MCB 198: Contemporary Research the Modern Scientific Method

Course description:
This course gives a bird’s eye view of how to apply scientific thinking to generate new questions and ideas in science. By studying relevant areas of contemporary neuroscience research, students will gain an understanding of how scientific knowledge is produced and expanded upon. Topics of discussion will include functional and structural analysis of ion channels, methods of investigating neuronal function, non-model organisms and visualizing protein expression. Primary reading material will be research papers, with references to textbook chapters for background and review.

Learning Goals
The goal of this class is to provide students low-stress opportunities to delve into scientific thinking and learn how to apply the scientific method to academic science questions. Students will learn how to read scientific papers, extract essential details from these papers, interpret results, and learn to develop their own scientific ideas.

Key concepts include how to manage scientific controls, how to design experiments to generate a desired outcome, and how to apply entry-level statistical tests. It is important to note that the goal of this class is not to teach any specific scientific topics or the details of specific statistical analyses, but rather to investigate and understand how these aspects of scientific research inform one another.

Prerequisites:
Required:
Bio 1A, or an equivalent course

Recommended:
MCB 160, MCB136, or an equivalent course.

Instructors:
Trevor Docter – Trevor_Docter@berkeley.edu.
Office hours: Monday morning 9:00 to 10:00 AM.

Organization:
This course will be held once a week for 90 minutes on Thursday mornings from 9:30 AM to 11:00 AM This class will meet a total of 14 times. We strongly encourage you to attend the lectures while they are being presented, as an essential pillar of this class is participating in discussion and engaging directly with lecture material. Each session will be divided into 50 minutes of lecture material, 20 minutes of individual / pair work, and 20 minutes of group discussion. Lectures will not be recorded unless there is a specific need for lectures to be recorded. Reading, problem sets, and lecture slides will be posted before class on bCourses. Maximum 20 students.

Grading:
Final grades will be based on class participation and a final project at the end of the semester. The grade for this class will follow the normal DeCal grading scheme of P/NP.
Evaluation will be entirely completion based. There will be three types of activities for students as follows:

1. Entry / Exit tickets.
2. Weekly experiment proposal worksheets
3. Final assignment

Each of these assignments are weighted equally. Failure to complete one of these assignments can result in an NP. More information will be provided about this during the first class session.

Final assignment:
There will only be one formal assignment for this class. At the end of the semester students will work in pairs on pre-analyzed data from a UC Berkeley laboratory. Students will need to interpret the results of these data and propose a series of follow-up projects to further investigate the topic at hand. Groups will be allowed to choose between up to 5 topics. Reports will be written as NIH-style proposals with specific aims and approaches and custom-made figures for their reports.

Textbook / Reading Requirements:
Most reading for this class will be papers presented during lecture periods. They are not required reading, but you are encouraged to read these papers and come with questions, or reach out to your instructor with questions directly.

There is no required textbook for this course, but these will be useful references:
4. "Vander's Human Physiology" 13th (or any other Edition) is a good reference.

Available as an e-book through the UC Library:
1. Free physiology e-book from the UC library: https://www.lib.berkeley.edu/research-support/books-ebooks

Safe, Supportive, and Inclusive Environment:
Whenever a faculty member, staff member, post-doc, or GSI is responsible for the supervision of a student, a personal relationship between them of a romantic or sexual nature, even if consensual, is against university policy. Any such relationship jeopardizes the integrity of the educational process. Although faculty and staff can act as excellent resources for students, you should be aware that they are required to report any violations of this campus policy. If you wish
to have a confidential discussion on matters related to this policy, you may contact the Confidential Care Advocates on campus for support related to counseling or sensitive issues. Appointments can be made by calling (510) 642-1988.

The classroom, lab, and workplace should be safe and inclusive environments for everyone. The Office for the Prevention of Harassment and Discrimination (OPHD) is responsible for ensuring the University provides an environment for faculty, staff and students that is free from discrimination and harassment on the basis of categories including race, color, national origin, age, sex, gender, gender identity, and sexual orientation. Questions or concerns? Call (510) 643-7985, email ask_ophd@berkeley.edu, or go to http://survorsupport.berkeley.edu/.

Diversity statement:

The University of California considers the diversity of its students, faculty, and staff to be a strength and critical to its educational mission. Our community is enriched and enhanced by diversity along a number of dimensions, including race, ethnicity, national origins, gender, sexuality, class and religion. We welcome all our students in our class and hope that you always feel included. If there are aspects of the instruction within this course that result in barriers to your inclusion, please let us know. Your suggestions are encouraged and appreciated.

DSP accommodations:

Students who need academic accommodations, should request them from the Disabled Students' Program, 260 César Chávez Center, 642-0518 (voice or TTY), https://dsp.berkeley.edu. DSP is the campus office responsible for verifying disability-related need for academic accommodations, assessing that need, and for planning accommodations in cooperation with students and instructors as needed and consistent with course requirements. We welcome students with disabilities in this course and will provide the accommodations in your DSP letter. Please discuss your accommodations with an instructor during the first weeks of the semester. We are here to help you.

Services for Students Encountering Food and Housing Insecurity:

If you are in a situation where you are facing challenges in gaining access to nutritious, affordable food during the semester, you can find help by going to the UC Berkeley basic needs program, the UC Berkeley Food Pantry, and/or the CalFresh program. Links below:

http://basicneeds.berkeley.edu/

https://pantry.berkeley.edu/

https://www.getcalfresh.org/

Other resources:

A list of important resources for all students can be found at the link below. You will find links for mental health, medical needs, sexual harassment, the Gender Equity Resource Center, emergency food/cash/housing needs, legal support and disability accommodations. Please use these resources whenever you need them.
Schedule:

Class and topic schedule is as follows:

1. **Week one – orientation, registration, and syllabus review**
   a. For this session we will go over the syllabus and conduct a pulse survey to ensure the class is properly tailored to the students’ needs and knowledge levels.

2. **Understanding perception** – How questions about mammalian perception of wetness allows for robust lines of questioning. Weeks 2 & 3.
   a. **Session one**: We will cover the fundamentals of sensory perception in mammals. We will focus predominantly on how humans perceive “wetness” and how this experience differs from other organisms.
      i. **Learning goals**: Review the fundamentals of sensory perception and how these systems work. Apply this knowledge and previous knowledge about sensory perception to predict and develop a model for how wetness perception may work. Students will develop experiments to test their theory.
   b. **Session two**: Review experiments proposed in session one. We will then learn about the specifics of wetness perception and will look at some “obfuscated” data that tests how these systems work.
      i. **Learning goals**: Students will interpret data from published works without having read the entire paper. They will propose follow-up experiments to prove or deny any conclusions they come to and design next steps. This will then be compared to the actual paper and students will need to evaluate how their interpretation differs from that of the paper and we will try to figure out why.

3. **The brain from inside out** – How the epistemological framework of psychology impacts how we approach neuroscience and impacts how we interpret neuroscience research. Weeks 4 & 5
   a. **Session one**: This section will focus on a recently proposed concept by Győrgy Buzsáki: learning about the brain from inside out. We will dive into the logic of how we come to conclusions about high-level cognitive processes and where our concepts for these processes come from. This class will be largely discussion based.
      i. **Learning goals**: Students will investigate different forms of cognitive research – from humans to animal models. Students will create maps to visualize where our concepts for neurological models of cognition come from.
   b. **Session two**: This session will expand from session one to develop new experiments to test this concept of “The brain from inside out.”
      i. **Learning goals**: Students will work in groups to develop experiments that follow the “brain from inside out” paradigm. Students will propose potential results to these experiments and will explain how these experiments don’t follow a brain from outside-in methodology. Students should leave this section with a new approach of how to think about scientific and in particular, neuroscientific concepts.
4. **Model & non-model organisms – how do we select what animals we use in research?** In this section we will talk about model organisms and non-model organisms. We will talk about how looking outside of traditional model organisms allows us to learn about our history and provides new avenues for understanding how our brains work. **Weeks 6 & 7**

   a. **Session One:** We will cover the basics of model organisms focusing on mice, zebrafish, and fruit flies. We will then enter the world of non-model organisms and talk about a series of different non-model organisms including, but not limited to, naked mole rats, octopuses, and cuttlefish.

      i. **Learning goals:** We will review fundamentals of choosing a model organism and enter into discussions about when and where it is ideal to use a non-model organism and what we can learn from these non-model organisms. Students will group up and select a non-model organism to conduct research on and prepare a presentation for the second section.

   b. **Session Two:** Students will take turns presenting original research about their non-model organism.

      i. **Learning goals:** Students will present on why their organism was chosen; what researchers learned from this organism and why this information could not be obtained from one of our model organisms. Students will answer complex questions about their animal model: If this information or similar information could be obtained from another organism, what distinguishes their results from what you would expect to see in other organisms?

5. **Functional and structural characterization of ion channels – How we can look at ion channel function at different levels of neuroscience, from the system to the molecule.** **Weeks 8 – 10**

   a. **Sessions One and Two:** We will cover how we study ion channels. We will discuss different techniques for recording ion channel activity (whole-cell versus patch recordings) and what information can derived from these different techniques. We will then discuss how the structures of ion channels can be determined. We will talk about different techniques (X-ray crystallography and Cryo-EM). Session one will largely focus on **structural** characterization and session two will focus more on **functional** characterization.

      i. **Learning goals:** Review the fundamentals of ion-channel function and how these systems work. Students will apply this knowledge to design experiments to study different families of ion channels. Students will be given data to interpret for session two. They will propose follow-up experiments to prove or deny any conclusions they come to and design next steps. This will then be compared to the actual paper and students will need to evaluate how their interpretation differs from that of the paper and we will try to figure out why.

   b. **Session Three:** Review data students interpreted in sessions one and two. We will then go over specific examples of how researchers have studied specific ion channels in the past.

      i. **Learning goals:** Students will discuss with each other how to interpret the ion-channel data that was given in session one. Students will then analyze the different presented examples of ion channel studies and will evaluate if the claims made can be fully explained by the data at hand.
6. **Imaging in neuroscience** – how we get a picture of the brain, what those images mean, and how we decide what kind of images to take. Weeks 11 & 12
   a. **Session One**: This section will review different scales of imaging. This unit will cover bright-field, confocal, two-photon, STED/STORM, and electron-microscopy. This list is not exhaustive. We will cover the differences between techniques and when each technique is traditionally used.
      i. **Learning goals**: Students will review the basics of biological imaging. Students will then synthesize an experiment that would require one of these types of imaging and will explain why that form of imaging is ideal for their experiment.
   b. **Session Two**: We will cover examples of the shortcomings of different imaging techniques and where an imaging technique does not provide enough information for a claim and look at why.
      i. **Learning goals**: Students will need to evaluate different scientific claims in relation to provided data and decide if the claim goes too far and why. Students will then propose additional experiments that may be able to provide needed details to allow for the claim to be considered true.

7. **Final project.** Weeks 12 – 14.
   a. Briefly detailed above. Weeks 12/13 students will have class time to ask questions and meet as a group to discuss their project. Week 14 students will give a 15-minute presentation of their project.