Bi23 Winter 2015 Tutorials – All 3 units

1. The Function and Regulation of Sleep

Sleep is conserved throughout the animal kingdom, with a typical human being spending one third of their life asleep. Despite the amount of time we dedicate to this behavior, the function and regulation of sleep remain poorly understood. Furthermore, sleep and circadian disturbances and disorders affect millions of Americans across all demographic groups, making sleep a high research priority. In this class, we discuss theories on the function of sleep, sleep disorders, genetic and neural regulation of sleep, as well as the environmental and homeostatic regulation of sleep. This class will be structured as a short lecture and discussion of assigned primary literature.

Organizational Meeting on Wednesday, January 7th, at 4 PM in Braun 151

Tutors: Audrey Chen, PhD, x8123, MC 156-29, audchen@caltech.edu, Daniel Lee, PhD, x8123, MC 156-29, leed@caltech.edu, Grigorios Oikonomou, PhD, x8123, MC 156-29, grigoris@caltech.edu

2. Topics in Microbial Ecology

Microorganisms constitute the greatest biomass of Earth's biosphere. They play a key role in geochemical cycles, biodiversity, bioremediation, and ecology. By focusing on these areas of environmental microbiology, we can improve existing microbe-based processes, develop novel biotechnological procedures, and broaden our knowledge on the limits of life when studying extremophile species. This tutorial offers a chance to learn more about general aspects of microbial ecology and how it affects the world we live in.

Organizational Meeting on Wednesday, January 7th at 4pm in Kerckhoff 024

Tutor: Aleksandra Checinska, PhD, M/S 89-102D JPL, 818-354-5799, Aleksandra.Checinska@jpl.nasa.gov

3. Sensing Voltage with Membrane Proteins

Most cells manufacture specialized proteins that are able to detect and respond to variations in the voltage that exist across their plasma membrane. This is typically done by allowing one or more electrically charged groups to re-arrange within the membrane electrical field thereby effectively transducing electrical energy into conformational changes. During the last decade, the fundamental bases of voltage sensing by membrane proteins (ion channels in particular) have been vigorously debated over conflicting biophysical, structural and computational data. We will present and discuss a series of recent scientific articles that have contributed to refine our modern comprehension of voltage sensing and to design more efficient molecular tools that enable us to remotely access neuronal information.

Organizational Meeting on Wednesday, January 7th, at 4 PM in Spalding 102

Tutor: Jérôme Lacroix, PhD, x8560 MC 210-41, jlacroix@caltech.edu

4. Personalized Medicine: From the Lab to the Clinic

Medicine can better conquer disease when it is able to understand and predict in what way each patient is unique. This paradigm, better known as "personalized medicine" will be examined in this course in detail as it relates to the future of medicine. We will look at how genome sequencing is changing therapies for diseases such as breast cancer (BRCA1/2) and Huntington's disease. We will chart progress in the burgeoning field of cancer genomics and how it has increased the efficacy of cancer treatments. Finally, we will discuss how emerging tools like viral gene therapy and genome editing (ZFNs/TALENs/CRISPRs) have the potential to become personalized medical treatments.

Organizational Meeting on Wednesday, January 7th at 4 PM in Braun 370

Tutors: Alok Joglekar, PhD, x3580, MC 147-75, alok.joglekar@gmail.com
Devdoot Majumdar, PhD, x3580 MC 147-75, devdoot@gmail.com

5. Form Follows Function: Learning How to Analyze Protein Structure

Have you ever taken a machine apart to learn how it works: A computer, part of your car, or a bike? How about a protein? Proteins function as molecular machines! Atomic resolution models of proteins, determined by methods including X-ray crystallography, electron microscopy and nuclear magnetic resonance, allow us to determine how each part of a protein contributes to its biological function. These data also allow us to engineer proteins with modified functions that can be used for novel purposes including therapeutics. We will use molecular modeling programs to analyze the molecular architecture of published protein structures in order to predict how they work. We will then compare and contrast our predictions with the original publications describing the structure. Specific topics include: proteins that chew up other proteins, proteins that allow viruses, such as HIV and Ebola, to infect humans, proteins that bacteria use to fight each other, and much more.

Organizational Meeting on Wednesday, January 7th, at 4 PM in 200 Broad

Tutors: Beth Stadtmueller, PhD, x8351, MC 114-96, beths@caltech.edu
Yunji Wu, MS, x8351, MC 114-96, wuy@caltech.edu

6. Mass Spectrometry-based Proteomics for Biological Discovery

The development of tandem mass spectrometry (MS) as a means to identify and quantify proteins from complex samples revolutionized the study of cellular physiology. Alongside this technical development, the field of chemical biology has provided experimental tools that increase the sensitivity and selectivity of MS-based proteomics. This class will provide a basic introduction to MS, covering the instruments themselves, bioinformatic techniques, and general applications of proteomics. We will then explore a variety of cutting-edge experimental approaches, with a special emphasis on novel biological discoveries enabled by each technique (e.g. subcellular protein synthesis, host-pathogen interactions, and the human proteome). Current research articles will be the primary sources and in-class discussion will be highly encouraged.

Organizational Meeting on Wednesday, January 7th at 4 PM in Spalding 317

Tutor: Brett Babin, B.S. x2508, MC 210-41, bbabin@caltech.edu

7. Controversies in Neuroscience: Learning to Ask the Right Questions

Modern science courses are structured in neat units of information, with precisely designed problems and answers in the back of the book. But scientific research has no informational units, no pre-fabricated problems, and by definition no current answers. What are textbooks and professors leaving out to make science clean and tidy? How do you go from the ambiguity of cutting edge research to the clarity of a textbook? This course will use controversies in modern cognitive science to debate unknowns in neuroscience, and through that discussion more deeply formulate the twists, turns, and ambiguities of scientific discovery. Class discussions will cover debates of experimental result implications and limitations, and the design of experiments to clarify ambiguities. Course topics may include questions such as: is fMRI adequate, and is visualization pictorial. Classes will be every week for an hour. Class requirements are to attend, and to give one 15-minute presentation. No neuroscience background is required. Course textbook will be "Controversies in Cognitive Neuroscience" by Scott Slotnick.

Organizational Meeting on Wednesday, January 7th at 4 PM in Moore 139

Tutor: Noelle Stiles, PhD, x2805, MC 139-74, nstiles@caltech.edu

8. A Practical Guide to Molecular Evolution and Phylogenetics

Have you ever wondered how genes and organisms evolve? In this course we will cover the evolution of hereditary molecules and focus on the bioinformatic methods used to study them. Topics will concentrate on phylogenetics and comparative genomics, but will be tailored to students' interests. Class time will include short lectures followed by discussions of assigned papers and demonstrations. In the second half of the course, class time will be devoted to guiding small independent research projects and covering student-selected topics. Successful students will leave the course confident in completing fundamental bioinformatic analyses and have an understanding of the theories behind them.

Organizational Meeting on Wednesday, January 7th at 4 PM in Kerckhoff 101

Tutor: Jessica Ricci, B.S., x4856 MC 147-75, jricci@caltech.edu

9. Epidemic: From Biology to Social Impact

Widespread infectious disease outbreaks occur regularly, and due to the differing natures of individual pathogens, there is no one-size-fits-all response. Public misunderstandings about a pathogen or its spread are not uncommon, and medical mistakes based on incomplete knowledge can occur. We will examine the unique biology of individual classes of infectious agents and societal response to outbreaks. We will begin with an overview of the biological nature of representative disease agents, and progress to the role of the media, the nature of humanitarian efforts, the economics of health in first and third world countries, and the political and ethical questions that arise as we consider not only the health of the individual, but also of the community. The course will draw on events from the current Ebola crisis as well as from recent epidemics stemming from other pathogens. This is a general interest class designed to promote discussion about the role of individuals, media, and policy makers as our society becomes globally integrated. Class meetings will begin with tutor presentation followed by class discussion. Weekly suggested readings, simulation activities, and the opportunity to present on a topic of interest will also be integrated into the class.

Organizational Meeting on Wednesday, January 7th at 4 PM in North Mudd 212

Tutor: Patricia Tavormina, PhD, Geological and Planetary Sciences, x6018, MC 100-23, pattytav@gps.caltech.edu