UN3004 Neurobiology I (Section 001)

Columbia University
Department of Biological Sciences
UN3004/GU4004: Cellular and Molecular Neurobiology

Fall 2023

Lectures: Tu/Th 10:10-11:25

Location: 717 Hamilton Hall

Instructor:

Prof. Jian Yang, PhD jy160@columbia.edu

Office Hours by appointment through e-mail.

TAs:

Claire Chen cc4590@columbia.edu
Gianluca Merello gbm2120@columbia.edu
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Xavier Westergaard xow2000@columbia.edu

Recitations:

Group 1	Tuesday	5:45 – 7 pm	800 Fairchild	TA: Xavier & Claire
Group 2	Wednesday	5:45 – 7 pm	C01 80 Claremont	TA: Gianluca & Charan

Prerequisites: one year of biology (UN2005 and UN2006, or equivalents); a course in physics is highly recommended but not required.

Required Text:

Neuroscience, 7th ed., 2023, George J. Augustine et al.

Sinauer Associates, Sunderland, MA

ISBN 9780197616246 (hardcover)

ISBM 9780197616253 (print other)

ISBM 9780197616680 (epub)

Supplemental Texts:

Principles of Neurobiology, 2nd ed., 2020, Liqun Luo

Garland Science, New York

ISBN 9780815346050

Principles of Neural Science, 6th ed., 2021. Eric Kandel et al.

McGraw-Hill Companies, New York

ISBN 9781259642234

Course Objectives: This is an advanced course intended to provide an in depth survey of the cellular and molecular aspects of nerve cell function. Topics include the cell biology and biochemistry of neurons, ionic and molecular basis of electrical signals, synaptic transmission and its modulation, function of sensory receptors. Although not required, it is intended to be followed by Neurobiology II (Systems Neurobiology).

Recitations: A strong emphasis is placed on readings from the primary literature, which will be discussed in weekly recitations. Students will read and discuss in depth selected research papers. Attendance of the recitations is mandatory and active participation will count in the final grade. Materials discussed in the recitations will be included in the exams.

Class Attendance: Attendance is not taken, however material will be presented in lectures that is not available in the text and will appear in the exams.

Exams and Grading: Three exams and a final examination are given. Each exam will cover material since the previous exam. The final examination is entirely on papers from the primary literature. The midterm exams will contribute 60% towards the semester grade; the final will contribute 35% and is required. 5% will come from recitation attendance and participation. **No make-up exams will be allowed** except in cases of serious illness or personal crisis, and the student is required to present a letter from the undergraduate dean as well as other supporting evidence (such as doctor's notes, airline tickets etc.).

Important information regarding Disability Services: In order to receive disability-related academic accommodations for this course, students must first be registered with their school Disability Services (DS) office. Detailed information is available online for both the Columbia and BarnardLinks to an external site. registration processes.

Refer to the appropriate website for information regarding deadlines, disability documentation requirements, and drop-in hours(Columbia)/intake sessionLinks to an external site. (Barnard).

For this course, students are not required to have testing forms or accommodation letters signed by faculty. However, students **must do** the following:

- The Instructor section of the form has already been completed and does not need to be signed by the professor.
- The student must complete the Student section of the form and submit the form to Disability Services.
- Master forms are available in the Disability Services office or online: https://health.columbia.edu/services/testing-accommodations

SCHEDULE

Part I: Membrane Electrical Properties

Sept. 5: **Lecture 1.** Introduction, Cell Biology of the Neuron

(Chapter 1)

Sept. 7: **Lecture 2.** Ionic Basis of the Resting Membrane Potential

(Chapter 2)

No recitation this week

Sept. 12: **Lecture 3**. Ion Channels

(Chapter 4)

Sept. 14: **Lecture 4**. Ion Channels

(Chapter 4)

Recitation 1: Zhang et al., "Small molecules efficiently reprogram human astroglial cells into functional neurons" Cell Stem Cell 17, 735-747 (2015)

Sept. 19: **Lecture 5**. Transporters

(Chapter 4 and slides)

Sept. 21: **Lecture 6**. Passive Electrical Properties of the Neuron

(Chapter 2 and slides)

Recitation 2: Doyle et al., "The structure of the potassium channel: molecular basis of

K^+ conduction and selectivity". Science 280, 69-77 (1998).

Sept. 26: **Lecture 7**. Ionic Basis, Generation and Propagation of the Action Potential

(Chapter 2, 3)

Sept. 28: **Lecture 8**. Ionic Basis, Generation and Propagation of the Action Potential

(Chapter 2, 3)

Recitation 3: Problem sets (I and II)

Oct. 3: **EXAM I (Lectures 1-8, Recitations 1-3)**

Part II: Synaptic Transmission

Oct. 5: **Lecture 9**. Synaptic Transmission: Overview, Neuromuscular Junction

(Chapter 5)

No recitation this week

Oct. 10: **Lecture 10**. Synaptic Transmission: Neuromuscular Junction, CNS

(Chapter 5, 6)

Oct. 12: **Lecture 11**. Synaptic Transmission: CNS

(Chapter 5, 6)

Recitation 4: Biederer et al., "SynCAM, a synaptic adhesion molecule that drives synapse assembly". Science 297, 1525-1531 (2002).

Oct. 17. **Lecture 12**. Synaptic Transmission: Slow Synapses

(Chapter 5, 7)

Oct. 19. **Lecture 13**. Presynaptic Mechanisms: Transmitter Release

(Chapter 5)

Recitation 5: Fernandez-Chacon et al. "Synaptotagmin I functions as a calcium regulator of release probability". Nature 410, 41-49 (2001).

Oct. 24. **Lecture 14**. Synaptic Plasticity

(Chapter 8)

Oct. 26. **Lecture 15**. Biochemistry of Neurotransmitters

(Chapter 6)

Recitation 6: Liao et al. "Activation of postsynaptically silent synapses during pairing-induced LTP in CA1 region of hippocampal slice". Nature 375, 400–404 (1995).

Oct. 31. **EXAM II (Lectures 9-15, recitations 4-6)**

Part III: Sensory Physiology

Nov. 2. **Lecture 16**. Introduction: Coding of Sensory Signals, phototransduction

(Chapter 11 and slides)

No recitation this week

Nov. 7. Off (election day)

Nov. 9. **Lecture 17**. Phototransduction and Color Vision

(Chapter 11)

No recitation this week

Nov. 14. **Lecture 18**. Mechanotransduction in the Ear

(Chapter 10)

Nov. 16. **Lecture 19**. Taste

(Chapter 15 and slides)

Recitation 7:

Woo et al. "Piezo2 is required for Merkel-cell mechanotransduction.Links to an external site." Nature. 2014 May 29; 509:622-626.

Nov. 21. **Lecture 20**. Olfaction

(Chapter 14 and slides)

Nov. 23. Off (Thanksgiving)

No recitation this week

Nov. 28. **Lecture 21.** Thermosensation, mechanosensation and pain

(Chapter 12, 13 and slides)

Nov. 30. **Lecture 22.** Thermosensation, mechanosensation and pain

(Chapter 12, 13 and slides)

Recitation 8: Zheng J. et al. “Prestin is the motor protein of cochlear outer hair cells.” Nature 2000 May 11; 405:149-155.

Dec. 5. **Q&As**

Dec. 7. **EXAM III (Lectures 16-22, recitations 7-9)**

Recitation 9: Caterina MJ, Schumacher MA, Tominaga M, Rosen TA, Levine JD, Julius D. “The capsaicin receptor: a heat-activated ion channel in the pain pathway”.Links to an external site. Nature 1997 Oct 23; 389:816-824.

Dec. 21. Final exam 9 am – 11 am

The final exam consists of two sets of questions on selected research articles. It is suggested that you read and analyze these papers prior to the exam, since the exam will be closed-book; i.e. you CANNOT look at the articles, notes or textbook during the exam. You may discuss these papers with other students, but not with the instructors or TAs.