Comprehensive Course Syllabus – MCB 166

BASIC INFORMATION

Course Title: Biophysical Neurobiology, MCB 166 (3 units)
Lecture Times: Tuesday, Thursday, 11-12:30 125 Li Ka Shing
Discussion Times: Monday, Wednesday, Time and Location TBA

Instructors: Tamira Elul, Alan Miller
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Alan Miller: alan.miller@tu.edu

Office Hours: After class from 12:30-1 PM in TBD and by appointment

GSI: TBE

COURSE DESCRIPTION

Prerequisites: Biology 1A/1AL, Physics 8A-8B, Chemistry 1A, 3A/3AL-3B, or consent of instructor.

Overview of Course: Electrochemistry and ion transport phenomena, Equivalent Circuits, Excitability, action potentials, voltage clamp and the Hodgkin-Huxley model. Biophysical properties of ion channels. Statistical and electrophysiological models of synaptic transmission, Quantitative models for dendritic structure and neuronal morphogenesis. Sensory transduction, cellular networks as computational devices, information processing and transfer.

Student Learning objectives:
By the end of this course students will be able to apply physical principles and quantitative techniques to understand the function and structure of the nervous system.

1) Derive equations for Nernst and GHK membrane potential from fundamental physics concepts.
2) Describe the experiments and theory underlying the Hodgkin-Huxley model.
3) Understand biophysical properties of gating particles called ion channels.
4) Apply and solve equivalent circuit models to describe resting and excitable cells, synaptic transmission and sensory transduction.
5) Use Poisson, Gaussian and binomial distributions to analyze the gating of ion channels, synaptic transmission, and absolute sensitivity of vision.
6) Model dendritic structure based on quantitative descriptors of shape and energy minimization theory.

7) Explain experiments and models of sensory transduction, neuronal integration and lateral inhibition.

Methods of Instruction: Lectures and Discussion Sections, Problem sets

MATERIALS

Required Readings:

1) Lecar Lecture Notes, (posted on Bspace course site);

2) Textbook: Foundations of Cellular Neurophysiology, Johnston and Wu, (Will be placed on reserve in bioscience library). Online versions of the book are also available. Specific readings will be assigned for each lecture.

REQUIREMENTS

Exams: One midterm and a final exam.

Problem Sets: Six problem sets throughout the semester.

These exams and problem sets will test students' ability to solve problems using physics of diffusion, circuit theory, ion transport equations, mathematical modeling, stochastic analysis, Hodgkin Huxley theory, electophysiological recordings of synaptic and sensory transduction processes.

POLICIES

Grading procedures: Homework: 40%, Midterm, 20%, Final Exam 40%.

There may be extra credit opportunities (i.e. extra problems) provided throughout the semester.

Collaboration: Collaboration is encouraged for the problem sets but students must write up their own answers. On exams students must work independently.

SCHEDULE:

***Lecture notes are numbered and correspond to the following lectures**

1. Introduction: Excitable cells of the nervous system.
2. Electrochemistry and Ionic currents.
3. Origin of membrane potentials.
4. Ionic and osmotic equilibrium, active transport.
5. Membrane Equivalent Circuits
6. Electrical properties of passive and active axons.
7. Excitation and action potentials.
8. Cable properties, passive spread vs. active propagation.
9. Ionic currents underlying excitation; voltage clamp
10. Hodgkin-Huxley theory
11. Gated ion channels; single-channel currents, noise
12. Statistical physics of gating; stochastic models
13. Molecular biology & structure of ion channels
14. Synaptic excitation
15. Excitatory & inhibitory synapses; synaptic channels
16. Pre-synaptic processes
17. Post-synaptic processes; Neural integration
18. Neural modeling—neural networks
19. Neurons in networks, network topology
20. Computational neuroanatomy – 1
21. Computational neuroanatomy – 2
22. Organization of sensory receptors
23. Sensory neural networks, lateral inhibition
24. Photo-transduction; absolute sensitivity of vision
25. Sensory transduction - hearing and olfaction
26. Color vision (or review)

RESOURCES:

Additional resources will be provided throughout the semester and posted or linked to on Bspace.

ACCOMMODATION:

Students should contact the instructor to discuss accommodations for physical, medial and learning disabilities.

Reasonable accommodations will also be made for students' religious beliefs, observances and practices, following discussion with the instructor.

EVALUATION OF THE COURSE AND ASSESSMENT OF STUDENT LEARNING:

Students will be evaluated informally through questions and discussions in lecture, and formally through problem sets and exams.

Students will formally evaluate the instructors at the end of the section of the course each instructor has presented.