Introduction to Neurobiology, Fall 2020

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General info

- **Instructor:** Arseny Khakhalin; khakhalin@bard.edu
- **Class meetings**: ___
- **Drop-in hours** (aka "office hours"): ___
  If you have a short question, also feel free to just stop by when the door is open! And if you have a long question, let me know, and we can schedule a meeting!

The main way of communication for this course is the **Piazza** discussion board. It's a sort of a dedicated forum created specifically for this course (a curious mix between facebook, reddit, quora, and stackexchange). By default it will also send updates to your emails, but I believe you can tune these updates to your liking, in the preferences.

- All announcements about the course will go on Piazza
- All materials for the course will be posted on Piazza.
- If you have general questions about the course, they should also be asked on Piazza
- For personal questions and updates, please use either office hours, or email
- Short homework assignments will be collected on Piazza. Please post them anonymously: I can still see who posted what, but your peers won't be able to see the author of a question / post.

Instructor will continue to improve this syllabus during the semester, to make the course even more amazing (for example, move topics around if we are slow, change reading materials, etc.)

Course description

Many neuroscience textbooks begin with descriptions of brain's nuts-and-bolts (neurons, synapses, ion channels), while all fun topics (behavior, cognition, memory) get clumped at the end. This happens because most textbooks pretend to be discussing human brains, even though the majority of what we know about the brain we learned from model organisms, such as rats, flies, and sea slugs. In this course, we will gradually climb up the ladder of complexity: from single neurons in invertebrates, through small circuits in fishes and birds, and up to large-scale networks in primates, to see how simple elements can combine and interact to produce meaningful behaviors. The course provides an introduction to neuroscience, and is recommended for students interested in biology, psychology, or computation. *Class size*: 18 Cross-listed in Brain Mind and Behavior

Course Goals

The ultimate goal of this course is to give you a chance to enjoy neuroscience.

In practice, it means that by the end of this course, I want you to be able to slowly read a modern neuroscience paper. It won't be easy, as this field is highly specialized, but I want you to reach a point at which you could make it through a paper in a day or two.

And in turn, this means that by the end of the course you should:

- Understand and be able to explain several key neuroscience concepts
- Get better in navigating, reading, and analyzing science papers
- Become familiar with key methods used in neuro research
- Have a first idea about how to collect, analyze, and present experimental data

Reading materials

There is no printed textbook associated with the course, but we'll use a free online textbooks as our main textbook. You are also encouraged to use Wikipedia for simple questions, terms, and definition. Overall, this course is topic-based, not text based. It means that there's no canonical text to interpret; instead we would have a topic to learn, and you can use any resources you want to learn about it.

The best free Neuro textbook right now is the one from the University of Texas:
https://nba.uth.tmc.edu/neuroscience/

If you need to go really deep, the magnificent Neuroscience grimoire by Dale Purves is also available online. For some weird copyright reasons you won't be able to browse it, but you can search within it, so just feed it some keywords and read the chapters that use these keywords:
https://www.ncbi.nlm.nih.gov/books/NBK10799/

Note that usually Neuro classes are taught at upper college, so you'll need to filter information. Your goal is to understand the basics, the get some general idea for HOW things work, not memorize all te currents, proteins, genes, brain regions etc. Look for the big picture, and then allow yourself to be creatively distracted by topics you like or care about.

If you know nothing about the brain, and want to read some really basic intro first, consider the "NIH primer to Neuroscience" (pdf link).

Grading

This course is graded using a "Specification Grading" system, which is known to work better than the standard "Point-based" system, both in terms of final results, and student experience. The gist here is that each letter grade comes with a certain list of criteria, and it is up to you to pick the level you want to achieve.

To get a **C:**

- Participate in 80% of classes
- Participate in 80% of labs
- Submit 60% of short written assignments (weekly reading reflections, labs, short exercises etc.) They don't have to be perfect, but they need to be reasonable. If any given submission is problematic, I'll let you know within a week, so that you could improve next time.

To get a **B:**

- Participate in 90% of classes
- Participate in 90% of labs
- Submit 90% of short written assignments
- Submit 2 reflective letters (each about 3 pages long; see the descriptions below). One before the mid-semester break; the other one before the completion week. The letters should be meaningful; if they are not, I'll let you know, and give you a chance to resubmit.
- Come to office hours at least once.

To get an **A:**

- **On top of everything specified in "B"**, write a good final essay about a neuroscience paper; then meet with me during the completion week, to discuss both the paper and the essay. See the detailed instructions below.

Attendance

If you miss more than 6 classes (labs and lectures combined) you will have to withdraw from the course. Please don't do it.

If you know in advance that you may have to miss a class, please let me (the instructor) know in advance!

Academic integrity and plagiarism

For homework and in-class tests, the *writing* should be done by *you*. Borrowing texts from other people or from the internet without an acknowledgement (such citation, reference, explicit acknowledgement) is unacceptable, and will result in bad things happening.

At the same time, for most assignments, collaboration and team work are heavily encouraged. Seek inspiration by talking to your peers before doing your work! Show your work to other people and ask for their suggestions and feedback! Offer your help to struggling compatriots! Except for quizzes and exams, I expect you to do your own work, but also productively collaborate, as it happens in real life.

Snow policy

During heavy weather classes are tied to the activity of Bard shuttle. If the shuttle is canceled, the classes are also canceled. If shuttle service is restored, and we have time to react, the class is typically held. If there is a risk of shuttle cancellation, make sure to frequently check Piazza (or email as a back-up).

Weekly Schedule

For the readings, UT s1ch1-2 stands for "University of Texas free textbook" section 1, chapters 1 to 2.

For the full list of readings, see The Appendix 2 below.

Week	Dates	Classes	Lab	Main reading / work
1	Sep 2, 4	Basic biology (cells, neurons, ions). Some terminology. Syllabus.	Sep 3. Safety training. Equipment training - pulse. (two sessions in one day)	UT s1ch1
2	9, 11	Resting membrane potential. Action potential. AP propagation. Note-taking activity.	Sep 12. Roach leg lab. (two sessions in one day)	UT s1ch2
3	16, 18	Excitatory synapse. Connectomics. Escape in shrimp.	Sep 19. Split groups: AP in Venus fly trap lab + Paper workshop 1 (M-cells).	UT s1ch4, 5. M-cell review paper.
4	23, 25	Inhibition. Integration. Neurotransmitters 1.	Sep 26. *Same lab as above, different groups*	UT s1ch0, s1ch6. Eyewire virtual lab.
5	30, Oct 2	Reflexes. Escape in fish. Ethology.	Oct 3. Patellar reflex. 2-point discrimination + data discussion (all together, big auditorium) + palfrey reading. First reflection letter due (9am)	*CPG review paper.*
6	Oct 7, 9	Central pattern generators. STG. Locomotion in vertebrates. Senses. Types of neural coding.	Oct 10. Split groups: Pre-pulse inhibition lab + Paper workshop 2 (owls). *Starting this day, workshops end by 3 pm, as 103 is booked after*	Simplewriter assignment. UT s2ch12 (hearing), glance through UT s2ch 13 (auditory pathways). Videos: ear, c.i., echo, echo2.
7	16	*14 – no class (Recess)* Hearing physiology.	Oct 17. *Same lab as above, different sections.*	Auditory neuroscience: ear and spatial hearing. Sound localization in owls (paper + reviews).
8	21, 23	Hearing: Early processing. Maps. Speech recognition. Neuroscience of music.	Oct 24. Split groups: OMR lab, group 1. (The other group: vision development paper)	UT s2ch14 (eye and retina); McGill retina; Dalton paper. Videos on retinal vessels and white blood cells.
9	28, 30	Vision: eye and retina. Saccades. Color vision.	Oct 31. *Same lab as above, different groups.*	s2ch15 + cortical column reading. videos on neurobiology of toads (1, 2, 3).

Week	Dates	Classes	Lab	Main reading / work
10	Nov 4, 6	On/off cells, lateral inhibition, motion detection. Vision in the cortex. Visual illusions. Blind spot and saccade exercises.	Nov 7. Emotions lab (two sessions in one day)	UT s4ch5-6 (limbic system). Neurotransmitters (list).
11	11, 13	Terms of location. Brain morphology. Methods of research. Motor systems.	Nov 14. EMG lab (two sessions in one day)	UT s2ch1 (overview of organization). A list of keywords (basal ganglia, cerebellum). QWOP.
12	18, 20	Limbic system. Emotions. Cortex. Higher associative regions. Language areas. Left and right brains.	Nov 21. Ulnar nerve lab (two sessions in one day)	UT s3ch3 (motor cortex); UT s4ch8 (Language): the very beginning of it (ignore details). Aphasias. Walker. Giraffe paper.
13	25, 27	Brain development.	*No lab 28 (Thanksgiving)* Draft of the final paper due (Wed, Nov 27)	UT s1ch7 (synaptic plasticity); LTP and patch-clamp. UT s1ch9 (synapse formation and elimination).
14	Dec 2, 4	PFC and decision making. Frontal patients and psychopaths. Integrity of perception (including visual illusions). Agency. Split brain. Schizophrenia.	Dec 5. Sheep brain dissection (two sessions in 1 day) Second reflection letter due (Wed, Dec 4)	UT s4ch9 (higher cortical functions). "Love hurts" paper. Geometrize?
15	9, 11	*No classes: advising week*	*No lab either * Final paper due (Mon, Dec 9)	
16	16, 18	Completion week (one-on-one meetings)		

Topics excluded that year, due to snow days: Pavlovian learning and Hebb's rule. Associative learning. Hippocampus.

Appendix 1. Assignment instructions

Reflective letters

To get a "B" or higher, you need to write two letters, reflecting on this class, and your work in it.

For the first reflective letter (to be written before the mid-semester break), please answer these questions. Each answer should be about half a page (200-300 words).

1. Please describe your personal goals for this course. What do you want to take from it? What do you want to learn and understand? Why?
2. Describe the coolest, most interesting thing you learned in this course so far. Try to write as if you were describing it to your friend who is not taking this course. Please tell me why you, personally, find it interesting.
3. Describe one topic you studied in this course that you still do not completely understand, but would like to understand. Try to explain how you know that you don't understand it fully yet. This is a tricky question, as it is hard to notice that you don't understand something, and it is even harder to write about it. Note that if what separates you from knowing this topic is a few minutes of googling, it clearly does not count as an answer. Try to think deeply about everything we studied in this course, and whether you really got it. It is an important skill: to know what you know, what you don't, why you want to know it, and how to get there.
4. Describe how you study for this course (half a page). How much do you study each week? How do you use this study time? What sources do you use? Have you tried to study with someone? Have you looked for help? Note that I will not judge your studying schedule, even if you confess that you don't study at all. I just want to know what you do, and I want you to think about it.
5. Tell me something else, one more thing, about this class, your work in it, and your experience of it. What seems to work well? What does not? Why? How to make it work better? If there are any particular things you would like me to address, please let me know. I'd like to know what you think, and how you feel.
6. If you had to give yourself a mid-term letter grade for the first half of this course, what grade would it be? Why not a higher, or a lower one? Note that this self-grading won't affect your actual grade at all, so let's just honestly think, and later talk about it.

Second paper (to be written in the second half of the semester, before the completion week). Each response should take about half a page (200-300 words).

1. Describe the most important, most useful thing, either conceptually or practically, that you learned in this course. Not necessarily the most interesting one, but the one that is consequential, for you, personally. What makes it important?
2. Reflect on your work in the second half of this course, compared to the first half of it. Is there anything that you did differently? Have you tried to deliberately change anything about your studies? Did it work?
3. What have you liked about this class? What worked well?
4. What one thing you would have changed about this class, and why? How to make it better?
5. If you had to give yourself a letter grade for this course, what grade would it be? Why not a higher grade? Why not a lower one? Again, this self-grading won't affect your actual grade, but I'd like us to talk about it.

6. What are you plans for next semester, and next year? What do you want to do? What do you want to learn? Have these plans changed since your arrived at Bard? If yes, why?

Final essay, and its discussion

This assignment is only required if you want to go an extra mile (above a letter grad of"B"). If you put good work in it, you can get an "A"; if you don't put enough work, you can get an "A minus", or a "B plus", depending on how far you get.

First, you need to find a neuroscience paper that you'd like to write about, from a journal named eLife (https://elifesciences.org/). It is an open-access journal, so all papers are freely available online. It may make sense to find a paper that has something to do with something we learned in class, but if you want to go rogue, it is also possible(just make sure it's neuroscience). Also, it has to be a primary paper: an experiment, a model, or a meta-analysis, but not a literature review, or an opinion piece.

Send me an e-mail with a link to the paper, to claim it. If I think that the paper is a poor choice, I'll let you know (it's unlikely, but just in case). The earliest you can claim the paper is a week before the mid-semester recess. The latest you can claim it, is immediately before the completion week. But note that the more time you have, the better you can prepare, and the more feedback I can give you, when you ask for it.

Read the paper of your choice. Read some of the papers that it references, to learn the background (especially those referenced in the "introduction" section). Make sure you understand what question this paper asks, and why it is important. What are the consequences of knowing it? What are the hypotheses the authors had? You need to understand the methods. You need to know the figures, and understand what they are trying to say. You also need to read the exchanges that the authors and the reviewers had before the paper got accepted (eLife is one of the few journals that publish these exchanges openly). You need to get a good idea of what happened there, at the review stage; what the concerns were, and how the authors responded to these concerns.

Then write your essay. It cannot be longer than 2500 words (about 5 pages single-spaced), but it should clearly address the following points, in this order:

1. The rationale for the paper (what makes its question important), and some background needed to understand the study. Explain what we need to know before we even start reading the paper.
2. Why did you pick this paper, out of all neuro papers in this journal? Why this one?
3. The narrow question (or questions) the paper posed, and associated hypotheses (like, conceivably, what could be the answers to this question? What were even the options?)
4. Methods used. Don't describe them in detail (they are already described in the paper), but you need to have a decent grasp of the general idea of each method. Try to explain the essence of these methods in simple words. Try to outline weak and strong points of each of these methods, compared to others methods authors could have conceivably used (assuming similar time and financial budgets).
5. Figure by figure, the key message of each figure. Why are these figures even there? What panels are most critical within each figure? How do different figures speak to each other, and create a narrative? How do their messages support and advance the overall message of the paper?
6. The answer eventually provided by the paper. Make sure to refer back to the narrow question the authors posed, and the hypotheses they had. What does this answer mean, in a broader scale of things?

7. What are the limitations of this study? What follow-up studies can be inspired by this study? Some of these are probably outlined in the Discussion, some may be identified from the peer review materials, some you can discover yourself. Make sure to go beyond the obvious; if a limitation is true for every paper ever written, it is probably not the most useful thing to discuss.

You need to submit the final version of the essay by the first day of completion week, and we'll schedule a meeting to talk about it. In the meeting, we will discuss the original paper that you were writing about, using your essay to answer the questions outlined above.

There will be a deadline to submit a draft version of your essay. If you submit something by this deadline, I will read your draft, and give you some feedback. We can also meet during drop-in hours, to talk about your project (it's not required, but we may, if you prefer to).

The measure of success here is the depth of your research towards understanding this one single paper. Some topics, methods, and analyses are inherently more complicated, while some are simpler, so we are not going after some predefined level that you need to reach. Rather, I want to see your independent work, and your ability to use what we learned in class to learn more science on your own. If the paper is "easy", I will expect a deeper understanding of it, and I may ask more follow-up questions in our meeting. If the paper is hard or long, a deep understanding of only one part of it, perhaps as little as one figure, may suffice. Again, what matters here is the amount of thought you put in your project. You definitely don't need to become perfect (it is impossible to know everything!!) but you need to kinda become a specialist in this one particular paper, compared to a person reading it for the first time.

Appendix 2. Full list of Readings, videos, and extra materials

Resting membrane potential

- https://nba.uth.tmc.edu/neuroscience/s1/chapter01.html
- Khan academy: https://www.youtube.com/watch?v=l3ngsl7FhTc

Action potential

- Main reading: https://nba.uth.tmc.edu/neuroscience/s1/chapter02.html
- http://faculty.washington.edu/chudler/ap.html
- https://www.youtube.com/watch?v=90cj4NX87Yk
- Death by coconut: Hakimian, J., Goldbarg, S. H., Park, C. H., & Kerwin, T. C. (2014). Death by coconut. Circulation: Arrhythmia and Electrophysiology, 7(1), 180-181. Google Drive Link
- On pain, about Steven Pete: https://www.bbc.com/news/magazine-18713585
- On pain, about Ashlyn Blocker: https://www.nytimes.com/2012/11/18/magazine/ashlyn-blocker-feels-no-pain.html
- A video on how pain relievers work: https://www.youtube.com/watch?v=9mcuIc5O-DE
- A chart about ion sizes: https://commons.wikimedia.org/wiki/File:Action_potential_ion_sizes.svg

Excitatory synapse. Connectomics. Escape in shrimp

- Main reading: chapters 4-5
  https://nba.uth.tmc.edu/neuroscience/s1/chapter04.html
  https://nba.uth.tmc.edu/neuroscience/s1/chapter05.html

Venus fly trap lab

- Video: https://www.youtube.com/watch?v=45v5L2u0Nj8

Inhibition. Integration. Reflexes. Escape in fish

- Main reading:
  chapter 0: https://nba.uth.tmc.edu/neuroscience/s1/introduction.html
  chapter 6: https://nba.uth.tmc.edu/neuroscience/s1/chapter06.html
- Eyewire virtual lab
  Description: https://blog.eyewire.org/about/
  Login: https://eyewire.org/signup (create an account, login, go through the tutorial, analyze at least one real cube, post your result)
- Review about M-cells:
  https://core.ac.uk/download/pdf/82507508.pdf
  Homework: 1) list words that you didn't understand at first and had to look up on google / Wikipedia; 2) Copy one sentence from the paper that you found confusing at first, but later understood. Describe what was confusing about it, and how did you manage to de-confuse yourself.

Ethology, STG, CPG

- Wikipedia article about Ethology: https://en.wikipedia.org/wiki/Ethology

- Wikipedia article about Neuroethology: https://en.wikipedia.org/wiki/Neuroethology
  Make sure to look through the list of model systems below. Figure out what was studied in each of these systems. Try to understand why this question (of all possible questions) was asked in this animal, and why this animal (of all possible animals) was used to answer this question?
- Review on Central Pattern Generators: https://www.cell.com/current-biology/pdf/S0960-9822%2801%2900581-4.pdf
- Two popular articles about palfreys:
  - https://amyraby.com/2012/09/26/history-for-the-fantasy-buff-the-palfrey/
  - http://blogs.discovermagazine.com/notrocketscience/2012/08/29/one-gait-keeper-gene-allows-horses-to-move-in-unusual-ways/#.XX6ekC5KjIV

Senses. Types of neural coding. Hearing: Physiology.

- How many senses do you have? In general, what senses may an animal have? Think about it. Then read this article: https://en.wikipedia.org/wiki/Sense
- Main reading on hearing: https://nba.uth.tmc.edu/neuroscience/s2/chapter12.html
  When you open the page, it may start downloading a media file automatically. Cancel this download. It's just bad programming from the authors of this site; we don't need this file.
- Watch this video (Auditory transduction): https://www.youtube.com/watch?v=PeTriGTENoc
- Read this comic: https://xkcd.com/1133/
  Watch this youtube video: https://www.youtube.com/watch?v=2p__8gx-XHJo
  This page from "Things explainer": http://i.cbc.ca/1.3390492.1452021709!/fileImage/httpImage/thing-explainer.jpg
- Then use this link to access the simple writer: https://xkcd.com/simplewriter/
- As a homework, pick any topic we studied in this course so far. Anything about ions, action potentials, synapses, neurons, escape responses, animal models, sensory systems, hearing – anything that we studied. Try to describe this topic using simple words only. (The SimpleWriter will alert you if your words are not simple enough) The *only* non-simple word you can use is the concept you are trying to explain, and even then you can only use it three times.

PPI lab

- Paper about PPI: https://pdfs.semanticscholar.org/e110/4edd4b6c3aebcd678dba2b9b2a2acbea1b48.pdf

Hearing 2: Maps, Speech, Music.

- Sound location in owls: https://en.wikipedia.org/wiki/Sound_localization_in_owls
- These topics on Wikipedia:
  https://en.wikipedia.org/wiki/Musical_acoustics
  https://en.wikipedia.org/wiki/Formant
  Feel free to explore deeper if any particular topics touch your heart!
- A video on cochlear implants: https://www.youtube.com/watch?v=icPsm9RnO2E
- Fox hunting by ear: https://www.youtube.com/watch?v=0yUwM5mHBD8
- Spatial hearing: http://auditoryneuroscience.com/spatial-hearing
- A video about echolocation in humans: https://www.youtube.com/watch?v=r9mvRRwu5Gw

- This site in general: http://auditoryneuroscience.com/
  There's a list of topics on top. Interested in music? In sound illusions? (They are like visual illusions, but for hearing) Speech and perception of speech? It's all there!
- Shepard's tone: https://www.youtube.com/watch?v=BzNzgsAE4F0
- Tuvan throat singing.
  - Demo of several styles: https://www.youtube.com/watch?v=7zZainT9v6Q
  - Actual Tuvans (Huun-Huur-Tu) Live on KEXP: https://www.youtube.com/watch?v=R2ovoRyv4kw

Vision: eye and retina. On/off cells.

- Main reading: https://nba.uth.tmc.edu/neuroscience/s2/chapter14.html
- Extra page from McGill; make sure to click through all three levels (Beginner, Intermediate, Advanced): http://thebrain.mcgill.ca/flash/i/i_02/i_02_cl/i_02_cl_vis/i_02_cl_vis.html
- Watch classic experiments with toads:
  - https://www.youtube.com/watch?v=l3Es9cNH7I8
  - https://www.youtube.com/watch?v=ITY9luBw3_I
  - https://www.youtube.com/watch?v=PoDJZ4Ln9Rw
- Why this is important (a toad playing on an ipad): http://www.youtube.com/watch?v=LbNl3J8HXw4
- A video about blindsight in humans: https://www.youtube.com/watch?v=9ABQ-U6V0tY
- Run these labs at home:
  - Floaters: https://www.youtube.com/watch?v=WKQT1MXfasM
  - Saccades: https://vimeo.com/54546597
- On color vision (this is not yellow; only watch the first third of the video or so, that is about vision; ignore the rest): https://www.youtube.com/watch?v=R3unPcJDbCc
- Dalton paper: Dalton, J. (1798). Extraordinary facts relating to the vision of colours: with observations. Memoirs of the Literary and Philosophical Society of Manchester,5, 28-45.

Vision 2: Cortex. Critical periods.

- Main reading: https://nba.uth.tmc.edu/neuroscience/s2/chapter15.html
- Orientation selectivity in a cat: https://www.youtube.com/watch?v=QzkMo45pcUo
- A short story that describes how it works (critical periods in development): https://www.youtube.com/watch?v=iRinGqREd4A
- Hubel and Wiesel:
  - about them: https://www.youtube.com/watch?v=4nwpU7GFYe8
  - experiment 1: https://www.youtube.com/watch?v=jIevCFZixIg
  - experiment 2: https://www.youtube.com/watch?v=8VdFf3egwfg

Neurotransmitters. Emotions. Limbic system.

- Main readings:
  - Hippocampus: https://nba.uth.tmc.edu/neuroscience/s4/chapter05.html
  - Amygdala: https://nba.uth.tmc.edu/neuroscience/s4/chapter06.html

- Drugslab channel: https://www.youtube.com/channel/UCvRQKXtIGcK1yEnQ4Te8hWQ/videos?flow=grid&view=0&sort=da
  Watch some of their older videos (the older - the better; the recent ones are less useful). They talk in Dutch, so turn on English subtitles. Watch something like Ketamine, MDMA, N2O. Or something else. Note that personally I would have drawn the line earlier than they do (they try cocaine, amphetamines, and GABA agonists that I definitely do not endorse). Note also that they don't touch opiates. Also in some of the videos they go through all sorts of simple motor and cognitive tests, which is instructive (I wish they did it more).
- Two articles about opiates:
  - A doctor and fentanyl: https://torontolife.com/city/crime/doctor-perfect-life-got-hooked-fentanyl/
  - Narrated reddit story about heroin: https://www.youtube.com/watch?v=Lbh13zwJc1g

Brain morphology.

- Keywords I'd like you to have some basic idea about: ventral, dorsal, lateral, medial, rostral, caudal, superior, inferior, contralateral, ipsilateral, forebrain, midbrain, hindbrain, cerebellum, olfactory bulbs, telencephalon, diencephalon, mesencephalon, rhombencephalon, brain ventricles, cortex, thalamus, hypothalamus, tectum, tegmentum, pons, medulla, decussation, commissure, pineal, pituitary, superior and inferior colliculi, hippocampus, amygdala, autonomic system, sympathetic system, parasympathetic system.
- Overview of nervous system: https://nba.uth.tmc.edu/neuroscience/s2/chapter01.html
- Wedel, M. J. (2011). A monument of inefficiency: The presumed course of the recurrent laryngeal nerve in sauropod dinosaurs. Acta Palaeontologica Polonica, 57(2), 251-257. https://www.app.pan.pl/archive/published/app57/app20110019.pdf

Motor systems.

- Main reading: Motor cortex: https://nba.uth.tmc.edu/neuroscience/s3/chapter03.html
- A video about motor cortex and brain-machine interfaces: https://www.youtube.com/watch?v=QRt8QCx3BCo
- Basal ganglia (the chapter in the book is way too detailed, so I'm linking Wikipedia instead): https://en.wikipedia.org/wiki/Basal_ganglia
  But even then, the main take-home message here is that "everything is super-complicated" =)
- Videos about basal ganglia:
  - Tourettes: https://www.youtube.com/watch?v=1SEKZLivG54
  - Parkinsonism and deep brain stimulation: https://www.youtube.com/watch?v=KcGLC_rOaKM
  - (Background: https://en.wikipedia.org/wiki/Deep_brain_stimulation)
- Cerebellum: only read the overview, the chapter itself is wa-ay too detailed: https://nba.uth.tmc.edu/neuroscience/s3/chapter05.html
- QWOP game: try to get it to 10 m: http://www.foddy.net/Athletics.html
  Post your personal record.

Cortex: associative regions, language, lateralization.

- Language: https://nba.uth.tmc.edu/neuroscience/s4/chapter08.html
- Videos to watch:

    - https://www.youtube.com/watch?v=f2IiMEbMnPM - Broca's aphasia, old video
    - https://www.youtube.com/watch?v=1aplTvEQ6ew - Broca's aphasia, teenage stoke
    - https://www.youtube.com/watch?v=a9z6eX85Zn4 - same person 6 years later (on her channel you can find some more in-between videos if you want to)
    - https://www.youtube.com/watch?v=aVhYN7NTIKU - Wernike's aphasia, old video
    - https://www.youtube.com/watch?v=3oef68YabD0 - Wernike's aphasia, a better (more recent) video
- Higher cortical regions: https://nba.uth.tmc.edu/neuroscience/s4/chapter09.html
- Point-walker: http://www.biomotionlab.ca/Demos/BMLwalker.html

Plasticity

- U Texas book, synaptic plasticity: https://nba.uth.tmc.edu/neuroscience/s1/chapter07.html
- Grokk information about LTP and patch-clamp on Wikipedia:
  https://en.wikipedia.org/wiki/Long-term_potentiation
  https://en.wikipedia.org/wiki/Patch_clamp
- Read about Pavlovian learning and Skinner's operant conditioning (also on Wikipedia)
- Review on LTP (ignore everything about LTD): https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3367554/
- Advanced: pages 3 and 4 on Hebbian plasticity, in this paper: https://pdfs.semanticscholar.org/f9fc/99a5c52aa5df1b530dfdeb25dfb6b10bdecf.pdf

Development

- U Texas book, synapse formation and elimination: https://nba.uth.tmc.edu/neuroscience/s1/chapter09.html
- Videos of growing neurons:
    - https://www.youtube.com/watch?v=EP4yeyD8ktY
    - https://www.youtube.com/watch?v=4Vx_FzG1m5E
- Video of a growth cone:
  https://www.youtube.com/watch?v=m1Y5ugEWF00
- Recursive drawing (as a metaphor for complex systems):
  http://recursivedrawing.com/draw.html

Visual illusions

- McGurk effect: https://www.youtube.com/watch?v=G-lN8vWm3m0
- On multisensory integration (this entire channel is gold):
  https://www.youtube.com/watch?v=_zCDvOsdL9Q
- After-motion effect: https://www.youtube.com/watch?v=GkRHN0rnfME

Cortex. Higher associative regions. Language areas. Left and right brains.

- Language in the cortex: https://nba.uth.tmc.edu/neuroscience/s4/chapter08.html

Beauty

- Geometrize: http://www.samcodes.co.uk/project/geometrize-haxe-web/
  Upload a picture; see it gradually appear on the screen. Every few seconds (use a timer?) note how pretty the picture is, on a 1-10 scale. Repeat with several pictures. Try to figure out, when the picture looks the prettiest: in the beginning, in the middle, or at the end? Why? If possible, find a friend and subject them to the same procedure; will their curve differ from yours?

Frontal regions, consciousness, abnormal psychology

- What happens when cerebral hemispheres are separated: https://www.youtube.com/watch?v=zx53Zj7EKQE
- On memory: Transient global amnesia: https://www.youtube.com/watch?v=N3fA5uzWDU8
- Four patients with schizophrenia: https://www.youtube.com/watch?v=bWaFqw8XnpA&t=4m37s
- A really wholesome interview: https://www.youtube.com/watch?v=7csXfSRXmZ0
- Paranoid schizophrenia simulation (a somewhat questionable attempt to make a training video. Not necessarily "bad", but also not entirely unproblematic): https://www.youtube.com/watch?v=LWYwckFrksg
- Personality changes after a trauma (and an interesting discussion of legal implications): https://longreads.com/2019/10/22/the-final-five-percent/

Sheep brain dissection

- https://psych.hanover.edu/classes/neuropsychology/syllabus/labs/dissection.pdf