PSL 425: Physiological Biophysics Spring 2018 Section 1

3 credits

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

TT 8:30-9:50, 1425 BPS

Dr. Patrick Dillon, 884-5040, dillon@msu.edu, Office Hours, Room 2178 BPS, W 11-12, 1-3; M,F by appointment

TA: Thomas Turkette, Office Hours TBA

Textbook: Biophysics: A Physiological Approach, Patrick F. Dillon, Cambridge University Press, 2012

Please note that in an emergency you should use the double doors at the back of the room to exit and gather at the nearest rally point outside, east of the building near the trellises.

This course will explore in detail the quantitative physical phenomena underlying kinetics and equilibria of physiological processes. The topics covered will include bonds, molecular excitation and energy transfer, molecular and ionic interactions, diffusion and directed transport, thermodynamics, biomechanics of forces and fluids, and load bearing. Analytical and critical thinking skills are emphasized in this class which requires a thorough background in the fundamentals of physiology so that the understanding of complex issues can be achieved.

This class will have both classroom lectures based on the textbook and student presentations of biophysical research papers. The first day will include discussion of the course goals and an introductory lecture which covers aspects from several different parts of the course. We will start on the material in Chapter 1 of the book on the second day of class. All the class power point slides are on D2L.

There will be 8 in-class quizzes in this class. The quizzes will be given at the start of class on each Tuesday on the dates below. The short answer quizzes will cover the material from the previous week. The critical thinking test (CTT) will cover all the material up to that point and will be open book, non-electronic: you may bring any book or papers you choose for the essays, but you cannot access any electronic resources, computer, tablet, phone, internet, etc.. For the first 4 quizzes, the questions will be posted on Monday, the day before the quiz. For Q1-Q4, you will get all the questions in advance, but you will not know which ones will be asked. For the last 4 quizzes, the questions will not be posted in advance. For Q5-Q8, you will not know the questions in advance, but you will get to choose which questions you want to answer. For the critical thinking test you will have to discuss the logic of an experiment or condition leading to its conclusions in four questions. Your answers will be in essay form. For some questions you will have seen the material during the semester, but for other questions the

experimental scenario will be new. You will not get the questions in advance or have a choice of questions on the CTT. This test will take up the entire class on that day. A table summary of the quizzes and CTT is below. Each quiz is worth 4 points toward your final grade. The total of quiz points is 32. The CTT is worth 18 points toward your final grade

Date	Quiz#	Format	Question Choice	Q's in Advance
1/16	1	Short Answer	2 of 4, no choice	Yes
1/23	2	Short Answer	2 of 4, no choice	Yes
1/30	3	Short Answer	2 of 4, no choice	Yes
2/6	4	Short Answer	2 of 4, no choice	Yes
2/13	5	Short Answer	2 of 4, choice	No
2/20	6	Short Answer	2 of 4, choice	No
2/27	7	Short Answer	2 of 4, choice	No
3/13	8	Short Answer	2 of 4, choice	No
3/20	CTT	Essay	4 of 4, no choice	No

All makeups of missed, excused quizzes (but not the CTT) will be at the end of the last class on April 26. A valid excuse, such as a doctor's note for illness or documentation of a medical school interview, for example, is needed to take a makeup.

All students will present a 12 minute (10 minute talk, 2 minutes for questions) power point presentation. There is a strict maximum of 8 slides, regardless of content (title, graphs, references, etc.: use your judgment). A video that is part of the paper would count as 1 slide. Videos from other sources may not be used. The talk will be based on a research paper in Biophysical Journal from 2015-present, volumes 108-114, which can be accessed for free through the MSU library portal. Students must inform the instructor by email of the paper they will present and select a presentation slot by midnight on January 30. All paper selections are on a first come first choice, whoever emails me their selection first**. Each selection email must include first author, volume, first page number, first two significant words of title, preferred date and slot.** The paper must be an Original Research Article from Biophysical Journal: it will say original research article right after the title on the BJ website. Do not choose a letter, commentary, review or stand-alone abstract. Available slots can be seen in the Student Presentation file on D2L. Each student must also provide an 800-1200 word summary of the research field of their paper. The research summary may have figures from both your selected paper and other papers if you wish. References will not count toward the summary word count. Both the power point presentation and the research area summary are due by midnight on Tuesday, February 27 in a D2L dropbox. Class presentations start on March 27. Students will fill in a question sheet during each presentation and some will ask the presenter questions following the talk. The paper presentation/research summary/questions assignment is worth 20 points.

The final will have two parts. The first part will be short answer questions similar to the short answer quiz questions. It will be closed book and will cover the technical material from the lectures and papers. The second part will be essay questions. The second part will be open book, non-electronic as in the CTT. You may bring any notes, papers or books to this part, but you can only use these during the second part of the final, after the first part has been turned in. The final will be during are final exam time, 7:45-9:45 AM on Tuesday, May 1 in 1425 BPS. The final is worth 30 points. Some questions previous tests are below.

My office hours are on Wednesday morning and afternoon. With biophysics classes on both Tuesday and Thursday morning and afternoon, those days are out for office hours. I will meet with students on Monday and Friday by appointment, but as I also have committee work and research activities on those days, I will not always be available. We can meet then if there is a mutually convenient time. The TA office hours are TBA.

The grading scale is the standard university scale, 90% for 4.0, 85% for 3.5, 80% for a 3.0, etc. Students who want to do an Honors option in this class should contact Dr. Dillon. Many students do very well in this class.

Three additional points: bonus points, letters of recommendation and attendance. (1) Every question, short answer, essay, power point, summary or question, has the potential to get an additional point over and above what the value of that assignment is: bonus points are given for truly exceptional answers and while rare, on average 6-10 are given out in a semester. (2) Each year a number of students in the class ask for letters of recommendation. I will write letters for students for whom I think the letter will help their future application. If you are in the bottom half of the class for example, a letter from me would not help a medical school application. Having received a bonus point on a question makes writing a letter both easy and helpful for the application. (3) If you regularly miss class without an excused absence I won't be able to write you a good letter.

Previous students have described this course as unlike anything they have ever had at MSU. It is meant to be that way. I look forward to meeting all of you soon. I hope we will have a great semester.

Guidelines for Paper Presentations/Research Summary in Physiological Biophysics.

1. What kind of paper is it: experimental research, new method, or model? Does the presentation explain the background of the paper: what previous work was done in this area; is the paper challenging or confirming previous work; are there any technical problems that have to be overcome or new technical developments that make the current work possible? What were the major conclusions of the paper? The student should have read the key papers cited in the paper that led to this work.

2. Did the student show technical proficiency in presenting the paper? Were any slides or handouts clear and understandable? Was there logical flow from slide to slide? Did the student bring in any additional information from other sources to make the presentation better while maintaining the primary focus on the chosen paper? Was the presentation timely?

3. In the summary, how does the paper presented fit with other work in the field? Does it confirm where the field is going or send it in a new direction? Does the summary appropriately describe what is happening in this field?

PSL 425 Previous Short answer Questions

1. What is kT (the concept, not the numerical value)? Explain why, in a system at equilibrium, no molecules will be at kT.

2. Below is the Maxwell energy distribution equation. Which part of this equation indicates that the molecules have only kinetic energy, not potential energy?

$$\frac{dn(v)}{n_o dv} = \frac{4}{\sqrt{\pi}}\left(\frac{m}{2kT}\right)^{3/2} v^2 e^{-\frac{mv^2}{2kT}}$$

3. Show why, during the formation of a thymine dimer by UV radiation, the energy is neither released as a photon nor entirely as heat. You may wish to use a graphical explanation.

4. Why can humans detect sounds with negative decibels at 3000 Hz?

5. Give an example showing the relationship between retention time and reaction time in probabilistic systems.

6. Why is the concept of a K_e more appropriate than a K_D near a membrane?

7. Give an example of how changes in absorbance are used to infer the formation of molecular complexes.

8. What did the paper on protein stability and folding kinetics conclude about the differences in protein folding in the nucleus and the cytoplasm? [This question was from a research paper that semester.]

9. In the paper presented in class on protein unfolding, what were the major differences between molecular dynamic simulation and constraint-based modeling? [This question was from a research paper that semester.]

10. What is the major technical difficulty that must be overcome for successful MRS proton measurements?

PSL Previous Essay questions.

1. Consider a molecular system at equilibrium. We are able to rapidly annihilate every molecule with an energy greater than 2kT, before the system is allowed to return to equilibrium. Please diagram and describe the molecular energy distribution before the annihilation event, at the exact moment of annihilation, and once the system has returned to equilibrium.

2. If an activated muscle is allowed to slide down its length-tension curve until it is generating no tension, although still being activated, how would this affect the small-square/basket-weave distribution?

3. Beginning at very low temperatures and increasing through very high temperatures, please explain how the addition of heat to an enzyme system will affect the rate of the catalyzed reaction.

4. Suppose you are treating a disease with an exogenous antibody that has both a greater retention time and a greater reaction time than native antibodies. How would the system respond?

5. How might the membrane electric field affect the orientation of a molecular dipole sufficiently close to the membrane?