Syllabus for Neurobiology (MCDB/NSCI S320 Summer 2025)

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May 26, 2025 – June 27, 2025

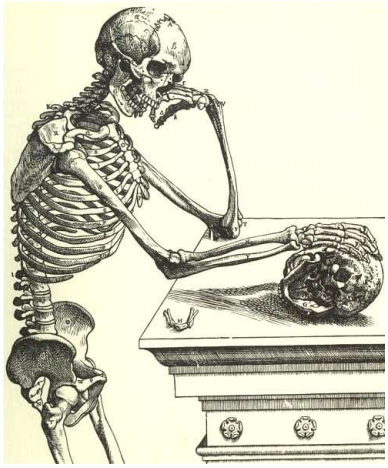
Course description:

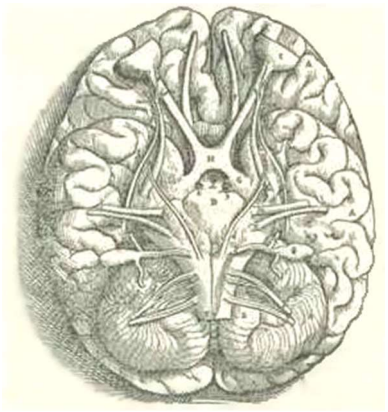
This is an ideal opportunity to learn about one of the most exciting and dynamic areas of science.

Neurobiology**,** MCDB S320 is the core course for the Neuroscience major at Yale, as well as for the existing MCDB Neurobiology track. The summer session class is the same as the one taught regularly in the fall semester, covering the same material as MCDB/NSCI 320. This course (taken during the summer or in the fall) is a required course for both the Neuroscience major and the MCDB Neurobiology track.

Students who take the summer course may then take the attached neurobiology lab, MCDB/NSCI 321La, offered during the fall semester. This is a great way to get a start on your course requirements for either major.

MCDB S320 provides a comprehensive introduction to neuroscience, divided into 3 course modules: 1) Cellular neurophysiology, addressing the excitable properties of neurons and the function of synapses, 2) Systems neurobiology, examining neural circuits as they relate to the functional properties of the nervous system, with each system that is addressed examined in detail, and 3) Neural development and plasticity, examining the cellular and molecular mechanisms governing neural development, plasticity, and the establishment of memory. The course takes specific topics and examines them in depth, seeking out general principles governing nervous system function.





Accurate descriptions of the brain were made in the 16th C by Andreas Vesalius, in his monumental work, *De humani corporis fabrica (1543).*

Other information:

I will use a whiteboard during the sessions. The whiteboards will be saved and posted in the Files section of Canvas. Class notes are provided for each session. They are more detailed than usual– and while they are not a transcription of the lecture, they will provide considerable detail and background material.

An important part of the course will be Canvas, where all material and announcements will be located. I am going to look into setting up a forum where students can upload questions in a way that the entire group can see. I will let all participants try their hand at providing an answer. I will moderate, select the best answer, and add or clarify any points that are needed. This way everyone in the class will have a chance to benefit from the questions.

Prerequisites. Students are expected to have the equivalent of a 1st year course in biology. In addition, at least 1 semester of college chemistry is strongly recommended. *These prerequisites may be waived*

at the discretion of the instructor. If you have questions, please contact haig.keshishian@yale.edu.

Readings. Readings are from Liqun Luo, *Principles of Neurobiology, 2nd edition*. The readings are chapters relevant to the lecture material. You may read the entire chapters, *but focus on the parts most relevant to the lecture material* as indicated in the syllabus. Any other reading material will be posted on Canvas.

Schedule. 15 135 min lectures MWF 10.00-12.15. Please note that there will be one lecture on Tuesday, June 24. If this will interfere with other classes or obligations, please see the instructor.

Attendance: The Yale Summer Session is very strict about lecture attendance. They can monitor attendance, and may drop students from a class if there are regular unexplained absences. If you have any questions about class attendance, please contact me as soon as possible.

Quizzes and final test.
In-class quizzes. On each Friday we will begin the class with a short quiz question, to be answered in class during the first ~10 minutes. These will be handwritten and closed book. There will be four of these in-class quiz questions (on 5/30, 6/6, 6/13, and 6/20) and each one is worth 5% of the course grade. The questions will relate to the material covered during the preceding week. I will return the graded questions on the following Monday. These short quizzes will be valuable for letting you know how you are doing.

Hour midterm exams. 1h quizzes are given at the end of the first and second modules. The hour quizzes will be closed book, in the classroom, at a time to be announced during the day. Each module ends on a Friday, and the quiz is given on the following Monday (June 9 and 23), so you have the weekend to review material. The quizzes are closed book

Final exam. The final exam is a standard Yale College 3.5 hr exam, and is also closed book, and will be taken in the classroom during the final day of the course, June 27, at 10AM.

Each hour quiz is worth 100 points and determines 20% of your course grade. The final test is worth 200 points, and constitutes 40% of the course grade. The final test covers the entire course. The hour quizzes and final test are closed book,

The course grade is normally calculated based on your cumulative score from the in-class questions, the two midterm exams, and the final exam. However, as the final exam covers the entire course material, doing well on the final indicates that you have mastered the course material. Thus, if you should get a better score on the final than the sum of the two midterms, your course grade will be upped by at least one grade step (e.g. B+ to A-, or even an A). That will reward your improvement during the course, and will result in a higher course grade.

Discussion sessions. Each week there will be a discussion/review session. These meetings cover the preceding week's lecture material, and will occur after our Monday sessions The meetings provide an excellent opportunity to discuss general questions concerning the course material. Please try to attend these sessions.

Course syllabus. Each lecture is divided into either two or three parts, as indicated (1a,1b, etc.), with a short break between each one.

Web Site. The course website is on Canvas, and will be updated throughout the session, and will include the lecture handouts, problem sets, and special class announcements. You can also upload material, and post questions on the web page.

Feedback. I strongly welcome feedback from the class on any subject: Please let me know if you have any questions about the material. These can be emailed to me at haig.keshishian@yale.edu or posted on the website. I will try to explain the answers to questions and will post my responses. Also let me know if you have any comments or questions about the course itself.

Other comments. Yale College's policies concerning academic conduct can be reviewed on the web. These rules apply to the summer session, and if you are new to Yale, you should review them.

Instructor and office hours. You are encouraged to contact with me to discuss issues/questions arising in this course. Email me and I will set up a Zoom session for the two of us. You should contact the instructor as soon as possible if any problems arise concerning the course.

Preparing for class. You should prepare by reading the lecture handouts that are located in the Canvas Files section, where possible prior to each session. The textbook readings in the syllabus are from Liqun Luo *Principles of Neurobiology 2nd edition.* The amount of detail in the textbook is impressive, and I don't expect you to master every concept, circuit diagram, or figure presented in the textbook! You should **focus** on those parts of the assigned readings that are directly relevant to the material presented in class, and treat the textbook as a resource to refer to for additional detail, background, and an explanation of concepts covered in class.

This doesn't mean that you shouldn't read other parts of the textbook if you are interested in the topics being presented. By all means do so! But I have highlighted the parts in the textbook that are most relevant to the material we will cover in class this summer.

Finally, you should also read Ch14 for background, which reviews the model systems, technical methods, and experimental strategies used in Neuroscience.

Session topics and readings

*In **Part I** of the course, we begin our studies by examining in depth the cellular and molecular mechanisms that are involved in information processing, which we will examine at the level of neurons and their synaptic connections.*

Part I: Information processing by neurons and synapses (weeks 1 and 2)

Date	Lecture	Topic	Readings from textbook
May 26	1a	Introduction to neuroscience. Mechanisms of neural excitability: models of membrane permeability and membrane conductance.	Ch1 all Ch2.1-2.4
	1b	The Goldman equation and the resting potential	Ch 2.55-2.9
May 28	2a	Voltage and time	
	2b	Voltage and space	
	2c	The cable equation and dendritic models	
May 30 (in-class quiz)	3a	Ion channel diversity and specialization	Ch 2,10-2.16 Download the Axovacs computer program
	3b	The action potential	
June 2	4a	Action potential signaling (cont.)	Axovacs computer program model
	4b	Computational models of excitability	
June 4	5a	Synapses structure and function	Ch 3.1-3.18
	5b	Synaptic inhibition and excitation	
June 6 (in-class quiz)	6a	Neurotransmitter release machinery: Testing the calcium hypothesis	
	6b	Neurotransmitter release: Molecular mechanisms	
June 9		**First hour quiz on Module 1.** *Monday,, time to be announced. The hour quiz is given in the classroom.*	

*In **Part II** of the course, we turn to neural circuits and systems. Our goal in this section is not to provide a survey of every system in the mammalian CNS, but to select systems where our understanding is particularly advanced, and then examine those systems in depth. In this way we can unearth some of the principles that are central to neuroscience.*

Part II. Neural systems (weeks 3-4)

June 9	7a	Synaptic modulatory mechanisms: Modulation of membrane excitability	Ch 3.19-3.26 Ch11.4-11.13
	7b	Synaptic modulatory mechanisms: Modulation of neural circuitry	Ch11.14-11.16 Ch 8.5
June 11	8a	Signal transduction; phototransduction	Ch 4.1-4.19
	8b	Retinal circuitry; outer plexiform layer	
	8c	Retinal circuitry: inner plexiform layer	
June 13 (in-class quiz)	9a	Processing of visual information: Part 1	Ch4.20-4.28
June 16	10a	Processing of visual information: Part 2	
	10b	Integration of visual information: areas V2 and beyond	
June 18	11a	Motor and somatosensory systems	Ch8.1-8.6
	11b	Spinal cord circuitry and motor control	
June 20 (in-class quiz)	12a	Somatosensory and proprioceptive systems and loops Nociception and modulation	Ch6.27-33
	12b	Sensory-motor integration; Voluntary motor control	Ch8.12-8.15
June 23		**Second hour quiz on Module 2.** *Monday., time to be announced. The hour quiz is given in the classroom.*	

Part III Development, Memory, and Cognition (week 5)

*In **Part III** of the course, we will study development, plasticity, and higher brain functions. Here we will examine the mechanisms that govern the development of the nervous system as well as how an assembled nervous system can change, respond to its environment, and establish various forms of memory.*

June 23 (Monday)	13	Cortical and brainstem motor systems; cortical reentrant loops. Cerebellum; Vestibulo-ocular control; motor learning	Ch 8.8-Ch8.11
June 24 (Tuesday)	14	Principles of Neural development Topographic map development	Ch7 (for reference) Ch5.1-5.16
June 25 (Wednes-day)	15a	Medial temporal lobe memory systems Declarative and procedural memory systems	Ch11 all
	15b	Space, memory and final thoughts about the nervous system	
June 27		**Final Test on all 3 modules.** *This is a 3 1/2h test, that will be given at 10AM in the classroom.*	

The in-class quizzes each have a single question that you will answer in about 10 minutes at the beginning of class. Each quiz covers topics from the preceding three class sessions, except for the first in-class quiz, that covers the first two sessions of the course.