Syllabus for Neurobiology (MCDB/NSCI S320 Summer 2021)

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June 7, 2021 – July 9, 2021

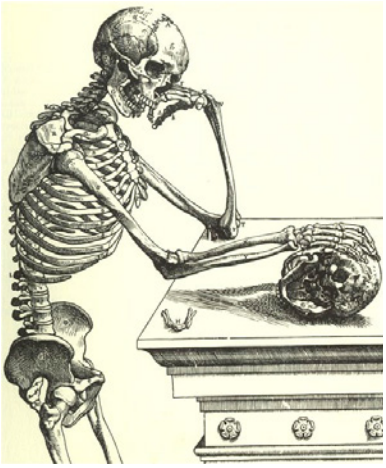
Course description.

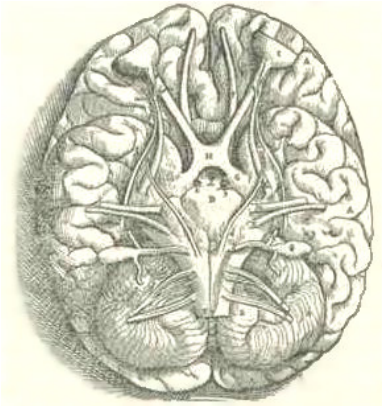
This is an ideal opportunity to learn about one of the most exciting and dynamic areas of science.

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 MCDB Neurobiology track and the Neuroscience major.

Students who take the summer course may then take the attached neurobiology lab, MCDB/NSCI 321La, offered live 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).*

Remote Learning: The best thing about classes held in person is the opportunity to interact: to ask questions in real time, to pace the flow of the class, and to have the instructor review new concepts as they are presented. This has been especially true of the summer session classes, where there are usually fewer students than during the regular semester, a situation that fosters group discussions.

The unusual nature of this summer's class places an extra challenge on both the instructor and the student. I have modified the course to encourage the normal communication and sharing of ideas that typically happens in this class. This will be the second time this class has been taught remotely during

the Summer Session, and I have adjusted things to help make the class run as smoothly as possible.

Each session will be presented and recorded on Zoom. The recordings of the lectures and discussions will be available in Canvas on the day they are given. Please note: The Yale Summer Session has strict rules about attendance, and can drop students from a class if the person fails to attend regularly. I understand live attendance may be an additional burden for students located in some time zones, but please make the effort to attend the session as it is given. By being on Zoom live means you can ask questions and participate in the class as it happens, a much better way to learn.

I will also ask everyone to keep their video feed live, so we can at least have the virtual sense of the presence of all of us. You can immediately ask questions by unmuting your microphone, and I will use those questions to encourage further discussion with the group as warranted. You can also post questions in the Chat box.

I will also 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 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.

Finally, everyone is developing best practices for the remote teaching of advanced material. If you have ideas you would like to share with me please do so! We are all learning how to do this effectively.

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.* Any other reading material will be posted on Canvas.

Schedule. 15 135 min lectures M-W-F by Zoom at 10 AM EDT. Each Zoom session is scheduled for up to an additional 1/2 hour, to accommodate post-lecture questions and discussions.

Quizzes and tests. 1h quizzes are given at the end of the first and second modules at 11AM on the

Saturdays listed in the syllabus. Each hour quiz is worth 100 points, and the final test 200 points. The final test covers the entire course. The hour quizzes and final test are open book, meaning that you can refer to your class notes, posted material in Canvas, and your textbook during the test. You are however required not to consult with anyone other than the instructor during the test. For the tests I ask that we all adhere to an honor system, to follow the instructions and time limits as specified.

The quizzes and tests are MS Word documents, and for many of the questions you can type in your answers into the document. For drawings and handwritten material, you should take a digital photo of the page and past it into the Word document. In addition to the formal times for the quizzes and tests, there is an additional 30 min to 1 hour provided for you to prepare the document to be emailed back to the instructor.

The course grade is calculated based on your cumulative score from the three tests (400 points). Last year during the regular semester we instituted a new grading policy. I will base your course grade entirely on the final exam, specifically for those students where this will result in a higher course grade than one calculated from all three tests.

Discussion sessions. Each week there will be a discussion/review session conducted by the instructor. These meetings cover the preceding week's lecture material, and will occur after our Monday sessions (at a time to be decided by the class). The meetings provide an excellent opportunity to discuss general questions concerning the course material. I expect everyone to attend these sessions.

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

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.

Notes on the readings. 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 additional 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 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 P**art 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
June 7	1a	Introduction to neuroscience. Mechanisms of neural excitability: models of membrane permeability and membrane conductance.	Ch1 all Ch2.1-2.5
	1b	The Goldman equation and the resting potential	Ch 2.8-2.9
June 9	2a	Voltage and time	
	2b	Voltage and space	
	2c	The cable equation and dendritic models	
June 11	3a	The action potential	Ch 2,10-2.16 Download the Axovacs computer program
	3b	Ion channel diversity and specialization	
	3c	Computational models of excitability	
June 14	4a	Synapses structure and function	Ch 3.1-3.18
	4b	Synaptic inhibition and excitation	
June 16	5a	Neurotransmitter release machinery: Testing the calcium hypothesis	
	5b	Neurotransmitter release: Molecular mechanisms	
June 19		**First hour quiz on Module 1.** *Note: This 1 hour quiz will be given on Saturday June 19, at 11AM*	

*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 18	6	Synaptic modulatory mechanisms: Modulation of synaptic transmission	Ch 3.19-3.26
June 21	7a	Synaptic modulatory mechanisms: Modulation of membrane excitability	Ch11.4-11.13
	7b	Synaptic modulatory mechanisms: Modulation of neural circuitry	Ch11.14-11.16 Ch 8.5
June 23	8a	Signal transduction; phototransduction	Ch 4.1-4.19
	8b	Retinal circuitry; outer plexiform layer	
	8c	Retinal circuitry: inner plexiform layer	
June 25	9a	Processing of visual information: area V1	Ch4.20-4.28
	9b	Integration of visual information: areas V2 and beyond	
June 28	10a	Motor and somatosensory systems	Ch8.1-8.6
	10b	Spinal cord circuitry and motor control	
	10c	Somatosensory and proprioceptive systems and loops	Ch6.27-6.33
June 30	11a	Nociception	
	11b	Sensory-motor integration; Voluntary motor control	Ch 8.12-8.15
July 2	12a	Cortical and brainstem motor systems: cortical reentrant loops.	Ch 8.8-Ch8.11
	12b	Cerebellum; Vestibulo-ocular control; motor learning	
July 3		**Second hour quiz on Module 2.** *Note: This 1 hour quiz will be given on Saturday, July 3 at 11 AM*	

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

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

July 5	13a	Cellular determination and neuronal differentiation	Ch7 all
	13b	Axon guidance: molecular mechanisms	
	13c	Synaptogenesis and system development	
July 6 (Tuesday)	14	Topographic map development Origins of understanding cortical plasticity	Ch5.1-5.16
July 7 (Wed)	15a	Medial temporal lobe memory systems Declarative and procedural memory systems	Ch11 all
	15b	Space, memory and final thoughts about the nervous system	
July 9		**Final Test on all 3 modules.** *This 3 1/2h test will be given from 10AM-1:30PM on July 9*	