Cellular Neurophysiology GS14 0143
Course Director: Dr. Ruth Heidelberger

Basics: 3 credit course.

Course Description: This course is a graduate level treatment of cellular neurophysiology. It is designed for first year students and will provide students with the basic tools for understanding electrical and chemical signaling in the nervous system. Students will learn about topics ranging from bioelectricity to synaptic transmission to plastic changes in synaptic strength that underlie learning and memory.

Course Prerequisites: This course is appropriate for students with an interest in neuroscience who are comfortable with the use of mathematical concepts to describe events that occur in the natural world. It is recommended that students have one semester of a calculus-based physical or life sciences course prior to taking this course.

Where/When: This course meets Tues/Thurs from 9:00-10:30 am in room B610. Room B610 is a classroom in the neighborhood of the blue elevators in the basement. Exit the blue elevators to the left and make another left down the long corridor leading towards the bookstore. B610 is on the left.

Note : Class will not be held on 11/15 due to SFN (11/12-11/16); Also there is one class to be rescheduled in Dr. Heidelberger's block.

Textbook: "Cellular and Molecular Neurophysiology, Third Edition, by Constance Hammond (Academic Press/Elsevier).

Evaluation: There will be three in-class examinations. These examinations are non-cumulative and will be a combination of multiple choice and short answer/essays. Final grades will be based on the average examination performance.

Examination Dates:

Exam 1: October 4th (in class); Exam 2: November 3 (in class); Exam 3: TBA (Finals week)

SCHEDULE OF LECTURES

Aug 30 : Introduction to electricity and components of electrical circuits *(Byrne)*

Sept 1: Membrane potential, pumps, leaks, and the equivalent electrical circuit of the membrane. *(Byrne)* Reading: Chapter 3.

Sept 6: Action potentials, Na channels, microscopic and macroscopic Na currents. *(Byrne)* Reading: Chapter 4 (Figs. 4.1 to 4.12).

Sept 8: TBA

Sept 13: Class discussion (*Heidelberger*)

Sept 15: Properties of voltage-dependent Na and K channels. *(Byrne)*

Reading: Chapter 4 (Figs. 4.13 to 4.24).

Sept 20: Diversity of Na and K channels, propagation of action potentials and single channel and macroscopic recording techniques. *(Byrne)*
Reading: Chapter 4 (Figs. 4.25 to 4.29, A4.1 -4.6, 4.9, 4.10)

Sept 22: Problem Set I *(Byrne)*

Sept date (to be scheduled): Voltage-gated calcium channels *(Heidelberger)*
a. overview of ion channels
b. voltage-gated calcium channel families
c. calcium tail currents
d. fluorescence measurements of calcium
Reading: Chapter 5; Nowycky et al. Nature. 316:440-3.

Sept 27: Neurotransmitter release, part I *(Heidelberger)*
a. role of calcium ions
b. presynaptic calcium channels
c. calcium clearance
Reading: Chapters 6 and 7. Heidelberger et al., 1994.

Sept 29: Neurotransmitter release, part II. *(Heidelberger)*
a. SNARE hypothesis
b. quantal nature of release
Readings: Chapter 7, Appendix 7.1

Exam 1 : Oct 4th, Tuesday (through voltage gated Ca^{2+} channels)

Oct 6: Nicotinic acetylcholine receptors *(Heidelberger)*
Reading: Chapter 8

Oct 11: Ionotropic glutamate receptors *(Heidelberger)*
Reading: Chapter 10

Oct 13: Metabotropic glutamate receptors *(Heidelberger)*
Reading: Chapters 12

Oct 18: GABA receptors *(Heidelberger)*
Reading: Chapters 9, 11; Heidelberger & Matthews, PNAS 88:7135-9.

Oct 20: Synaptic integration in dendrites and spines *(Beierlein)*
a. Introduction to dendrites & dendritic integration
b. Cable properties of dendrites, time and length constant
c. Attenuation of synaptic responses, temporal and spatial summation
d. Properties and functions of spines
e. Computations in passive dendrites
Reading: Chapter 13

Oct. 25: Properties and functions of dendritic Na channels *(Beierlein)*

a. Techniques for measuring dendritic signals via Na channels
b. Action potential initiation and propagation through dendrite and axon
c. Boosting of synaptic inputs by slowly inactivating Na channels

Reading: Chapters 14, 15, 16, on Na channels; and Stuart and Sakmann, Nature 367, 69-72

Oct 27: Dendritic signaling via Ca channels *(Beierlein)*

a. Measuring Ca signals in dendrites and spines
b. Properties and functions of dendritic low-threshold Ca channels
c. Properties and functions of dendritic high-threshold Ca channels

Reading: Chapters 14, 15, 16, on Ca channels

Nov 1: Control of voltage and calcium- dependent dendritic signals by K channels *(Beierlein)*

a. Properties and functions of A-type K channels
b. SK channels in spines and dendrites
c. BK channels in Purkinje cells

Reading: Chapters 14, 16 on K channels

Exam 2: Nov 3rd, Thursday (through dendritic signaling via Ca channels)

Nov 8: Neuronal firing patterns *(Beierlein)*

a. State-dependent firing patterns of thalamic relay neurons
b. Up- and down states in medium spiny neurons
c. Complex spike in Purkinje neurons

Nov 10: Functions of astrocytes in the brain *(Beierlein)*

a. K and energy regulation
b. Properties and functions of glutamate uptake
c. Neurovascular coupling
d. Tripartite synapse

Nov 15: class cancelled due to SFN

Nov 17 and Nov 22: Electrical synapses (*O'Brien*)

a. general overview
b. electrical properties and permeability
c. combined synapses roles in circuits

Nov 29 and Dec 1: Long-term changes in Synaptic Strength (*Shouval*)

a. LTP
b. LTD

Dec 6: Neurophysiological mechanisms of plasticity in Aplysia - (*Byrne*)

Dec 8: Retrograde synaptic signaling via endocannabinoids *(Beierlein)*

Reading: Kreitzer and Regehr, Neuron 29: 717-727

Exam 3: Finals week. Date and Time TBA