NEU 152 - Neurotechnology (Spring 2025)

Tier 3: 3-unit in-person course
Format: 3 hrs of LEC
TTh 12:30p-2p, Donner lab 155

Instructors:

Markita Landry, landry@berkeley.edu
Preeya Khanna, pkhanna@berkeley.edu
Office hours for Prof. Khanna: Tuesdays 3:30-4:30pm in 519 Cory Hall (January 21 – March 4)

Office hours for Prof. Landry: Thursdays 2:30-3:30 pm in 106 Gilman Hall (March 6 – May 1)

Graduate Student Instructor:

Vidhi Sinha, vidhisinha@berkeley.edu
Office hours: TBD from student poll

Health safety guidelines:

If you feel unwell, please do not come to class and the course instructors are glad to make accommodations for your absence. We will be posting all course slides, and posting recordings of all class sessions, so if you are unwell you can have access to all of the course materials without coming into class. If you are unwell during an in-course exam or presentation, reach out to your instructors and we can reschedule your exam or provide remote accommodations.

Course Description and Objective:

NEU 152 is a comprehensive course covering topics in emerging neurotechnology including a primer on the basic rates and biophysical timescales of cellular processes, electrophysiological recordings, electrical stimulation of nervous tissue, and discussions on how technologies can be built to understand and control the nervous system.

In the first part of the course, we will focus on technologies to monitor and manipulate the nervous system that have been leveraged for use in implantable medical devices and brain-machine interface applications. This includes high-density extracellular electrophysiology and invasive and non-invasive neurostimulation techniques. We will review fundamental electrophysiological principles underlying recording and stimulation techniques, including the neuron's action potential, population electrophysiological signals, neuroplasticity, and population neural excitability. We will discuss advances in recording and stimulation materials, wireless communication approaches, and algorithmic design of neuromodulation interventions with a focus on movement disorders applications. In the second part of the course, we will describe technologies prolifically used to learn about the brain, focusing on electron and fluorescence microscopy, and including recent advances in these technologies such as super-resolution and expansion microscopy. We will discuss how these technologies have built the knowledge base of modern cellular and circuits neuroscience. We will also discuss technologies that we can use to measure neuron activity and neurochemical efflux, fundamental processes which drive higher cognitive and motor function.

Student preparation:

It is expected that students have the knowledge and background equivalent of junior- or senior-level neuroscience or BioE students + an introductory biology course. Prerequisites include 1) Biology 1A *or* Bioengineering 11 *and* 2) Physics 7A.

Homework Sets
- Assigned weekly
- Homework solutions posted a week later

- Homework sets not graded, but similar in structure and scope to exam questions

Example reading assignments:
- Beyene, A.G.*, Delevich, K.*, Yang, S.J., Landry, M.P. New Optical Probes Bring Dopamine to Light. ACS Biochemistry (2018)
- Emerging Horizons in Neuromodulation Clement Hamani, Elena Moro, in International Review of Neurobiology, 2012
- Fluorescence microscopy Jeff W Lichtman & José-Angel Conchello, Nature Methods (2005)

Course structure:
- No required textbooks – reading assignments posted prior to every lecture
- No final exam – final presentation and project in lieu of final exam
- Course website: https://bcourses.berkeley.edu/courses/1541717

Grading:
- 2 Midterm exams (both midterms will be in-class exams) (60% total; 30 % each).
- Final project (40%): In groups of 3-4, students will peer review a manuscript in the scientific literature. Students will be tasked with reading through, and editing, a scientific manuscript posted to the bioRxiv preprint server. Students will be provided with a grading rubric for their critique of the manuscript and will be expected to email their critique to the corresponding author of the manuscript.

Final Project information:

The final project will take place in a take-home format, where you will use out of class time to complete the project with your group. **Your final project will be due on the first day of the final exam period.**

The process of peer-review ensures that literature is reviewed by experts in the field prior to publication. However, the process of peer review, editing, revisions, and publication can be lengthy, and is thought by some to delay the public sharing of results on which scientific progress is based. Therefore, an increasingly common practice is for research groups to post 'preprints', which are research manuscripts that have not yet (or are in the process of undergoing) peer-review. Preprints are posted to servers that are accessible by scientists and the public, and can be updated by the authors anytime new results become available. Additionally, comments can be posted to preprints, as can suggestions for additional experiments or questions pertinent to the work being presented.

Good practice in science relies on the expertise of the scientific community, and also the public, to provide feedback to research being shared on preprint servers. You will help contribute by editing a *bioRxiv* preprint, and sending your review to the corresponding author (primary investigator, lead investigator) of the preprint author. Your goal is to generate a short summary of the work being presented in the preprint, followed by a list of suggestions by which the authors can strengthen their work. While participating in this project, you will learn how to write with a neutral tone and how to find resources that educate you on this topic. Through participation in this project, you will learn how to critically analyze a scientific manuscript that has not yet been through review by experts in the field.

Learning objectives:

• Develop analysis skills by learning how to identify the hypothesis, results, and conclusion of a research article that has not yet undergone peer review (i.e. a preprint).

• Perform a literature search to determine whether the study being presented is novel within the field.

• Gain an understanding for how scientific articles are edited in the scientific community.

• Collaborate with students to develop and achieve actionable goals.

• Communicate with a principal investigator of the study you are evaluating, to share your suggestions for strengthening their scientific manuscript.

Course help:

You're not alone in this course; the instructor and GSIs are here to support you as you learn the material. It is expected that some aspects of this course will take time to grasp, and the best way to grasp challenging material is to ask questions. You are encouraged to do this during lecture, after class, and/or in office hours.

Students with Disabilities and absences due to illness:

If you require course accommodations due to a physical, emotional, or learning disability, contact UC Berkeley's Disabled Students Program (DSP). Notify the instructor and GSI through course email of the accommodations you would like to use. You must have a Letter of Accommodation on file with UC Berkeley to have accommodations made in the course. UC Berkeley is committed to providing robust educational experiences for all learners. We will be glad to record course lectures for students who need to miss class occasionally due to illness or personal emergencies, though note that these recorded lectures are *not* a substitute for consistent in-person attendance otherwise. Recorded lectures are also a good resource for students who wish to re-review lecture materials on their own time or to prepare for course assessments.

Statement on Academic Integrity

You're a member of an academic community at one of the world's leading research universities. Berkeley creates knowledge that has a lasting impact in the world of ideas and on the lives of others; such knowledge can come from an undergraduate paper as well as the lab of an internationally known professor. One of the most important values of an academic community is the balance between the free flow of ideas and the respect for the intellectual property of others. Scholars and students always use proper citations in papers; professors may not circulate or publish student papers without the writer's permission; and students may not circulate or post materials (handouts, exams, syllabi—any class materials) from their classes without the written permission of the instructor.

Any test, paper or report submitted by you and that bears your name is presumed to be your own original work that has not previously been submitted for credit in another course unless you obtain prior written approval to do so from your instructor. In all of your assignments, including your homework or drafts of papers, you may use words or ideas written by other individuals in publications, websites, or other sources, but only with proper attribution. If you're unclear about the expectations for completing an assignment or taking a test or examination, be sure to seek clarification from your instructor or GSI beforehand. For additional information on plagiarism and how to avoid it, read the UC Berkeley Library Citation Page, Plagiarism Section.

As a member of the campus community, you're expected to demonstrate integrity in all of your academic endeavors and will be evaluated on your own merits. The consequences of cheating and academic dishonesty—including a formal discipline file, possible loss of future internship, scholarship, or employment opportunities, and denial of admission to graduate school—are simply not worth it. Read more about Berkeley's Honor Code.

Statement on Collaboration

Reviewing lecture and reading materials and studying for exams can be enjoyable and enriching things to do together with one's fellow students. We recommend this. However, homework assignments should be completed independently and materials turned in as homework should be the result of one's own independent work. Some assignments, namely the final project, are meant to be done together in a group.

Statement on the use of AI tools

While tools like ChatGPT can be incredibly useful for quickly performing simple writing tasks, remember that they have not been trained to perform the same level of evidence-backed analysis that is expected of your group

in your final project. These tools can invent non-existent citations, often make broad assertions without citations, and only tend to provide very surface-level summaries of scientific concepts. Since you will be submitting this final project to the **actual authors of the study**, you'll want to make sure you do your absolute best to understand their study and provide constructive feedback. As outlined above, the scientific community relies on this service from its members to identify weaknesses and provide real suggestions for strengthening studies. Finally, per the plagiarism guidelines mentioned above, you are required to cite AI-generated content if it contributes significantly to your work. Use phrases like: "This summary was partially generated using ChatGPT."

Tentative Course Outline: 27 class meetings including 2 in-class midterms and 4 guest speakers (no class on midterm dates):

Part I: Monitoring and modulating the brain with electrophysiology and electric neuromodulation
Jan 21 – Introduction to the course, Introduction to electrophysiological recording of action potentials
Jan 23 -- Field potential signals
Jan 28 -- Brain-Computer Interfaces (BCI) for cursor and movement control
Jan 30 -- BCIs for speech
Feb 4 -- Electrical neuromodulation of the brain
Feb 6 – BCIs and electrical neuromodulation for upper limb rehabilitation
Feb 11 – GUEST SPEAKER – closed-loop stimulation for Parkinson's disease
Feb 13 – Electrical neuromodulation of the peripheral nervous system
Feb 18 – Non-electrical neuromodulation methods
Feb 20 - AI in Neurotech
Feb 25 – GUEST SPEAKER – principles of neurotechnology device design
Feb 27 -- GSI REVIEW SESSION
March 4 – MIDTERM 1

Part II: "Molecular" tools to study the brain
March 6 – Overview of central dogma in neuroscience – cells and synapses
March 11 – Protein folding and disorders thereof in neuroscience + enzyme inhibition
March 13 – DNA sequencing and inherited neurological diseases
March 18 – Dr. Daniel Robbins – Drug development for CNS disorders
March 20 – Basics of fluorescence microscopy & electron microscopy
April 1 – Basics of neurochemical communication – synaptic neurochemical signaling
April 3 – Tools to image the brain "anatomy" and "electricity" – IHC, expansion microscopy, Brain cell atlas, and neuronal activity, Ca 2+ indicators
April 8 – Tools to image brain chemistry – FSCV, microdialysis, CNIFERs, FFNs, FVNs, GPCR based probes
April 10 – Tools to image brain chemistry part 2 – applications to study neurodegeneration, addiction, developmental disorders
April 15 – Dr. Lenia Chae, Counseling Psychologist: Mental health
April 17 – GSI REVIEW SESSION
April 22 – MIDTERM 2
April 24 – Experimental Design
April 29 – Ethics
May 1 – In-class group project finalization/discussion

Final Project – Due on the first day of final exam period

Brief final project description: For our course final project, you will be provided with a bioRxiv preprint that is related to a topic covered by the course, in a group of 3-4. You are also welcome, if your group prefers, to search https://www.biorxiv.org/ for a preprint of your choice, and review this preprint instead of the one provided to you. Each group member should individually read the preprint and write a summary of the preprint. Next, you will get together with your teammates to discuss the preprint, and compare each of your summaries. You will discuss areas where you agree, and discuss any discrepancies in your assessment of the work. Next, compile each of your summaries into a single summary that encompasses everyone's feedback. Based on this merged summary that contains everyone's feedback, you will create a peer-review of the preprint. Lastly, groups will receive feedback from instructors for refining their preprint reviews. Based on this feedback, group members will edit their review, and create a PDF of the review. An email template and instructions will be provided on bCourses so that one group member will email a final PDF version of the review to the corresponding author (principal investigator) of the preprint by email. Emailing the review to the preprint's corresponding author is necessary to receive the grade for the final course project.