Biology 201
Cell Biology & Metabolism

Winter 2018

Dr. Gary Brouhard

Overview

The cell is the basic unit of life, but each cell contain thousands of different enzymes and proteins. These proteins can be viewed as tiny, intricate, molecular machines. Our goal will be to understand how these machines work. More precisely, we will study how proteins and enzymes (1) harness energy from the environment, (2) use this energy to change their structure/conformation, and (3) use these conformational changes to do the work of staying alive. We will learn how malfunctions in protein machines are the basis of many diseases. No protein works alone, of course. Therefore we will study how groups of proteins interact, either working together in teams or competing against one another. The balance of these interactions is what defines cell physiology.

The lectures will focus on key experiments that established what we know now, paying attention to the individual scientists who drove progress. In addition, we will look at experiments being performed at world-class research institutions today. Students will learn how to analyze the data produced by these experiments and to predict results. The course is divided into 3 parts.

1. Biological Energetics
   We will learn about the types of energy relevant to cells, how cells harvest energy from their environment, and how cells convert this energy into usable forms.

2. Building a Cell
   We will learn how cells use energy to create internal organization and to determine their shape and structure, focusing on the building blocks of complex behavior.

3. Cell Physiology
   Using the concepts from Parts 1 and 2, we will learn about the mechanisms behind complex cell behaviors.

Course #	Biol-201-001
Credits	3
Lectures	MWF 11:30 – 12:30 in Leacock 132
Textbook	Lodish et al. *Molecular Cell Biology*, 8th edition ISBN-13: 978-1464183393
Grades	10 % Quizzes 25 % Midterm 1 25 % Midterm 2 40 % Final

Evaluation

The quizzes and exams will emphasize the concepts behind cell biology rather than rote memorization. If the answer to a question can be Googled, then the question is not worth our time. For the online quizzes, you are free to use the textbook, your notes, and the internet. The midterms and final will be "open note" exams. You will be allowed to bring an $8\frac{1}{2} \times 11$" sheet of notes, written in your own hand, to assist you during the exam. If I write an exam that is too difficult, the final grade distribution may be curved at my discretion to match the historical grade distribution for this course.

Grades

- Quizzes (10 %)

  There are 6 "in-class" quizzes throughout the semester. Your top 5 scores will each contribute 2 % to your grade. The quizzes will be administered online through myCourses for one hour during a normal class period. Members of the teaching team will be present in Leacock 132 to answer clarifying questions. Consult the course calendar for the dates of the quizzes.

- Midterm 1 (25 %)

  Wednesday, 07 February 2018, sometime between 18:00 – 21:00, covering the material in Part 1.

- Midterm 2 (25 %)

  Monday, 19 March 2018, sometime between 18:00 – 21:00, covering the material in Part 2.

- Final Exam (40 %)

  The Final Exam will be scheduled by the Exam Office. The Final Exam will emphasize the material in Part 3 (25 % of final grade) but also include questions that integrate across the whole course (15 % of final grade).

Deferred Exams

If you miss a midterm exam or the final exam for a legitimate reason, you will be allowed to take a deferred exam. Legitimate reasons include illnesses and emergencies but do not include sports and extracurricular activities. For the midterm exams, a medical note or similar document is required in order to take the deferred exam. These documents must be delivered to Dr. Torsten Bernhardt within 48 hours of the conclusion of the regular midterm exam. For the final exam, it is the Exam Office that determines your eligibility for a deferred exam; contact Service Point to declare your illness or absence. Please consult McGill's policies regarding deferred exams for more detail.

Supplemental Exam

Students who receive a final grade of "F" or "D" are eligible to take a Supplemental Exam. The Supplemental Exam will count for 100 % of your final course mark. Please consult McGill's policies regarding supplemental exams for more detail.

Teaching Team

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Help & Resources

myCourses & Discussion Boards

The Biol 201 myCourses page will include PDFs of the lecture slides, the lecture recordings, and the discussion boards. Please post your questions to the discussion boards rather than emailing them to the teaching team. By posting your questions, other students will benefit from the answers. Students are encouraged to answer each others questions, so you will probably receive a more prompt response. The TAs and mentors will monitor the discussion boards to ensure that any confusions are cleared up.

Tutorials & Office Hours

We're here to help! The TAs and mentors will offer "help sessions" in the form of tutorials, office hours, and exam reviews. Both the tutorials and the office hours will offer you time to ask open-ended questions. Exam review sessions will be offered before the midterms and the final exam. Consult the course calendar for the times and locations of these help sessions.

Policies

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.

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.

See http://www.mcgill.ca/students/srr/honest/ for more information.

Language of Submission

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. This does not apply to courses in which acquiring proficiency in a language is one of the objectives.

Conformément à la Charte des droits de l'étudiant de l'Université McGill, chaque étudiant a le droit de soumettre en français ou en anglais tout travail écrit devant être noté (sauf dans le cas des cours dont l'un des objets est la maîtrise d'une langue).

Laptops, Phones, and Tablets

Mobile computing and communications devices are permitted in class insofar as their use does not disrupt the teaching and learning process. Your fellow students have the right to freedom from distraction in the classroom. All devices must be completely silent (e.g., set to "Do Not Disturb" for iPhones). The back rows of Leacock 132 are available for students who wish to watch videos, check Facebook, play HearthStone, or otherwise slack off (in silence). The use of devices must, in all cases, respect the policies and regulations of the University, including the Code of Student Conduct and Disciplinary Procedures, the

Policy Concerning the Rights of Students with Disabilities, and the Policy on the Responsible Use of McGill IT Resources.

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Instructor-generated course materials (e.g., handouts, notes, summaries, exam questions, etc.) are protected by law and may not be copied or distributed in any form or in any medium without explicit permission of the instructor. Note that infringements of copyright can be subject to follow up by the University under the Code of Student Conduct and Disciplinary Procedures. Do not post my lecture slides on Docuum or Course Hero!

Students with Disabilities

As the instructor of this course I endeavor to provide an inclusive learning environment. However, if you experience barriers to learning in this course, do not hesitate to discuss them with me and the Office for Students with Disabilities.

Pandemics, Wars, and other Catastrophes

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

Lectures & Readings

The readings from Lodish et al., *Molecular Cell Biology*, are important primers for the lectures. You should read the textbook prior to attending the lectures in order to master the material. I have provided the section numbers (§), which are somewhat consistent between the 7th and 8th editions of the textbook. It is important to note, however, the cell biology is rapidly evolving, and older editions of the textbook may be inaccurate or incomplete. All figures shown in lecture are consistent with the 8th edition. Furthermore, the lectures will include information that extends beyond the textbook and provides additional context. In some cases, information in the textbook will not be covered in the lectures. For the quizzes and exams, you are responsible only for the material covered in the lectures.

Part 1: Biological Energetics

1. *Energy in Cell Biology 1*
   – Coupling of chemical reactions
   – Energy carriers
   Lodish et al. §2.3–2.4, 3.3

2. *Energy in Cell Biology 2*
   – Chemical potentials
   – Thermal energy and mechanical forces
   Lodish et al. §2.3–2.4, 3.3

3. *The Nature of Cytoplasm*
   – Components of cytoplasm
   – Viscosity, elasticity, and porosity
   Lodish et al. §1.2–1.3

4. *Glycolysis*
   – Breakdown of glucose into pyruvate
   – Allosteric regulation of glycolysis
   Lodish et al. §12.1

5. *Mitochondria 1*
   – Mitochondrial ultrastructure
   – Mitochondrial DNA and its inheritance
   Lodish et al. §12.2

6. *Mitochondria 2*
   – Fission and fusion of mitochondria
   – Mitochondria-ER interactions
   Lodish et al. §12.2

7. *The Citric Acid Cycle*
   – Cyclical regeneration of intermediates
   – Malate-aspartate shuttle
   Lodish et al. §12.3

8. *The Electron Transport Chain*
   – Complexes I–IV
   – The Q cycle
   Lodish et al. §12.4

9. *ATP Synthesis*
   – F1/F0 ATP synthase
   – ATP transport
   Lodish et al. §12.5

10. *Photosynthesis*
    – Photosynthetic electron transport
    – CO_2 fixation
    Lodish et al. §12.6–12.8

Part 2: Building a Cell

11. *Actin 1*
    – Overview of the cytoskeleton and cell shape
    – Introduction to actin and actin structures
    Lodish et al. §17.1–17.2

12. *Actin 2*
    – Lamellopodia, filopodia, cell migration
    – Actin regulatory proteins 1
    Lodish et al. §17.3–17.4

13. *Actin 3*
    – Actin regulatory proteins 2
    Lodish et al. §17.7

14. *Muscle Contraction*
    – The sliding filament mechanism
    – The ATPase cycle of muscle myosin
    Lodish et al. §17.5–17.6

15. *Microtubules 1*
    – Microtubule structure and organization
    – Microtubule dynamics
    Lodish et al. §18.1–18.2

16. *Microtubules 2*
    – Microtubule-associated proteins
    Lodish et al. §18.3

17. *Microtubules 3*
    – Kinesin and dynein motor proteins
    – Cilia and flagella
    Lodish et al. §18.4–18.5

18. *Membrane Manipulation*
    – Bending membranes
    – Fission and fusion of membranes
    Lodish et al. §14.2

19. *Protein Targeting*
    – Targeting proteins across the ER membrane
    – Inserting proteins into membranes
    Lodish et al. §13.1–13.2

20. *Secretion and Vesicle Transport*
    – Vesicle-mediated transport of proteins
    – Vesicle budding
    Lodish et al. §14.3–14.4

21. *Pumps and Membrane Transport*
    – ATP powered pumps
    – Symporters and antiporters
    Lodish et al. §11.3, 11.5

Part 3. Cell Physiology

22. *The Extracellular Matrix*
    – Components of the ECM
    – Focal adhesions
    Lodish et al. §20.1–20.5

23. *Cell Signaling 1*
    – Introduction and cytoplasmic receptors
    – G-protein coupled receptors
    Lodish et al. §15.1–15.3, 15.5

24. *Cell Signaling 2*
    – Receptor tyrosine kinases
    – Ras/MAP kinase pathway
    Lodish et al. §16.3–16.4

25. *Neurons 1*
    – Neurotransmitters
    – Synaptic vesicle cycle
    Lodish et al. §22.3

26. *Neurons 2*
    – Neuronal migration
    – Guidance
    Lodish et al. §17.7

27. *Mitosis and Cytokinesis*
    – Positioning the mitotic spindle
    – Chromosome segregation and cell cleavage
    Lodish et al. §18.6

28. *Cell Cycle 1*
    – Cyclin and Cyclin-dependent kinase
    – Regulation of CDK activity
    Lodish et al. §19.1–19.3

29. *Cell Cycle 2*
    – Exit from mitosis
    – The spindle-assembly checkpoint
    Lodish et al. §19.6–19.7

30. *Cell Death*
    – Apoptosis
    – Cell Murder
    Lodish et al. §21.5

31. *Surprise!*
    No Readings