, compose a statement of the problem, a list of goals and objectives, a research plan and timeline, and an evaluation plan with expected outcomes.
- SLO: Assemble a research budget (faculty start-up and/or single-PI research project), while employing both cost-versus-benefit and risk-versus-reward reasoning.
- SLO: Assemble a complete, professional quality grant proposal and participate in peer-review of others' written proposals.

VI. Methods of Instruction

As this course focuses on Inquiry and Analysis, Quantitative Reasoning, and Written (and oral) Communication skills, formal lectures will be minimized in favor of a discussion-driven, active-

learning environment in which students regularly engage in exploring scientific conventions and methods, evaluating and critically assessing those conventions and methods, and developing the skills needed to be successful research scientists. Online assignments and instruction will be integrated into the standard classroom discussion to promote independent thought and to allow for assessment of individual motivation and success, as will student-led application and critical discussion of course content.

VII. Extent and Nature of the Use of Technology

- A. Power Point presentations for lectures and guided discussions
- B. Web-based or internet research for student assignments and projects.
- C. Video recording and presentations.
- D. Computer word-processing for student assignments.
- E. Internet based searches to evaluate PhD programs, funding opportunities and published research articles.

VIII. Bibliography (one page limit)

- a) Taylor, John R. "An Introduction to Error Analysis, 2nd Edition". University Science Books, 1996.
- b) Fleming, Edward G. "An Introduction To Error Analysis: Calculating the Value of Uncertainty When Using Measured Values". CreateSpace Independent Publishing Platform, 2014.
- c) Glass, David J. "Experimental Design for Biologists, Second Edition". Cold Spring Harbor Laboratory Press, 2014.
- d) NIST. "Engineering Statistics Handbook". National Institute of Standards and Technology/Dept. of Commerce, <http://www.itl.nist.gov/div898/handbook/>.
- e) Gregory, Paul A. "A Brief Introduction to Logic". Washington and Lee University, <http://philosophy.wlu.edu/gregoryp/class/Brief%20Intro.pdf>.
- f) Hurley, Patrick J. "A Concise Introduction to Logic, 12th Ed." Cengage Learning, 2014.

IX. Instructional Policies Requirements

Instructors may specify their own policies with regard to plagiarism, withdrawal, absences, etc., as long as the policies are consistent with the University policies published in the CSULB Catalog. It is expected that every course will follow University policies on Attendance (PS 01-01), Course Syllabi and Standard Course Outlines (PS 11-07), Final Course Grades, Grading Procedures, and Final Assessments (PS 05-07), and Withdrawals (PS 02-02). All sections of the course will have a syllabus that includes the information required by the syllabus policy adopted by the Academic Senate. Instructors will include information on how students may make up work for excused absences. When class participation is a required part of the course, syllabi will include information on how participation is assessed. When improvement in oral communication is an objective of the course, syllabi will include a rubric for how oral communication is to be evaluated.

X. Student-Level Assessment

University policy requires that no single evaluation of student achievement may count for more than one-third of final grade. Appropriate assignments may include:

1. Writing Assignments designed to challenge and hone students' skills in evidence-supported technical composition, with an emphasis on argument-based communication.
2. In-class and take-home exercises to promote application of course materials in real-world contexts and to allow assessment of students' understanding of those materials.
3. Midterm examinations (2) to assess students' knowledge of, and ability to apply, topics/concepts inherent to course objectives and stated learning outcomes.
4. Final course project in written and oral formats: the written research proposal and oral presentation of the material within that proposal may account for approx. one third of available points in the course; this capstone project will allow students to demonstrate their appreciation for, and ability to apply, all course materials in a single effort, alongside their ability to effectively communicate scientific information at an advanced level in both written and oral formats.

To ensure continuity in the curriculum, instructors must use each of the following assessments.

1. Numerous written assignments that allow for assessment of students' technical writing skills and ability to compose logically sound arguments.
2. Numerous opportunities for peer-review of written assignments to foster development of perpetual analysis of logical rigor and technical precision in all scientific documents.
3. In-class exercises and numeric assignments to foster student learning and appreciation of topics in statistical and error analysis, including application of these concepts to an interdisciplinary, real-world data set that requires the use of a commonly-used modeling software (Excel, Mathematica, MatLab, etc.).
4. In-class exercises and conceptual assignments to foster student learning and appreciation of fundamental scientific concepts including hypothesis generation and testing; methodological limitations; the logic of scientific argument; and budgeting.
5. Final course project in written and oral formats: this capstone course project will center on preparing a formal, high-caliber research proposal, including the presentation of preliminary and/or published evidentiary data, project budget, and timeline.

Instructors must follow the general policy on grading outlined by their institution. For CSU Long Beach, the final course grades must be based on at least three separate evaluations of student achievement and the final exam may count for no more than one-third of the final course grade. Aside from these constraints, the exact number of assignments and value of each assignment is left to the discretion of each instructor.

XI. Course Level Assessment

- A. Exam grades will be used to assess students' learning of critical, foundational and research information contained in the SLO's.
- B. GE skills will be assessed utilizing rubrics and criteria sheets generated by faculty and based on best-practices for each domain assessed. All instructors will utilize the same rubrics and criteria sheets for all skill-based assessments.
- C. When applicable, at the close of the each semester, the Faculty Coordinator for the course will convene a meeting of all instructors to conduct an assessment of all rubrics, and any necessary edits will be made at that time.

XII. Consistency of SCO Standards Across Sections

Course instructors meet twice a semester, once at the beginning and once at the end. They review course assignments, criteria sheets and student outcomes. As a result of the meetings, necessary changes are made in instruction and assignments. All course syllabi are in close alignment with the SCO. All course sections use the same textbook and grading guidelines for assessments.

XIII. FACULTY INSTRUCTIONAL REQUIREMENTS

A. Textbooks

Instructors must assign written materials (textbook, workbook reading packet, handouts, etc.) that reflect all Course Objectives and Outcomes (Section III). These materials also should cover the information listed under each primary topic (A-D) described in the Outline of Content (section IV). Recommended and acceptable textbooks include:

Suggested resources to consider:

- g) Taylor, John R. "An Introduction to Error Analysis, 2nd Edition". University Science Books, 1996.
- h) Fleming, Edward G. "An Introduction To Error Analysis: Calculating the Value of Uncertainty When Using Measured Values". CreateSpace Independent Publishing Platform, 2014.
- i) Glass, David J. "Experimental Design for Biologists, Second Edition". Cold Spring Harbor Laboratory Press, 2014.
- j) NIST. "Engineering Statistics Handbook". National Institute of Standards and Technology/Dept. of Commerce, <http://www.itl.nist.gov/div898/handbook/>.

B. Other Required Materials

Publications from the scientific literature and online resources, as needed

XV. COURSE OUTLINE (order may vary by instructor)

Course Component	Associated Student Learning Outcomes
Hypothesis-driven and curiosity-driven approaches (approx. 2 weeks) <ul style="list-style-type: none">○ The scientific method & alternative flows of research design○ Ethics in research: mistakes, errata, and fraud○ The peer-review system in publishing and funding of grants	<ul style="list-style-type: none">• Distinguish between basic, applied, translational, and clinical research approaches and paradigms.• Apply the scientific method to design and critically assess experimental procedures and the conclusions drawn from empirical data.• Compare and contrast the various types of scientific publications, and identify and assess metrics commonly used to judge the quality of scientific publications.• Discuss, practice, and assess the manuscript preparation and peer-review processes.

	<ul style="list-style-type: none"> • Weigh the importance and severity of experimental mistakes, errata, and fraudulent reporting.
<p>Statistical analysis & error analysis (approx. 2 weeks)</p> <ul style="list-style-type: none"> ○ Sources of experimental and numerical error ○ Error propagation and effects of error on fitting to quantitative models ○ Variance, regression, t-test, Q-test, outliers ○ Hands-on, software-based statistical and error-analysis workshops 	<ul style="list-style-type: none"> • Identify sources and types of errors in experimental procedures and weigh their significance. • Conduct statistical characterization of collected data, assess confidence intervals, and identify outliers. • Propagate quantitative errors associated with multiple values within a numerical analysis; visualize and interpret data with error bars. • Fit quantitative data, with errors, to analytical models and assess the quality of such fits.
<p>Data analysis: the complementarity of experiment and modeling (approx. 1 week)</p> <ul style="list-style-type: none"> ○ Hands-on learning: the modeling of kinetic data (relevant for all biomedical fields) ○ Students to apply statistical analysis, error analysis, and best-fit modeling 	<ul style="list-style-type: none"> • Appreciate the complementary nature of experimental, theoretical, and computation/modeling approaches in scientific inquiry. • Apply basic computer programming to perform data analysis and statistical characterization using common scientific software (Mathematica, MatLab).
<p>More complex analysis methods and critical analysis of the literature (approx. 3 weeks)</p> <ul style="list-style-type: none"> ○ How to learn and appreciate new analytical methods found in the literature ○ Applied skepticism: over- and under-interpretation, testing “speculative” interpretations ○ Interpret and evaluate analytical methods within published research articles ○ Students to identify, study, and present a novel analytical method 	<ul style="list-style-type: none"> • Critically analyze, and identify the limitations within, past studies. • Investigate and assess unfamiliar experimental techniques and methods of analyzing data, including both fundamental and cutting-edge methods. • Define resolution and the resulting experimental constraints needed to probe questions of interest. • Draw connections between new and previously applied methods, and assess contradictory results stemming from varying approaches.
<p>The logic of scientific arguments, advanced writing and critiquing skills (approx. 2 weeks)</p> <ul style="list-style-type: none"> ○ Argument structure and components ○ Deductive and inductive reasoning, validity, and soundness ○ Formal fallacies 	<ul style="list-style-type: none"> • Distinguish between deductive and inductive arguments, and identify formal fallacies within such arguments. • Assess and critique the structure, reasoning, validity, and soundness of published scientific texts. • Analyze the logical writing of self and peers and apply such analysis during composition of final course projects.

Final project: research grant identification and proposal

(approx. 5 weeks)

- Budgeting, cost analysis, and cost/benefit thinking
- Graduate Research Fellowship application (with complete budget)
- Written and oral presentation of proposal
- Peer-review of students' oral and written proposals

- Analyze and interpret the results of preliminary data with the mindset of planning a complete experiment.
- Define a research project: based on the scientific literature, develop a list of research questions to be addressed and hypotheses to be tested, including rationales for each hypothesis, and design a series of experiments to undertake the project.
- Identify appropriate funding agencies and programs that could fund the project of interest.
- After reviewing the most recent literature relevant to the project, compose a statement of the problem, a list of goals and objectives, a research plan and timeline, and an evaluation plan with expected outcomes.
- Assemble a research budget (faculty start-up and/or single-PI research project), while employing both cost-versus-benefit and risk-versus-reward reasoning.
- Assemble a complete, professional quality grant proposal and participate in peer-review of others' written proposals.
- Demonstrate advanced use of technical PowerPoint presentations including discussion of data in the form of figures, tables, and related graphical representations.