

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 MSB B.612. Room MSB B.612 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. Room MSB B.612 is on the left.

Note 1: On 11/18 class will be held in MSB B.610, which is adjacent to MSB B.612.

Note2: Class will not be held on 11/16 due to SFN (11/13-11/17)

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: September 30th (in class); November 2 (in class); TBA (Finals week)

Lecture outline:

Aug 31 – Sept 2 : Ionic gradients, membrane potential and ionic currents (*Byrne*)

- a. introduction to electricity and components of electrical circuits
- b. origin of membrane potential and the Nernst Equation
- c. ionic currents and the GHK equation
- d. equivalent circuits and changes in membrane potential
- e. pumps

Sept 7- 21: Active conductances and the action potential (*Byrne*)

- a. recording techniques
- b. action potentials and Na current
- c. Na, K channel mechanisms, single channel studies
- d. I-V relationships
- e. Hodgkin-Huxley analysis of voltage-sensitive conductances
- f. Na current propagation
- g. introduction to patch clamp techniques

Sept 23: Voltage-gated Calcium Channels (*Heidelberger*)

- a. description of properties, tail currents

- b. fluorescence measurements

Sept 28 – Oct 12: Chemical Synapses and Neurotransmitter Release (*Heidelberg*)

Exam 1 : Sept 30 Tuesday (through voltage gated Ca^{2+} channels)

- a. synapses and the quantal nature of NT release
- b. calcium and NT release
- c. calcium, synaptic vesicle dynamics and short term plasticity

Oct 14 - 21: Ligand Gated Ion channels (*Heidelberg*)

- a. nicotinic receptor
- b. ionotropic glutamate receptors
- c. metabotropic receptors – GABA_B and glutamate

Oct. 26 - Nov 9: Postsynaptic potentials and synaptic integration (*Beierlein*)

Exam 2: Nov 2nd Tuesday (synapses through passive properties of dendrites)

- a. passive properties of dendrites
- b. active conductances in dendrites: Na channels
- c. active conductances in dendrites: Ca channels
- d. active conductances in dendrites: K channels
- e. the firing patterns of neurons

Nov 11, and Nov 18 (MSB B.610) and Nov 23: Electrical synapses (*O'Brien*)

- a. general overview
- b. electrical properties and permeability
- c. combined synapses roles in circuits - mauthner cell and photoreceptors
- d. modulation of retinal gap junctions and photoreceptor signaling – 12/1 O'Brien

Note: class will not be held on 11/16 due to SFN

Nov 25 and Nov 30: Long-term changes in Synaptic Strength (*Shouval*)

- a. LTP
- b. LTD

Dec 2: Role of glia in synaptic transmission (*Beierlein*)

- a. myelin, salutatory conduction, glutamate- glutamine cycle, K regulation
- b. tripartite synapse

Dec 7 and Dec 9: Neurophysiological Mechanisms Underlying Plasticity (not covered in textbook)

- a. Aplysia - (*Byrne*)
- b. Retrograde synaptic signaling by endocannabinoids (*Beierlein*)

Finals week: Exam 3 Date and Time TBA (active conductances in dendrites through retrograde modulators)