PRINCIPLES OF NEUROSCIENCE I
NEUR 630

3 credits

Fall, 2021

Due to uncertainty associated with COVID19 we are planning to deliver this course remotely through MyCourses.

Course Coordinators: Austen Milnerwood & Gary Armstrong

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Calendar course description: An overview of cellular and molecular neuroscience at the graduate level. Topics include synthesis, processing and intracellular transport of macromolecules; development of the nervous system including neurogenesis, axonal pathfinding, synaptogenesis and myelination; neuronal survival and response to injury; generation and propagation of action potentials; neurotransmitters and synaptic transmission.

Academic Integrity*:* McGill University values academic integrity. Therefore, all students must understand the meaning and consequences of **cheating, plagiarism and other academic offences** under the Code of Student Conduct and Disciplinary Procedures (see www.mcgill.ca/students/srr/honest/ for more information).

Language Policy: In accord with McGill University's Charter of Students' Rights, students in this course have the right to submit in English or in French any written work that is to be graded.

Mobile computing and communications devices are permitted in class insofar as their use does not disrupt the teaching and learning process.

In the event of extraordinary circumstances beyond the University's control, the content and/or evaluation scheme in this course is subject to change.

LECTURE SCHEDULE - PRINCIPLES OF NEUROSCIENCE 1 NEUR 630 (2021)

PREREQUISITES: BIOL 200 and BIOL 201 or equivalent; general mammalian physiology.

TIME: Tuesday and Thursday from 12:15pm to 2pm.

PLACE: Zoom lectures will be delivered through the *my*Courses website.

WEBSITE: MyCourses: https://mycourses2.mcgill.ca/d2l/home

The following textbooks provide a broad overview of the material taught in the class which some students may find helpful for clarifying topics: ***Neuroscience***, Sixth Edition Edited by Dale Purves, George J. Augustine, David Fitzpatrick, William C. Hall, Anthony-Samuel LaMantia, and Leonard E. White, published by Sinauer Associates (https://oup-arc.com/access/purves-6e); ***Principles of Neural Science***, Fifth edition Edited by Eric R. Kandel, James H. Schwartz, Thomas M. Jessell, Steven A. Siegelbaum, and A. J. Hudspeth, published by Elsevier (https://neurology.mhmedical.com/book.aspx?bookID=1049#59138630).

SECTION I: DEVELOPMENT OF THE NERVOUS SYSTEM; Section Coordinator: Dr. G Armstrong

Sept 7th, and 9th: - Introduction to neural cells; cytology; synthesis and transport of neuronal proteins; mechanisms of motility [**G. Armstrong**]

Sept 14th and 16th: - Cell survival
- Myelination [J.-A. Stratton] – **Pre-recorded.**

Sept 21st and 23rd: - Embryology: Formation of the nervous system
- Neurogenesis [**A. Suvrathan**]

Sept. 28th and 30th: - Axonal pathfinding [**J.-F. Cloutier**]

Oct 5th: - Section I exam – Coordinated by Armstrong

Oct 8th: - Final assignment stage 1: The Question due

SECTION II: HOW CELLS COMMUNICATE: ELECTRICAL AND CHEMICAL SIGNALING
Section Coordinator: A Milnerwood

Oct 12th and 14th: - Mechanisms of transmitter release: The quantal hypothesis [**P. McPherson**]

Oct 15th: - Peer review of stage 1: The Question due

Oct 19th and 21st: - Passive membrane properties
- Introduction to excitation [**E. Ruthazer**]

Oct 26th and 28th: - Function and structure of voltage-gated channels
- Function and structure of ligand-gated channels [**D. Bowie**]

Nov 2nd: - Section II exam – Coordinated by Milnerwood

Nov 8th: **- Final assignment stage 2: Notice of Intent due**

Nov 9th and 11th: - Synaptogenesis
- Fine tuning of synaptic connections: Development of the visual system [**A. Milnerwood**]

Society for Neuroscience (Chicago) meeting Nov 13th-17th

Nov 16th and 18th: - Effector mechanisms in synaptic transmission
- Classes of neurotransmitters [**Y. Zhou**]

Nov 19th: **- Peer review of stage 2: Notice of Intent due**

Nov 25th: - Generation and function of activity patterns [**A. Peyrache**]

Nov 30th and Dec 1st: - Modulation of ion channels; phosphorylation, etc.
- Modulation of synaptic transmission, i.e. LTP [**W. Sossin**]

Dec 7th: **- Section III exam** – Coordinated by Milnerwood

Dec 14th: **- Final assignment due**

PREAMBLE TO PRINCIPLES OF NEUROSCIENCE I (NEUR 630)

PURPOSE OF THE COURSE: Neuroscience is a multidisciplinary topic attracting students from a variety of background programs including biology, biomedical sciences, psychology, physics, engineering, etc. As students you will be conducting your research in a variety of diverse topics from physics and computer programming in neuroimaging to various systems of the nervous system, such as the motor and visual systems, control of blood flow, to cellular and molecular studies such as gene regulation. At one level, it is impossible to cover all the topics of neuroscience at an advanced level and you would probably hate us if we tried. However, more and more neuroscientists are being required to work together in multidisciplinary teams to attack problems; i.e., a variety of specialists with different training must work together and be able to communicate in each other's language. The purpose of this course is to give you enough of an overview that:

(1) You graduate from this program with a good general knowledge of the discipline of neuroscience in addition to your specialty.
(2) You can go to a seminar or read a research paper in any area of neuroscience and understand it.
(3) You have sufficient background knowledge to learn on your own.
(4) You can communicate with fellow scientists with different expertise.
(5) You can see beyond the scope of your specialized area of interest.

You can expect that your perception of the level of difficulty will vary with different sections of the course, depending on your background. Because of the diversity of students, we do have to start at the beginning even though it is difficult to impart basic information to those who are new to the topic, while still keeping the interest of those who have had experience in that particular area. This is a course in principles of neuroscience, not the principles of science and a background in general and cellular biology, basic chemistry and physics is a prerequisite. If you don't know the general properties of ions, you will not understand current flow in neurons; if you don't know the building blocks of cells, you won't understand how they are regulated in neurons. Even still, we know from our experience that there are among you those for whom studies of the general properties of cells such gene transcription, protein synthesis, cell motility, etc., may have been a while ago. You are expected to review and be familiar with these concepts before attending class.

The first section of the course will deal with cellular aspects of development. Where the cells of the nervous system come from and how they get to the right place; how they form appropriate connections with one another, how they maintain these connections and what happens when they are injured.

The second section of the course deals with information transfer. How messages are received and sent: electrical and chemical transmission of signals: how they are effected and modulated. In the final session, how neurons work together to generate patterns of activity and neuronal networks will be discussed. This will lead into Principles of Neuroscience II (NEUR 631), which covers the various systems of the nervous system, how they function and how they are integrated.

EXAMINATIONS

In accord with McGill University's Charter of Students' Rights, students in this course have the right to submit in English or in French any written work that is to be graded.

(1) **3 midterm exams** (25% each) on course work worth 75% of total mark. The format will be short answers/essays and will be based on the material from the immediately preceding lectures. The exams will be a take-home/online format and will be submitted electronically. Students will be able to access their notes; however they are to work individually on the exam and are **NOT** to consult with others. The questions will not be restricted to regurgitation of facts. You will be asked to utilize the information to formulate thoughtful answers.

(2) One **take-home final assignment** worth 25% of total mark due at the end of the course (see schedule above).

Format for Take-Home Final Assignment & Peer Review:
The final assignment is a 5-page mock grant on a set of topics that will be assigned near the beginning of the course and will be written individually. There may be an element of topic choice. **Pay attention to the deadlines specified in each section. Extensions will not be given** (except for emergency situations with medical certificate). Late submissions will be penalized 5% per day up to 25%.

This form of examination has been chosen in order to give you experience in relating different pieces of information and in writing skills that you will require in the scientific field (*e.g*., grant and scholarship applications). Therefore, **you must follow the guidelines set out for the assignments exactly**. Marks will be deducted for failing to follow the correct format. Your mark will take into consideration proper spelling and grammar and effectiveness of communication in addition to content.

Peer review: The 5-page mock grant writing assignment will be worked on by students throughout the term (see "process" below) and other students in the class will anonymously provide feedback (using PeerGrade in *my*Courses). The benefits of this are multifaceted: i) students will become familiar with peers assessing their work, ii) they will get the benefit of seeing others' work, which will help guide their assessment of their own output, iii) a boost to learning through repetition / revision of concepts, iv) transferable knowledge and appraisal skills, v) witnessing and contributing to the evolution (or not) of a project proposal through constructive peer feedback, vi) improved final assignments by the end, and vii) assessing which feedback is constructive and which isn't (*e.g*., peer feedback will be marked by recipient as helpful or unconstructive (NOT positive or negative, but useful)).

Process: The mock grant assignment will have 2 submission stages and peer review prior to the final submission at the end of term.
Early in the term (2nd or 3rd week of the course), 11 topics (one from each Professor) will be posted to *My*Courses and the students will choose one of these to work on throughout the course. Students will sign up for their preferred topic on a first-come first-served basis, with limited sign-up per question i.e., maximum of 10 students per Professor topic. Students are expected to choose a topic that is not directly related to their thesis project. Students will be allowed to switch their topic with another student who is also willing to switch, but they are responsible for finding another student to trade their question with.

Stage 1: The Question – Due Oct 8th
Using a maximum of 250 words students will compose a research question that fits within the topic that they have chosen. Students will make a good case for why this question is interesting / critical / timely, and how answering it will address an important issue in contemporary neuroscience. This written text will be copy and pasted by students into PeerGrade on *my*Courses on **October 8th** (anytime that day).

Peer Review of Stage 1 – Due Oct 15th
Each student will receive ~5 other student's questions in PeerGrade on **October 9th**. Both the author of the question and the ~5 other students who give peer review will be anonymized. In PeerGrade there will be text box were the peer reviewer will provide constructive feedback to each of the ~5 student questions they are assigned. Constructive feedback could entail pointing out a research question that has been studied and maybe answered already in the scientific literature, refinement of hypothesis, improvement in a sentence, refocusing ideas or concepts *etc*. Peer review is commonly practiced at the highest levels of academic research. Every one of your professors has had colleagues read their papers and grants and this exercise will set a foundation for you to improve your own critical scientific writing.
Your peer review of ~5 other student Questions will be due October 15th (copy and pasted into PeerGrade anytime that day).
Peer reviews will be returned to each student and each student will provide a mark on how useful/helpful the peer review was to their question (see below for mark weightings).

Stage 2: Notice of Intent – Due Nov 8th
Building upon your stage 1 submission and the feedback you received during the peer review, each student will compose a more detailed outline of the mock grant that they will eventually write. The term "Notice of Intent" is a commonly used phrase that some of the big granting agencies use in Canada and throughout the world to describe this sort of text document. Each students' Notice of Intent will be composed of a **title, a short background, 5 key words, 2-4 objectives each with their own hypothesis and methods used to address**

the objectives, and a summary statement. The Notice of Intent text can either be copy and pasted into PeerGrade or uploaded as a .pdf file. In either case, a maximum of 1.5 pages of text + 0.5 pages for references (if needed) or maximum 1000 words total using 1.5 line-spacing with margins of 2cm on each side and Arial 11 font is permitted. To help the students an example Notice of Intent will be provide. This will be due November 8th and will be uploaded by students onto PeerGrade in *my*Courses (anytime that day).

Peer Review of Stage 2 – due Nov 19th
As with peer review of stage 1, stage 2 peer review will consist of each student receiving anonymously ~5 other student Notice of Intents documents on PeerGrade that they will peer evaluate. This peer evaluation will consist of a series of questions for each peer reviewer to address. These will be specifically noted in PeerGrade but could include items such as: is the title appropriate for the objectives described in the Notice of Intent, is the background well composed and understandable, are the objectives clearly stated and understandable for someone not necessarily familiar with the science, and are the hypotheses clearly stated and appropriately designed for the stated objectives? **Your peer review of ~5 other student Questions will be due November 19th** (copy and pasted into PeerGrade anytime that day). Peer reviews will be returned to each student and each student will provide a mark on how useful/helpful the peer review was to their question (see below for mark weightings).

Final assignment – due Dec 14th
Building upon the written work done and the peer review that students have received throughout the term; each student will construct a mock 5-page NSERC/CIHR style grant proposal. Up to 2 additional pages for references will be allowed.

Guidelines for paper: The final assignment must be 1.5-spaced text (11 point Arial Font) with 2 cm margins. Papers may be written in English or French. All statements referring to the work of others must be referenced, quoted and footnoted appropriately. References must be listed in the bibliography in full format (All authors names, year, full title, journal name and inclusive pages).
Each grant proposal must have the following sections:

1) Title and up to 5 key words
2) Background
3) Objectives
4) Summary statement

Please name the essay file in the following format:

Question #_ last name
i.e. If you are answering question 2 and your last name is Smith:
2_Smith.doc

Final Assignment Mark Weightings

1 mark peer review of Stage 1
4 marks peer review of stage 2
20 marks for final assignment

GRADING OF MOCK GRANT ASSIGNMENT
Principles of Neuroscience I and II

A	85-100%	17-20/20
A-	80-84%	16/20
B+	75-79	15/20
B	70-74	14/20
B-	65-70	13/20
F	0-64	0-12/20 FAILURE

Summary: To be awarded a grade of A or A-, it is not sufficient to summarize the published literature. As graduate students, you are expected to provide your own analysis of the key literature, identify controversies and important holes in our knowledge, and suggest possible solutions, as well as exhibiting excellent communication skills. The page limitations force you to consolidate both the literature and your interpretation.

A: A paper that is excellent in both scientific content and presentation. The key original literature is in the bibliography. Literature is

cited appropriately. All statements of others are referenced. The paper directly addresses the question. The material is well organized and logically presented. The style is grammatically correct and easy to understand. The student has demonstrated the ability to organize and to interpret the literature. The student has provided intellectual input. Controversies in the literature have been addressed and evidence for each side weighed. Suggestions have been made how controversies might be resolved or unanswered questions addressed experimentally.

A-: similar criteria to A, but not quite as good (i.e. not excellent in one of the criteria).

B+: A well written paper that does a superb job summarizing the key literature, but is lacking in interpretation or a paper that is very insightful, but not particularly well written and organized.

B: Similar to B+, but lacking in focus, missing some information, or containing misinterpretations or inconsistencies.

B-: A borderline paper at the graduate level. The paper makes good points, but key literature is missing and there is no evidence of interpretation; alternatively, the paper is poorly organized, the style is awkward, and there are many grammatical and spelling errors. Grading such a paper B- is giving you a break - next time it will be F.

F: Not acceptable at the graduate level.

Academic Integrity:

McGill University values academic integrity. Therefore, all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the Code of Student Conduct and Disciplinary Procedures (see **http://www.mcgill.ca/integrity** for more information).

L'université McGill attache une haute importance à l'honnêteté académique. Il incombe par conséquent à tous les étudiants de comprendre ce que l'on entend par tricherie, plagiat et autres infractions académiques, ainsi que les conséquences que peuvent avoir de telles actions, selon le Code de conduite de l'étudiant et des procédures disciplinaires (pour de plus amples renseignements, veuillez consulter le site **http://www.mcgill.ca/integrity.**

In accord with McGill University's Charter of Students' Rights, students in this course have the right to submit in English or in French any written work that is to be graded.

Text-matching software may be used in this course to verify the originality of students' written course work.

University rules and regulations governing essays and term papers must be followed (see the "Green book" on students' rights and responsibilities available online at http://www.mcgill.ca/students/srr/publications/. You are expected to use your own words throughout this essay, even when describing the ideas, results or conclusions of others. Reference the source of the information immediately after each statement (a global reference at the end of a paragraph is not sufficient). Paraphrasing or quoting long segments of text from a published article is not acceptable. If you find it necessary to quote text directly from another author's work, this text must be placed in quotation marks and properly footnoted. Not to do so could be considered **plagiarism, a serious academic offence.** If you have any doubt, consult the instructor for guidance.

What will happen if you are accused of plagiarism? You will be reported immediately to the Associate Dean of Graduate Studies. If you are found guilty, you will be punished according to procedures outlined in the Handbook on Student Rights and Responsibilities.

What is Plagiarism?[1] Using the ideas or words of another person in your own writings without providing the appropriate acknowledgement. Proper acknowledgement means putting any text copied from another source in quotation marks ("……") plus providing a footnote on the same page and the reference in the bibliography; and providing a reference for every statement you make that refers to someone else's idea, work, writing or communication from any source (article, book, web, oral presentation, course notes, etc).

1) Use your own words and organization, not the words or organization of others - no matter how good they are! As graduate students you should be reading the original literature and providing your interpretation of the work and how it fits in with the work of others, not just putting together what other people have written. *Assembling sentences or passages from various documents and putting a footnote or reference at the end of each sentence or paragraph is still plagiarism. Copying organization of information is plagiarism.*
2) Reference everything! This applies to the internet as well as other publications. Some very general information that most people have known for a long time may not need to be referenced (e.g., the earth orbits around the sun, $E=mc^2$, V=IR, genes have promoters, nerves conduct action potentials, common techniques such as SDS-PAGE and intracellular recording…). To know what is 'common knowledge', read articles published in good journals in your field and ask your professors. Any specific information should be referenced. When in doubt, give a reference!
3) If you copy sentences or even parts of sentences from the work of another person, you must use quotation marks and provide the reference in a footnote as well as list the reference in the bibliography. It is not good enough to just give the reference. It is not good enough to just change a few words around and put a citation at the end – put quotation marks around the copied text - paraphrasing without footnoting is still plagiarism.
4) Do your own work. It can be good to discuss the literature with your fellow students. However, organize and write your own essay for any individual assignment. Do not submit work done by others.

BASIC KNOWLEDGE REQUIRED FOR PRINCIPLES OF NEUROSCIENCE I

Because of the multidisciplinary nature of neuroscience, students come to our graduate programme with a variety of background preparations (biology, physics, psychology, medicine, etc). The purpose of this course is to ensure that all students graduate with a general knowledge of the field of neuroscience as well as specialized knowledge in their chosen area of research. This course will cover the principles of neuroscience beginning at a basic level and progressing to more advanced information. However, this is a graduate level course and the lecturers will assume that students have a basic knowledge of the principles of science, in particular biological sciences. Students who have not taken an undergraduate course in biology (**BIOL 200A and BIOL 201B**), and an introductory course in mammalian physiology, or do not have a basic understanding of the subjects listed below should meet with the Course Coordinator to identify suitable prerequisite courses and course of action. Review sections are included on the website as a guide for self-study for students who need to refresh their knowledge.

1. Basic organic chemistry
- atomic and molecular structure, ionic charge, molecular interactions (bonding: ionic, hydrogen, covalent)
- general structure of organic molecules

2. Basic Building Blocks of Cells
- amino acids and proteins
- fatty acids and lipids
- carbohydrates, glycoproteins, enzymes
- nucleic acids (DNA, RNA)
- post-translational modification of proteins (phosphorylation, glycosylation, tyrosination)
- catabolism (proteases, lipases, oxidation, dehydrogenation, conjugation)

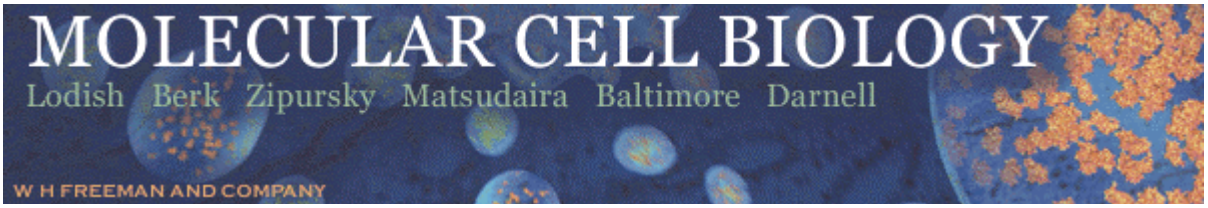
3. General Organization of Cells
- membrane structure
- organization of the cytoplasm - placement of organelles (nucleus, Golgi apparatus, endoplasmic reticulum, ribosomes, mitochondria, lysosomes, synapses...)

4. Basic Biochemistry and Cellular Physiology
- osmolarity, electrolytes, solutions, pH
- ionic composition of intracellular and extracellular fluid
- cellular metabolism (oxidative, glycolytic; ATP)
- transport mechanisms (active, passive, facilitated, exocytosis, pinocytosis)
- mitosis and meiosis
- second messengers (cell signalling pathways)

In addition, elementary knowledge of the following concepts of neurobiology will be helpful
- basic types of cells found in the nervous system, i.e. neurons, glia
- general concepts of neurotransmitters
- basic structure of synapses
-concepts of receptors

We shall not be covering this material in class and assume students have this general knowledge. If this material is new to you or you are having difficulty, please discuss this with the coordinator at the beginning of the semester. In some cases, prerequisite courses may be recommended before you take Principles of Neuroscience. I caution students who do not have sufficient background: Don't take a chance thinking things will work out. You could end up with a bad mark on your transcript.

http://www.ncbi.nlm.nih.gov/books/bv.fcgi?call=bv.View..ShowTOC&rid=mcb.TOC



Chapters that should be covered with an emphasis on eukaryotic systems:
Chapter 4: Nucleic Acids, the Genetic Code, and the Synthesis of Macromolecules
Chapter 10: Regulation of Transcription Initiation
Chapter 11: RNA Processing, Nuclear Transport, and Post-Translational Control
Chapter 17: Protein Sorting: Organelle Biogenesis and Protein Secretion
Chapter 13: Regulation of Eukayotic Cell Cycle
Chapter 18: Cell Motility and Shape I: Microfilaments
Chapter 19: Cell Motility and Shape II: Microtubules and Intermediate Filaments

Note: Several of the figures for Chapters 18&19 are not reproduced. You can find similar subject matter in Molecular Biology of the Cell (Chapter 16: The Cytoskeleton and Chapter 18: Mechanism of Cell Division. Note the 1994 edition, not the newest edition is available online at:

The old 1994 edition of Alberts et al. Molecular Biology of the Cell can be accessed on the web at:
http://www.ncbi.nlm.nih.gov/books/bv.fcgi?call=bv.View..ShowTOC&rid=cell.TOC&depth=2

These and other books/data bases can be accessed through: http://www.ncbi.nlm.nih.gov/books