

**Physiological Biophysics (PSL 425, 3 credits)
Fall Semester, 2024**

<https://d2l.msu.edu/d2l/home/2222761>

**Section 001 - Tuesdays and Thursdays 8:30 am – 9:50 am Eastern Time (ET)
Room 19 Natural Resources Building**

**Section 002 - Tuesdays and Thursdays 1:00 pm – 2:20 pm Eastern Time (ET)
Room 228 Erickson Hall**

Instructor:

Joseph A. Beatty, Ph.D.

Assistant Professor

Department of Physiology

Office: 5007 Interdisciplinary Science and Technology Building (ISTB)

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Office Hours: By email appointment (either in person at ISTB or via Zoom)

Course Description:

This advanced undergraduate course will examine the quantitative aspects of biophysics with an emphasis on membrane biophysics and electrophysiology. Course instruction could change at any time given changes in public health guidance or changes in MSU operations.

Course Prerequisite: PSL 250 or PSL 310 or both PSL 431 and PSL 432

Course Competencies: At the end of this course, you should be able to answer the following questions in short essay form:

- 1.1) What influences the passive, noncoupled transport of a solute across a permeable membrane?
- 2.1) What is the ionic basis of the membrane potential?
- 2.2) How does the cell membrane behave like an electrical circuit?
 - 2.2.1) How does voltage clamping deduce properties of ion channels?
- 2.3) What is the molecular physiology of ion channels?
- 3.1) What are the mechanisms/components of an action potential?
 - 3.1.1) What are the properties of the ionic conductances responsible for an action potential?
- 4.1) What is the physiology of voltage-gated sodium and calcium channels?
- 4.2) What is the physiology of voltage-gated potassium channels?
- 4.3) How does the action potential propagate?
- 5.1) What are the mechanisms of synaptic transmission?
 - 5.1.1) What are the basic electrophysiological principles of synaptic transmission at the neuromuscular junction?
 - 5.1.2) What are the principles of neurotransmitter release?
 - 5.1.3) How do toxins and drugs affect synaptic transmission?

Required Resources:

- ✓ [Free Online Textbook - Boron, Walter F, and Emile L. Boulpaep. Medical Physiology, 2017.](#)
- ✓ Calculator w/logarithmic capability
- ✓ [PubMed](#)
- ✓ Laptop Computer with [Respondus LockDown Browser in D2L \(see the end of the syllabus for download instructions\)](#)

Attendance Expectations:

You are expected to attend class ready to participate during your scheduled class time. Ready to participate entails reading the required readings and completing the required assignments before class. You will need to be prepared for each class so that you can contribute to the class discussion. This course involves active discussion among the entire class and within small groups on the readings. The ideal student will contribute to discussions in class but will also let others participate. You are required to be in class and have a laptop computer, or similar device, to access D2L for completion of research paper questions (RP?s) assignments, quizzes, and the final exam. There will also be a group oral presentation/discussion of a student-chosen research paper with the whole class. Your attendance and participation in class discussions are critical for your success in this course. Please contact me via email before any absences. Unexcused absences will result in a zero for all assignments missed.

Academic Integrity:

Please make all assignments in your own words. Quizzes and the final exam will be administered via the D2L website with Respondus Lockdown Browser enabled to minimize the possibility of academic dishonesty. Please adhere to the restriction of only a calculator, blank paper, and a writing utensil being allowed during these assessments.

- ❖ [MSU Academic Integrity website](#)

Tentative Course Schedule:

This schedule is tentative and subject to change.

| Date | Covered Readings | Activities | Assignments | Covered Competencies | |
|------------------------|--|---|---|---|-----|
| Tues. 8/27 | - | Syllabus and What is Biophysics? Pamphlet | Review Syllabus and Class Expectations, Intro to Biophysics Lecture | Week 1/2 Guided Reading Questions (GR?s) Due 8/29* | - |
| Thurs. 8/29 | Chapter 5 - "Solute transport across cell membrane" up to "In simple diffusion..." | - | Discuss Week 1/2 GR?s, and Clarification Lecture | - | 1.1 |

| Date | Covered Readings | | Activities | Assignments | Covered Competencies |
|-----------------|--|--|---|-----------------------------------|----------------------|
| Tues. 9/3 | - | Instructor Chosen Research Paper | Discuss Research Paper, and Week 2 Research Paper Questions (RP?s) | - | 1.1 |
| Thurs. 9/5 | - | - | More Equilibrium Potential Work | Week 3 GR?s Due 9/10 | 1.1 |
| Tues. 9/10 | Chapter 6 - "Electrophysiology of the Cell Membrane" up to "Electrical Model of a Cell Membrane" | - | Discuss Week 3 GR?s, and Clarification Lecture | - | 2.1 |
| Thurs. 9/12 | - | Instructor Chosen Research Paper | Quiz 1, Discuss Research Paper, and Week 3 RP?s | Week 4 GR?s Due 9/17 | 2.1 |
| Tues. 9/17 | Chapter 6 - "Electrical Model of a Cell Membrane" up to "A voltage clamp measures..." | - | Quiz 1 review, Discuss Week 4 GR?s, and Clarification Lecture | - | 2.2 |
| Thurs. 9/19 | - | Group Organization | Group Organization and Presentation Expectations | Week 5 GR?s, Due 9/24 | 2.2 |
| Tues. 9/24 | Chapter 6 - "A voltage clamp measures..." up to "Molecular Physiology of Ion Channels" | - | Discuss Week 5 GR?s, and Clarification Lecture | - | 2.2.1 |
| Thurs. 9/26 | - | Instructor Chosen Research Paper | Discuss Research Paper, and Week 5 RP?s | Week 6 GR?s, Due 10/1 | 2.2.1 |
| Tues. 10/1 | Chapter 6 - "Molecular Physiology of Ion Channels" up to the End of Chapter | - | Discuss Week 6 GR?s, and Clarification Lecture | - | 2.3 |
| Thurs. 10/3 | - | Group 1 Chosen Research Paper | Quiz 2, Discuss Research Paper, and Week 6 RP?s | Week 7 GR?s, Due 10/8 | 2.3 |
| Tues. 10/8 | Chapter 7 - "Electrical Excitability and Action Potentials" up to "The Na ⁺ and K ⁺ currents..." | - | Quiz 2 review, Discuss Week 7 GR?s, and Clarification Lecture | - | 3.1 |
| Thurs. 10/10 | - | Group 2 Chosen Research Paper | Discuss Research Paper, and Week 7 RP?s | Week 8 GR?s, Due 10/15 | 3.1 |
| Tues. 10/15 | Chapter 7 - "The Na ⁺ and K ⁺ currents..." up to "Physiology of Voltage-Gated Channels and Their Relatives" | - | Discuss Week 8 GR?s, and Clarification Lecture | - | 3.1.1 |

| Date | Covered Readings | | Activities | Assignments | Covered Competencies |
|---------------------|--|--|---|--|----------------------|
| Thurs. 10/17 | - | Group 3 Chosen Research Paper | Quiz 3. Discuss Research Paper, and Week 8 RP?s | Week 9 GR?s, Due 10/24* | 3.1.1 |
| Tues. 10/22 | FALL BREAK | | | | |
| Thurs. 10/24 | Chapter 7 - "Physiology of Voltage-Gated Channels and Their Relatives" up to "K+ channels determine..." | - | Quiz 3 review, Discuss Week 9 GR?s, and Clarification Lecture | Week 10 GR?s, Due 10/31 | 4.1 |
| Tues. 10/29 | Chapter 7 - "K+ channels determine..." up to "Propagation of Action Potentials" | - | Discuss Week 10 GR?s, and Clarification Lecture | - | 4.2 |
| Thurs. 10/31 | - | Group 4 Chosen Research Paper | Discuss Research Paper, and Week 10 RP?s | Week 11 GR?s, Due 11/5 | 4.2 |
| Tues. 11/5 | Chapter 7 - "Propagation of Action Potentials" up to the End of Chapter | - | Discuss Week 11 GR?s, and Clarification Lecture | - | 4.3 |
| Thurs. 11/7 | - | Group 5 Chosen Research Paper | Quiz 4. Discuss Research Paper, and Week 11 RP?s | Week 12 GR?s, Due 11/12 | 4.3 |
| Tues. 11/12 | Chapter 8 - "Synaptic Transmission and the Neuromuscular Junction" up to "Synaptic Transmission at the Neuromuscular Junction" | - | Quiz 4 review, Discuss Week 12 GR?s, and Clarification Lecture | - | 5.1 |
| Thurs. 11/14 | - | Group 6 Chosen Research Paper | Discuss Research Paper, and Week 12 RP?s | Week 13 GR?s, Due 11/19 | 5.1 |
| Tues. 11/19 | Chapter 8 - "Synaptic Transmission at the Neuromuscular Junction" up to "Miniature end-plate potentials..." | - | Discuss Week 13 GR?s, and Clarification Lecture | - | 5.1.1 |
| Thurs. 11/21 | - | Group 7 Chosen Research Paper | Discuss Research Paper, and Week 13 RP?s | Week 14 GR?s, Due 11/26 | 5.1.1 |
| Tues. 11/26 | Chapter 8 - "Miniature end-plate potentials..." up to "Toxins and Drugs Affecting Synaptic Transmission" | - | Discuss Week 14 GR?s, and Clarification Lecture | Week 15 GR?s, Due 12/3 | 5.1.2 |
| Thurs. 11/28 | THANKSGIVING | | | | |
| Tues. 12/3 | Chapter 8 - "Toxins and Drugs Affecting Synaptic Transmission" up to the End of Chapter | - | Discuss Week 15 GR?s, and Clarification Lecture | - | 5.1.3 |
| Thurs. 12/5 | - | Group 8 Chosen Research Paper | Quiz 5. Discuss Research Paper, and Week 15 RP?s | - | 5.1.3 |

Grading plan:

Final grades will be determined based on the scores from the assignments noted below.

| <u>Points Received</u> | <u>%Points Received</u> | <u>Grade</u> |
|-------------------------------|--------------------------------|---------------------|
| 309-343 | 90-100 | 4.0 |
| 292-308 | 85-89.99 | 3.5 |
| 275-291 | 80-84.99 | 3.0 |
| 258-274 | 75-79.99 | 2.5 |
| 241-257 | 70-74.99 | 2.0 |
| 223-240 | 65-69.99 | 1.5 |
| 206-222 | 60-64.99 | 1.0 |
| <205 | <59.99 | 0.0 |

1) Guided Reading Questions (14 assignments worth 3 points each, 42 total points, ~12%)

Guided reading questions (GR?s) are approximately 6 questions to guide you in your weekly textbook reading. These weekly questions will help highlight text sections I find particularly interesting/important. Please do not skip reading sections of text that are not highlighted with GR?s. These portions of the text are still testable. Think of the GR?s answers as notes you would take while reading. *It is best if you make these in your own words.* We will devote approximately 20 minutes of class time to discuss the GR?s and any questions from the readings, first in small groups, then as a class. It is your responsibility to understand what you completed wrong. *These assignments will be scored based on completion only. Assignments turned in after the due date will receive half credit until 8 am ET the day after the due date.* Answers to the GR?s will be posted on D2L at this time and assignments turned in after that time will earn zero points.

GR?s for the next week will be available on D2L by the previous class day at 4 pm ET.

GR?s will be due on D2L at 8 am ET on the days listed in the course schedule.

2) Research Paper Questions (11 assignments worth 9 points each, 99 total points, ~29%)

We will have approximately one research paper a week to read. The goals of these research papers are for you to see how biophysics concepts we learn from the text are applied in practice or papers meant to further clarify concepts learned. *The emphasis should be on all the biophysics content present in the paper that we have covered in the semester with less emphasis on the true science being conducted.* I will choose the first 3 research papers and lead the discussions on them. The remaining 8 research papers will be chosen by student groups.

After each research paper presentation (instructor and group), research paper questions (RP?s) will be answered in class on D2L. RP?s will consist of questions worth a total of 9 points. RP?s are questions designed to help highlight concepts in the paper and/or to ensure students have read the research paper. *These assignments are only available in class during the scheduled presentation class time.* The week of your group discussion the group will need to provide me with at least 5 research paper questions with answers to assign to the class. These questions can be true or false, multiple choice, fill-in-the-blank, or matching questions. The presenting group members

will not be required to answer the RP?s for that week (see **Research Paper Presentation**). They will receive their points based on the submission of their RP?s to me.

RP?s will be completed in class on D2L during the days listed in the course schedule.

3) Quizzes (5 quizzes worth 25 points each, drop lowest quiz score for 100 total points, ~29%)

There will be 5 (on 9/12, 10/3, 10/17, 11/7, and 12/5) 30-minute quizzes on the material covered since the last quiz. You will be allowed to drop your lowest quiz score. **The quizzes will be administered in class via D2L with Respondus Lockdown Browser enabled to minimize the possibility of academic dishonesty.** The quizzes will be multiple-choice questions. You will be allowed a calculator, blank paper, and a writing utensil. In the class meeting following a quiz, we will spend the first 20 minutes of class reviewing the quiz. Make-up quizzes for excused absences need to be done either before the quiz date or before the following class meeting when the quiz is reviewed in class. No quiz make-ups will occur after the quiz is reviewed in class. Proctoring arrangements will be decided at the discretion of the instructor and are subject to change in the event of an unanticipated circumstance.

4) Research Paper Presentations (16 points group, ~5%; 16 points individual, ~5%: 32 total points, ~10%)

The remaining 8 research papers will be chosen by student groups and the groups will lead the discussion that day (see table below). We will spend a class early in the semester organizing groups (9/19), there will be no research paper or RP?s assignment that week. Groups should use my research paper presentations and discussions as examples of how to prepare for their presentation. Student-chosen groups of 4-5 will choose a research paper that highlights biophysics topics we have covered, or we will cover in class (I can help guide the groups on topics that we have not covered yet). *This paper should **NOT** be a review article.* Groups should have their suggested research paper and research paper questions with answers chosen and given to me based on the table below.

| Group | Competency Covered That Week | Research Paper Chosen | RP?s Chosen | Disc. Day |
|---------|---|-----------------------|-------------|-----------|
| Group 1 | 2.3) What is the molecular physiology of ion channels? | 9/19* | 10/1 | 10/3 |
| Group 2 | 3.1) What are the mechanisms/components of an action potential? | 9/26 | 10/8 | 10/10 |
| Group 3 | 3.1.1) What are the properties of the ionic conductances responsible for an action potential? | 10/3 | 10/15 | 10/17 |
| Group 4 | 4.2) What is the physiology of voltage-gated potassium channels? | 10/17 | 10/29 | 10/31 |
| Group 5 | 4.3) How does the action potential propagate? | 10/24 | 11/5 | 11/7 |

| | | | | |
|---------|---|-------|-------|-------|
| Group 6 | 5.1) What are the mechanisms of synaptic transmission? | 10/31 | 11/12 | 11/14 |
| Group 7 | 5.1.1) What are the basic electrophysiological principles of synaptic transmission at the neuromuscular junction? | 11/7 | 11/19 | 11/21 |
| Group 8 | 5.1.3) How do toxins and drugs affect synaptic transmission? | 11/21 | 12/3 | 12/5 |

The research paper presentation is an oral slide presentation and class discussion based on your research paper. **By Noon ET the Wednesday before your group presentation, each group should email me their slide presentation.** The presentation should follow the examples I have given in the first half of the semester. Groups should plan on the research paper presentation lasting ~30-40 minutes of class time. **Do not have one person present the results section of the paper.** The results should be a major focus of your presentation and should be divided amongst your group.

You will be evaluated both as a group and as an individual, each consisting of 5% of your final grade. You will be evaluated on your **preparation** (quality of slide show and knowledge of the content), **oral presentation** (logic, delivery, and timing), **discussion period** (asking and answering questions), and **clarity** of presentation and discussion.

5) Final Exam (70 points, ~20%)

| Date | Section | Time | Location |
|------------------------------|--------------------|----------------------------|---|
| Tues. 12/10/2024 | Section 001 | 7:45 am-9:45 am ET | Room 19 Natural Resources Building |
| Thurs. 12/12/2024 | Section 002 | 12:45 pm-2:45 pm ET | Room 228 Erickson Hall |

The final exam will be cumulative over all material covered during the semester. It will consist of multiple-choice questions and short-answer questions. You will be allowed a calculator, blank paper, and a writing utensil. **The final exam will occur in person via D2L similar to the quizzes.** Students will be required to use Respondus Lockdown Browser for the final exam.

Proctoring arrangements will be decided at the discretion of the instructor and are subject to change in the event of an unanticipated circumstance.

“A student absent from a final examination without a satisfactory explanation will receive a grade of 0.0 on the numerical system, NC on the CR-NC system, or N in the case of a course authorized for grading on the P-N system. Students unable to take a final examination because of illness or other reason over which they have no control should notify the associate deans of their colleges immediately.” From the Office of the Registrar website: Academic Programs

– General Information, Policies, Procedures, and Regulations found at
<http://www.reg.msu.edu/AcademicPrograms/Text.asp?Section=112#s499>

Accommodations for Students with Disabilities:

Michigan State University is committed to providing equal opportunity for participation in all programs, services, and activities. Requests for accommodations by persons with disabilities may be made by contacting the Resource Center for Persons with Disabilities at 517-884-RCPD or on the web at rcpd.msu.edu. Once your eligibility for an accommodation has been determined, you will be issued an Accommodation Letter. *Please present this letter to me at the start of the term and/or two weeks before the accommodation date (test, project, etc.).* Requests received after this date will be honored whenever possible.

Internet accessibility and help:

All students will need some form of connectivity for this semester. In the United States, hotspots are available for a low price and often carry one month of free internet connection. Some assistance might be available through the Office of Financial Aid or Student Services because connectivity will effectively become a requirement for the course. A map of free hotspots in Michigan is available here:

<http://cngis.maps.arcgis.com/apps/webappviewer/index.html?id=od69accbb5ff422a82eccc2c9101b69d>

If you need technical assistance at any time during the course or to report a problem, you can:

- ❖ [Visit the Online and Distance Learning Services Support Site](#)
- ❖ [Visit the Desire2Learn Help Site](#)
- ❖ Or call Distance Learning Services (24x7 with the exception of University Holidays): 1-800-500-1554 or 517-355-2345

Respondus LockDown Browser:

This course requires the use of LockDown Browser for online exams (Quizzes and Final Exam). Watch this video to get a basic understanding of LockDown Browser:

<https://www.respondus.com/products/lockdown-browser/student-movie.shtml>

Download Instructions

- Select the exam in the course.
- Under Quiz Requirements you will see "To take this quiz you must use the Respondus LockDown Browser"
- Below this will appear: "You can use the button below if you have not already downloaded LockDown Browser". Click the button to go to the download page and then follow the instructions.
- Use the link to download the Respondus LockDown Browser to your computer; follow the installation instructions.
- Return to the Quiz page in Brightspace (it may still be open in another tab) and select the quiz.
- Select "Launch LockDown Browser"
- The exam will now start.

Note: *LockDown Browser only needs to be installed once on a computer or device. It will start automatically from that point forward when a quiz requires it.*

Emergency Procedures:

If an emergency arises within the classroom, I will notify you of what actions may be required to ensure your safety. It is the responsibility of each student to understand the evacuation, “shelter-in-place,” and “secure-in-place” guidelines posted in each facility and to act safely. You are allowed to maintain cellular devices in silent mode during this course, to receive emergency SMS text, phone, or email messages distributed by the university. When anyone receives such a notification or observes an emergency, they should immediately bring it to the attention of me in a way that causes the least disruption. If an evacuation is ordered, please ensure that you do it safely and facilitate those around you who may not otherwise be able to safely leave. When these orders are given, you do have the right as a member of this community to follow that order. Also, if a shelter-in-place or secure-in-place is ordered, please seek areas of refuge that are safe depending on the emergency encountered and assist if it is advisable to do so.

Honors Option Credit:

Students must earn a 3.5 or greater in this course to be eligible for Honors Option credit. An agreement between the instructor and student to undertake an Honors Option project should be reached no later than the end of the first month of the term. An honors option project in this course consists of reading a research paper on membrane biophysics (a topic of your choice, with my approval) and giving a short (~30-40 minutes) slide presentation where we discuss the paper and how it relates to the concepts learned throughout the course. This assignment is similar to the group presentation in the class, but solo and outside of class time. Students should wait until approximately halfway through the semester or later to choose an honors paper. By waiting you are better prepared to choose a worthy paper and discuss the biophysics content.