Bi23 BIOLOGY TUTORIALS, SECTIONS 1 - 4
WINTER TERM 2013

Design in Nature (3 units) 1-13

Recent advances in tissue engineering paired with growing interest in biologically inspired technologies have given rise to various strategies of analyzing and implementing biomechanical features. We will review examples of bio-inspired engineering and how the notion of design in nature has evolved throughout the history of science. Teams of students will then pick a particular biological design exhibiting an interesting (fluid-) mechanical function, such as heart valve: flow regulation; squid mantle: jet propulsion; cellular cilia: swimming; marine sponge: filtering; or others. Based on independent literature review, each team will then lead an interactive discussion on potential key structure-function relationships and how these could be studied and/or transferred to engineered systems. No specific background required.

Organizational Meeting on Monday, January 7th, at 4 PM in Keck 111

Tutor: Janna Nawroth, M.Sc., MC 138-78, jnawroth@caltech.edu

Synchrotron Light Techniques for Studies on Metals in Biology (3 units) 2-13

Trace amounts of various transition metals play essential roles in all living organisms, but overloading would lead to toxicity. Studies on the uptake, homeostasis in the cell and export of metals provide crucial information for treatment of disorders in transition metal homeostasis, control of pathogenic bacteria/virus, and environmental remediation. A case study approach will be used to highlight a wide range of synchrotron radiation-based X-ray absorption spectroscopy and scattering techniques in such studies, with emphasis on in situ mapping of the metals and probing the coordination chemistry of the metal binding sites in metalloproteins. Each participant will either prepare a presentation based on relevant literature or design a small project for the application.

Organizational Meeting on Monday, January 7th, at 4 PM in Broad 300

Tutor: Limei Zhang, PhD., x2662, MC 114-96, lmzhang@caltech.edu

Human Birth Defects (3 units) 3-13

About 150,000 babies are born in the United States each year with birth defects. Both genetic and environmental factors can cause birth defects. However, the causes of about 60 to 70 percent of birth defects are currently unknown. This course will first introduce human embryonic development and several common birth defects, such as heart defects, neural tube defects, craniofacial defects, skeletal defects, etc. Then, molecular mechanisms underlying the defects and new findings towards their treatment will be discussed. Each participant will research a disease to present to their classmates.

Organizational Meeting on Monday, January 7th, at 4 PM in Beckman Institute 11

Tutor: Shuyi Nie, PhD., x3361, MC 139-74, synie@caltech.edu

Knowing your Machine (3 units) 4-13

Every device used in scientific research is built upon certain assumptions about usage and applicability. In the absence of the understanding of both the theoretical and the practical constraints involved in the usage of a device, one always runs the risk of either using it incorrectly or not asking questions the devise is capable of answering. This course aims to cover discussion of topics related to flow cytometry and microscopy, two technologies used extensively in biology. While cytometric techniques enable differentiation of cells with a sample based on fluorescence, shape, size, complexity, and other parameters, using these parameters fairly and accurately can be tricky, and the use of built-in functions to analyze data generally produces suboptimal results. Similarly, different kinds of light microscopes enable visualization of biological samples; however, their limitations can often restrict the proper applicability of the device. This section of the course will emphasize the fundamental issues of spatio-temporal resolution, birefringence in biological samples, arrangements of filters and epi-illuminator, problems of bleed-through in multiply stained samples like multiplexed in-situ, and dos and don'ts of image processing for scientific publication. Coursework will include independent reading and discussion of the technologies that enable cytometry and microscopy, and examining existing cytometry data and published images. No prior knowledge of cytometry or microscopy will be assumed.

Organizational meeting on Monday, January 7th, at 4 PM in Broad 100

Tutorials twice a week for 1.5 hours

Tutors: Aneesh Acharya, B.S., x8840, M/C 114-96, aneesh@caltech.edu &
Vikas Trivedi, B.Tech. x2863, MC 139-78, viktri@caltech.edu

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

Bi23 BIOLOGY TUTORIALS, SECTIONS 5 - 8
WINTER TERM 2013

The Neurobiology of Pain (3 units) 5-13

Pain is a complex experience, with internal and external factors such as danger and belief influencing the perception of a painful stimulus. Both sensory and emotional brain circuits are engaged during the neural processing of pain. Although acute pain is primarily beneficial and serves a protective function, chronic pain (which affects ~25% of adults in the U.S.) can be debilitating and is a major target for medical research. We will first cover the neuroscience of acute pain processing, from the periphery to the central nervous system. We will then move on to topics such as individual differences in pain perception, the biology of the placebo effect, and current theories of and therapies for neuropathic pain.

Organizational Meeting on Monday, January 7th, at 4 PM in Beckman Behavioral Biology 3

Tutor: Lindsay Bremner, PhD., x8332, MC 216-76, lindsay@vis.caltech.edu

Parasite-Host Interactions (3 units) 6-13

All free-living organisms have other organisms that are specifically adapted to live within or on them. We will cover the mostly hidden, intimate, and fascinating relationship between parasites and their hosts. These are the most highly co-evolved relationships: parasites have adaptations that allow them to detect and invade hosts, evade host defenses, and use host energy to reproduce, while hosts have evolved ever more elaborate ways to evade or kill parasites, or at least to limit their damage. We will discuss the behavioral, cellular, and molecular weapons used on both sides of this "arms race". Topics may include public health scourges (e.g., malaria, African sleeping sickness, guinea worm), the hygiene hypothesis (why a few parasites may be good for us), the Red Queen paradox (the evolutionary arms race), population ecology, and even zombies (how parasites control host behavior). No background courses required.

Organizational Meeting on Monday, January 7th, at 4 PM in Kerckhoff 205

Tutor: Mary Yui, PhD., x4915, MC 156-29, yui@caltech.edu

Neurocognitive Science of Conscious and Unconscious Vision (3 units) 7-13

Understanding the extent and limits of non-conscious visual processing has been a focus of intense research recently, as a step towards understanding the cognitive and neural bases of conscious perception. We will give a critical review of research on subliminal perception, as investigated with a variety of psychophysical techniques used to present information to the visual system without allowing it to reach awareness. Although initially controversial, it is now well established that a broad variety of brain processes can be activated by an invisible stimulus. We will give students the tools to understand research papers in this domain: overview of the architecture of the visual system, methods for rendering visual stimuli invisible, measures to establish unawareness, etc. Then we will review and evaluate key papers in the field of unconscious processing. Finally, we will give an overview of current theories of consciousness. Evaluation will be based on short presentations of articles. No specific background is required.

Organizational Meeting on Monday, January 7th, at 4 PM in BBB200

Tutors: Julien Dubois, MSc. x8960, MC 216-76, jdubois@klab.caltech.edu; Nathan Faivre, PhD x8964, MC 216-76, nfaivre@caltech.edu

Introduction to Systems Biology (3 units) 8-13

An introduction to modeling of biological signal transduction pathways will be provided. Several modeling approaches will be introduced and a simple mechanistic model of receptor-ligand interaction and intercellular signal transduction will be developed and solved using Matlab software. Familiarity with Matlab is not required.

Organizational Meeting on Monday, January 7th, at 4 PM in Spalding Lab 311

Tutor: Alborz Mahdavi, MS, x2510, MC 210-41, alborz@caltech.edu

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