Bi23 TUTORIALS: WINTER TERM 2018
TUTORIALS 1 - 4

1. Axiomatic Perspectives in Systems Biology: Chemical Reaction Networks (3 units)

Observe a phenomenon for long enough and patterns will start to become apparent. The formalization of key observations often allows us to design an axiomatic system whose consequences match the observed patterns and predict unobserved behavior. More than a century of observing reacting chemical systems have led to a profound understanding of many aspects of their dynamics. Chemical reaction networks (CRNs) are an abstract mathematical model that provide a concise language to describe systems of interacting chemicals as well as their dynamics. CRNs have been used extensively in systems biology to elucidate the principles behind a multitude of biological processes. In the emerging field of molecular programming, CRNs have served as a common language to describe the behavior of programmable molecular systems. We will study the mathematical theory of CRNs, beginning with its precise axiomatic definition and building up to a variety of theorems of relevance to biology and bioengineering. We will focus on the theory of CRNs with the principle of detailed balance going from the discrete-stochastic theory, which is appropriate for the description of systems with small volume, to the continuous-deterministic theory, which better describes systems with a large volume.

Organizational Meeting on Wednesday, January 3 at 4pm, Broad 200

Tutor: Andres Ortiz-Munoz, BS, x6994, MC 136-93, aoortiz@caltech.edu

2. Diseases of the Central Nervous System Through Clinical Cases (3 units)

We will explore diseases of the human central nervous system with a focus on their clinical management, molecular pathophysiology, and neurobiological substrates. Each week a different clinical scenario will be presented, and students will be guided through the clinical evaluation (including physical exam), differential diagnosis, and treatment in an interactive and informal setting. The cases will also serve as an opportunity to learn and reinforce neuroanatomy and brain function in non-perturbed states. Any student with an interest in human health is encouraged to enroll, including those whose background is outside the biological sciences.

Organizational Meeting on Friday, January 5 at 4pm, Kerckhoff 101

Tutor: J. Elliott Robinson, MD PhD, x6862, MC 156-29, jerobins@caltech.edu

3. Nanorobotics (3 units)

Nanorobotics holds the potential to transform science, medicine, and engineering. It was recognized by the 2016 Nobel Prize in Chemistry. Students will learn how to design, build, and study several types of nanoscale robots. Through a combination of interactive lectures, exercises, and literature, research students will gain an understanding of engineering principles and techniques necessary to construct and investigate biologically inspired robots. Each student will design a nanobot for applications in medicine, computer science, and engineering.

Organizational Meeting on Thursday, January 4 at 4pm, B101 (Beckman Behavioral)

Tutor: Greg Tikhomirov, PhD, x1231, MC 138-78, dnano@caltech.edu

4. *In-situ* Structural Biology (3 units)

Deciphering the structure and dynamics of biomolecules at atomic resolution in cellular settings is the ultimate aim of structural biology. To achieve this, different imaging and spectroscopic methods have been developed. In this course, the students will be introduced to recent developments in Cellular solid-state Nuclear Magnetic Resonance, Ultrafast Electron Microscopy and Electron Cryo-tomography. First, the basic physical principles of each technique will be explained. Consequently, recent applications of each of these methods (alone or in combination with other techniques) on challenging prokaryotic and eukaryotic biological complexes *in-situ* will be discussed. The biological systems tackled in this course are bacterial secretion systems and human tyrosine kinase receptors.

Organizational Meeting on Friday, January 5 at 4pm, Broad 331

Tutor: Mohammed Kaplan, PhD, x8848, MC 127-72, mohammed@caltech.edu

Faculty Responsible for Bi23: Dr. Alice S. Huang, x3446, MC 156-29

Bi23 TUTORIALS: WINTER TERM 2018
TUTORIALS 5 - 8

5. Brain Chemistry: Real-Time and On-Line Sensing (3 units)

The reciprocal interplay between our environment and the processes, which determine our actions, are principally governed by electrical and chemical pathways in the brain. The stimulated synaptic release of brain chemicals i.e. neurotransmitters (NT's) facilitates cell-to-cell communication in the brain, to define our actions and behaviors. If we are to fully understand brain function/dysfunction and associated neuro-drug performance/dependence, real-time & on-line chemical signaling sensing in the brain is required. Here we are interested in the following on-line *in vivo* brain chemistry monitoring techniques: (a) Electrochemical sensors & biosensors (traditional method) and (b) Fluorescent biosensors (modern method). Our objective is to discuss the pros and cons of (a) and (b). We will research the potential advantage of emerging *in vivo* brain chemistry sensing technologies over traditional methods and *vice versa*. We will investigate current hurdles/obstacles in emerging fluorescent biosensor technology. Finally, we will attempt to put forward suggestions to advance and improve upon fluorescent biosensor methodologies for sensing of NT's and neuro-drug action & function in the living brain.

Organizational Meeting on Thursday, January 4 at 4pm in Kerckhoff 101

Tutor: Saidhbhe O'Riordan, PhD, MC 156-29, oriordan@caltech.edu

6. Genome Editing Technologies, Applications and Implications (3 units)

The advent of complete genome sequences beginning twenty years ago made it easy to examine the genome, but not necessarily to probe its function or to intervene medically. A developing technology of engineered nucleases designed to target specific sequences proposes to change this; in particular, CRISPR enables easy programming of nucleases and other sequence-specific activities in the laboratory and soon in the clinic. Class topics will include the development of engineered nuclease technology, their uses in the laboratory, and their clinical and ethical implications in the treatment of disease. Format: 1 hour meeting, consisting of a 45 minute discussion of paper(s) assigned at the previous meeting, followed by 10-15 minute presentation giving background and explaining methods for the papers being assigned at that meeting.

Organizational Meeting on Wednesday, January 3 at 4pm in Kerckhoff 101

Tutors: Han Wang, PhD, x5803, MC 156-29, han.wang@caltech.edu, Hillel Schwartz, PhD, x5803, hillels@caltech.edu
& Brandon Weissbourd, PhD, x6822, bweissb@caltech.edu

7. Designing a Genetic System for Non-Model Microbes (3 units)

This course is designed to teach students how to genetically manipulate microorganisms. We will focus on various techniques related to plating, introduction of foreign DNA, vector design and mutant construction. Each topic will be introduced with a brief lecture followed by discussion of relevant journal articles. Successful students will leave the course confident in performing genetic analyses of microbes to better understand their physiology and gene regulation.

Organizational Meeting on Wednesday, January 3 at 4pm in Braun 320

Tutor: Gargi Kulkarni, PhD, x4856, MC 147-75, gkulkarn@caltech.edu

8. Neurobiology of Insects (3 units)

For over 100 years, insects have been used to study diverse topics in neurobiology ranging from neurogenesis to neural circuit function. We will work our way through understanding the basic organizational principles of insect nervous systems including sensory, motor and interneuronal systems in order to understand how they govern various aspects of behavior. This course will use Drosophila melanogaster neurobiology as the primary lens upon which to focus our studies, but will extend to primary literature where larger insects were used to understand neurobiology. Lectures and student-led discussion will cover topics such as neural development, systems neuroscience, behavior, and physiology. Students will leave with a better understanding of why insects continue to be at the forefront of understanding how animals interact with their world.

Organizational Meeting on Friday, January 5 at 4pm in B101 (Beckman Behavioral)

Tutor: Matthew Clark, PhD, x4562, MC 216-76, mqclark@caltech.edu

Faculty Responsible for Bi23: Dr. Alice S. Huang, x3446, MC 156-29