PSL 425: Physiological Biophysics
3 credits
Prerequisite: PSL 250 or PSL 310 or both PSL 431 and PSL 432
TT 8:30-9:50, 136 Chemistry
Dr. Patrick Dillon, 884-5040, dillon@msu.edu, Office Hours, TT 2-3:15
TA: James Barger, bargerj@msu.edu. Office Hours, M 2:30-3:30 3162 BPS;
W 9:30-10:30 2235 BPS
Textbook: Biophysics: A Physiological Approach, Patrick F. Dillon, Cambridge University Press, 2012

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, equilibrium and non-equilibrium ionic distributions, thermodynamics, biomechanics of forces and fluids, bioelectric fields, systems theory, kinetic analysis of compartments and enzymes, and models of complex biological processes.

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 go on to the material in the book starting on Chapter 1 and continuing from there.

There will be 10 in-class quizzes in this class. The quizzes will be given at the start of class on each Tuesday from January 19-March 29. The short answer quizzes will cover the material from the previous week. Essay questions will cover the material of the previous 5 weeks 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 5 quizzes, the questions will be posted on Monday, the day before the quiz. For Q1-Q5, you will get all the questions in advance, but you will not know which ones will be asked. For the last 5 quizzes, the questions will not be posted. For Q6-Q10, you will not know the questions in advance, but you will get to choose which questions you want to answer. A table summary of the quizzes is below. Each quiz is worth 5 points toward your final. The total of quiz points is 50.

Date	Quiz#	Format	Question Choice	Q's in Advance
1/19	1	Short Answer	2 of 4, no choice	Yes
1/26	2	Short Answer	2 of 4, no choice	Yes
2/2	3	Short Answer	2 of 4, no choice	Yes
2/9	4	Short Answer	2 of 4, no choice	Yes
2/16	5	Essay	1 of 2, no choice	Yes
2/23	6	Short Answer	2 of 4, choice	No
3/1	7	Short Answer	2 of 4, choice	No
3/15	8	Short Answer	2 of 4, choice	No
3/22	9	Short Answer	2 of 4, choice	No

3/29	10	Essay	1 of 2, choice	No

All makeups of missed, excused quizzes will be at the end of the last class on April 28. 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 10 minute (8 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). The talk will be based on a research paper in Biophysical Journal from 2013-present, which can be accessed for free through the MSU library portal. Students must inform the instructor of the paper they will present and select a presentation slot by February 16. 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.** Available slots can be seen in the Student Presentation file on D2L. All power points are due by March 22 so they can be posted on D2L, with class presentations starting on April 5. Part of your presentation grade requires your attendance at other students' presentations. The paper presentation is worth 10 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, limited time 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 quizzes. 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 assigned final exam time, 7:45-9:45 AM on Wednesday, May 4. The final is worth 40 points. Some questions previous tests are below.

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. 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 in Physiological Biophysics.

1. 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 conclusion 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? Was the presentation timely?

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. What is the concept of activity? How would this concept apply to a system without sufficient molecules to be considered an ensemble?

4. 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.

5. 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?

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