Bi 23 Tutorials 1 - 2: Winter Term (2022-23)

1. Analyzing Time Series (Neural) Data with MATLAB (3 units)

This course aims to provide foundational knowledge and support the development of programming skills targeting the execution of standard computational analysis – relevant to time series data sets. MATLAB is one of the most popular programming languages for neuroscience and psychology research. Its balance of usability, visualization, and widespread use makes it one of the most powerful tools in a scientist's toolbox.

The course will be largely based on Mike Cohen's book - MATLAB for Brain and Cognitive Scientists, and will focus on applications most commonly used in neuroscience and psychology. By the end of the course, students will have gained knowledge and programming expertise relevant (but not limited) to:

a. Basic MATLAB operations. Loops and conditional statements, Functions, and plotting.
b. Matrix algebra operations, signal detection theory, covariance, and correlations analysis.
c. Dimensionality reduction techniques and their interpretation.
d. Frequency analyses and filtering methods.
e. Linear and nonlinear methods to fit models to data.

The course will be based on a mix of instructive talks in which we will go through rigorous explanations of MATLAB code along with programming tips and tricks. Students will learn not only how to but also how not to program, with examples of bad code that they are invited to correct or improve. At the end of every lecture, we will pursue exercises that test and develop the skills taught in each chapter.

Organizational Meeting on Thursday, January 5, 2023, at 4 PM, in TBD

Tutor: Stefanos Stagkourakis, Ph.D., stefanos.stagkourakis@caltech.edu
Anderson Laboratory

2. Unraveling a Brain - One Neuron at a Time (3 units)

A core goal of neuroscience is to understand how individual neurons interact with one another to collectively execute brain function. The roundworm *Caenorhabditis elegans* has a nervous system composed of 302 neurons, each of which is stereotyped in its position, function, and wiring. Researchers can measure and perturb the activity of neurons at the single cell level, making *C. elegans* an unmatched animal model through which we can ask fundamental questions about how individual neurons collaborate within neural circuits. In this course, we will read primary literature articles that uncover core principles of how neurons interact in this seemingly simple brain. By the end of this tutorial, students will be able to understand experimental approaches in *C. elegans* to study neuron function, identify principles and motifs that govern neural circuit design, and propose new experiments to further probe the *C. elegans* brain.

Organizational Meeting on Friday, January 6, 2023, at 4 PM, in 340A CNRB

Tutor: Mark Zhang, G5, mgzhang@caltech.edu
Sternberg Laboratory

Bi 23 Tutorials 3 - 5: Winter Term (2022-23)

3. Cryo-electron Tomography: Visualizing Molecular Sociology in the Cell (3 units)

Cellular cryo-electron tomography is a high-resolution technique that enables imaging of the molecular machinery of a cell at close-to-native conditions. With the advent of dedicated cryo-TEM and cryo-FIB instruments, modern energy filters, fast direct electron detectors, and advanced data acquisition, exciting new opportunities have opened for cryo-electron tomography to shed light on fundamental questions in cell and structural biology. It has been successfully applied to study whole bacterial cells, viruses, eukaryotic cells, primary neural cells, and even larger samples like *C. elegans*. This tutorial will cover the basics of cryo-EM, some latest applications, and future perspectives. It is meant for anyone interested in the burgeoning fields of cryo-EM, including cell biologists or molecular biologists without extensive training in mathematics or imaging physics who want to broaden their understanding of the field.

Organizational Meeting on Thursday, January 5, 2023, at 4 PM, in 300 BRD

Tutor: Wei Zhao, PhD, weizhao7@caltech.edu
Jensen Laboratory

4. Synthetic Embryology: The Present and Future of Developmental Biology (3 units)

Synthetic embryology, the engineering of in vitro embryo-like structures from cultured stem cells, has become the new frontier of research in Developmental Biology. Rooted in classic embryology knowledge and cutting-edge stem cell science, this rapidly evolving field allows us to investigate previously inaccessible developmental events, and to reconsider the paths the embryo follows to self-organize. In this tutorial we will review the current status of the synthetic embryology field, its limitations and future directions, and we will discuss how building embryos with stem cells will help address unanswered (and still unasked) questions in development.

Organizational Meeting on Friday, January 6, 2023, at 4 PM, in 240 CNRN

Tutor: Sergi Junyent, PhD, sjunyent@caltech.edu
Magdalena Zernicka-Goetz Laboratory

5. Classical and Modern Aspects of Genetic Engineering (3 units)

In the first part of this tutorial, we are going to discuss a bit of history of genetic engineering and look at the ways humans altered the genomes of agriculturally important organisms. After a glimpse of classical aspects, we are going to dive into the myriad of modern gene and genome editing techniques, including but not limited to CRISPR/Cas9. We will discuss technical details and applications in various model organisms. The last part of the tutorial will focus on the representation of genetic engineering in pop culture. We will critically investigate how accurately are these technologies described, what future and ethical concerns are pictured by these artworks.

Organizational Meeting on Friday, January 6, 2023, 3 PM, in B136 KRK

Tutor: Levente Kovacs, PhD, lkovacs@caltech.edu
Glover Laboratory

Bi 23 Tutorials 6 - 8: Winter Term (2022-23)

6. A survey of bacteriophage diversity and its application to medicine (3 units)

The rise of antibiotic resistant bacteria is worldwide public health emergency. There is thus an urgent need for unconventional interventions to quell this growing pandemic. Therapeutics revolving around bacteriophages, the viruses that infect and kill select bacteria, are an attractive alternative to antibiotics. They have been shown to succeed in killing multi-drug resistant bacteria when all antibiotics fail. In this course, we will describe the diversity of bacteriophages, from the smallest microphage to the largest megaphages, and explore their varied life cycles and mechanisms of host selection. We will review the history of bacteriophage discovery and how their application to clear bacterial infections evolved in different parts of the world.

Organizational Meeting on Thursday, January 5, 2023, at 4 PM, in BRD 200

Tutors: Jolena Zhou, jzzhou@caltech.edu, G4 & Raymond Zhang, rjzhang@caltech.edu, G3
K. Wang Laboratory

7. Readings in Bioethics (3 units)

What are the major ethical questions facing today's scientists in biology, bioengineering, and medicine? How do we identify bioethical questions and address them productively? This tutorial seeks to explore bioethics from multiple perspectives—scientific and philosophical, community-based and individual—to equip future researchers for ethical decision-making in a rapidly changing world. Readings will be drawn from a variety of disciplines and genres, ranging from scientific research publications to philosophy and history, to investigative journalism and memoir, to speculative fiction. Based on the interests of participating students, texts may address topics such as biomedical technology, gene therapy or genetic engineering, use of human and non-human animal research subjects, ethics of medical care, and/or environment and climate change.

Organizational Meeting on Wednesday, January 4, 2023, at 4 PM, in 200 BRD

Tutor: Ariane Helou, PhD, ariane@caltech.edu
Beckman Institute

8. Tumor immunology (3 units)

As part of its mandate to ensure survival of the host organism amid countless threats, the immune system eradicates nascent tumors. In this tutorial, we will cover core concepts in tumor immunology, from the detection of cancer by the innate immune system and elimination of cancer cells by T cells, to the many ways in which tumors can evade the immune system and how immunotherapies restimulate the anti-tumor immune response. Through discussions centered around foundational and current primary literature in the field, students will become familiar with the intellectual framework and experimental techniques used to study the immune response to cancer.

Organizational Meeting on Thursday January 5, 2023, at 4 PM, in 101 KRK

Tutor: Brendan MacNabb, PhD, bmacnabb@caltech.edu
Rothenberg Lab