Syllabus

Physics 220/01 (Medical and Biological Physics)

Fall 2019

Instructor: Professor Brad Antanaitis (Dr. A)

Office: Room 015 Hugel Hall of Science (Hours and other useful information are posted on the Physics 220 Moodle site.)

Lab: Room 015 Hugel Hall of Science or 310 HSC (NMR Lab)

Phone: x5209 (Office); 215-736-8999 (Home – Leave message on answering machine, I'll respond as soon as possible.)

E-mail: antanaib (I check my email frequently, so this may be the best and fastest way to get in touch with me.)

Classes on Snow Days and Other Emergencies: If I am unable to make it to class (I live in Morrisville, PA, about 55 miles from Easton), I will send the class an email message via Moodle. I typically arrive on campus around 6:30 AM.

Text: **Physical Biology of the Cell, 2nd edition** by Rob Phillips, Jane Kondev, Julie Theriot and Hernan G. Garcia, 2013, Garland Science, Taylor and Francis Group, LLC.

Be sure to take full advantage of the rich array of resources available at: https://www.crcpress.com/Physical-Biology-of-the-Cell/Phillips-Kondev-Theriot-Garcia/p/book/9780815344506

Supplementary References: Some of these are available from the library or, in many cases, can still be purchased from Amazon or elsewhere:

1. **Biological Physics: Energy, Information, Life** (Updated 1st Edition), Philip Nelson, 2008.
2. **Molecular Driving Forces: Statistical Thermodynamics in Biology, Chemistry, Physics and Nanoscience, 2nd ed.,** Ken Dill and Sarina Bromberg, 2011.
3. **Physical Models of Living Systems,** Philip Nelson, W. H. Freeman and Co., 2015.
4. **Statistical Physics of Biomolecules: An Introduction,** Daniel Zuckerman, CRC Press, 2010.
5. **Introductory Biophysics**, Hallett, Speight and Stinson, 1977.

6. **The Physics of Proteins: An Introduction to Biological Physics and Molecular Biophysics**, Hans Frauenfelder (Shirley S. Chan and Winnie S. Chan, eds.), 2010.
7. **36 Lectures in Biology**, S. E. Luria, 1975.
8. **Medical Physics -** Selected Reprints, ed. R. K. Hobbie, AAPT, 1986.
9. **Mathematical Models in the Social and Biological Sciences,** E. Beltrami, 1993.
10. **Applied Biophysics: A Molecular Approach for Physical Scientists**, Tom Waigh, 2007.
11. **Fractals in Chemistry, Geochemistry and Biophysics** – **An Introduction**, K. S. Birdi, 1993.
12. **Mathematical Techniques for Biology & Medicine**, W. Simon, 1986.
13. **Physical Biology of the Cell**, R. Phillips, J. Kondev, J. Theriot, 2009.
14. **Consider a Spherical Cow: A Course in Environmental Problem Solving**, J. Harte, 1985.
15. **Physics with Illustrative Examples from Medicine and Biology** – vols. 1-3, F. M. H. Villars and G. B. Benedek, 2000. This excellent resource is, once again, in print!
16. **Intermediate Physics for Medicine and Biology**,4^{rth} edition, Russell K. Hobbie and Bradley J. Roth, 2007
17. **Fractals and Chaos: Simplified for the Life Sciences**, Larry S. Liebovitch, 1998. A wonderful introduction to the subject.
18. **Physics in Biology and Medicine**, 2nd ed., Paul Davidovits, 2001.
19. **Biomedical Applications of Introductory Physics**, 2nd ed., Paul Davidovits, 2001.
20. **Fractals and Chaos: Simplified for the Life Sciences,** Larry S. Liebovitch, 1998.

Textbook readings and supplementary references will be augmented by material typically but not exclusively taken from the author's suggested reading list. Where appropriate appendices and other relevant sources focusing on mathematical tools will be presented in class. Students are strongly encouraged to consult introductory physics or mathematical textbooks to reinforce their knowledge of a subject or technique in a timely way. **For problem solving and theoretical jam sessions, students are strongly encouraged to partner with a student from a different discipline, to enhance and make more fertile such experiences and to mirror what actually happens in carrying out interdisciplinary research.**

The main purpose of this course is to demonstrate to a wide audience how the principles, tools, models and strategies of physicists can be applied to problems having biological, medical or ecological import. Methods taught can be fruitfully applied to a wide range of interdisciplinary or multidisciplinary problems, and much of the material underlying the growing and dynamic fields of Bionanotechnology, Bioengineering and Soft Materials is introduced. The course is aimed at students nearing a decision on career direction, who are curious about areas of research open to them or who may simply wish to broaden their biophysical or biomedical horizons. The course also fulfills a “W” requirement.

Student Learning Outcomes:

- Students will be able to apply the laws, tools and methodologies of physics to understand the biology of living systems and discover models that characterize biological entities or phenomena.

- Students will learn to use computer simulations to model important biophysical phenomena, such as diffusion, nerve propagation and membrane potentials.

- Students will learn how to develop dynamical models to describe nonlinear oscillations in population dynamics, DNA vibrational modes and formation of branching networks, among others.

- Students will apply quantitative model-building to real data and thus learn how to extend a simple model to encompass phenomena normally beyond its reach.

- Students will acquire and sharpen the mathematical skills necessary to describe biophysical phenomena.

- Students will see the relationship between empirical data and the theory that ties those data together in a concise, elegant and unified way.

- Students, in dealing with cellular hierarchy, will be introduced to the relatively new and rapidly expanding field of complexity.

- Students will sharpen their technical writing, research and presentation skills by writing a term paper and presenting essential results of their findings to classmates.

- Students will appreciate the foundational nature of physics and its relationship to other related disciplines, especially biology, biochemistry, medicine, neuroscience, pharmacology, and bioengineering as well as its connection with the solution of real-world problems.

Term Paper: Guidelines, topical suggestions and deadlines for the term paper are available on the Physics 220 Moodle site as separate documents. Our WA this semester is: Dr. A + WA drop-in sessions.

Grading: Grades for this course will be determined as follows:

Graded Homework (about once a week) ------------------- 50%
Midterm Exam (in-house) ------------------------------------ 20%
Term Paper (start early) -------------------------------------- 30%
Attending BRM-Add 1 pt. for each meeting up to ten pts -10%
Any accumulated points will be added to scores in the other three categories.

Topics Covered: While the material covered in this course may be determined, in part, by the interests of the class, I have tentatively chosen the following:

(Week 1) Chapters 1&2 (Why: Biology by the Numbers and What and Where: Construction Plans for Cells and Organisms)

(Week 2) Chapters 2 & 3 (When: Stopwatches at Many Scales)

(Week 3) Chapter 4 (Who: Bless the Little Beasties)

(Week 4) Chapter 5 (Mechanical and Chemical Equilibrium)

(Week 5) Chapter 6 (Entropy Rules)

(Week 6) Chapter 7 (Two-State Systems)

(Week 7) Chapter 8 (Random Walks and the Structure of Molecules)

(Week 8) Chapter 8 (Random Walks and the Structure of Molecules)

(Week 9) Chapter 13 (A Statistical View of Biological Dynamics)

(Week 10) Lecture Notes (Microscopic Dynamics)

(Week 11) Lecture Notes (Phase Transitions)

(Week 12) Lecture Notes (Phase Transitions + Cooperativity)

(Week 13) Lecture Notes (Cooperativity: the Helix-Coil, Ising and Landau Models + Current Research)

(Week 14) Thanksgiving Break (Class on Monday only)

(Week 15) Short Term Paper Presentations and Wrap-up

Academic Honesty: Working with others is often a helpful way to learn physics. I encourage you to collaborate with each other on homework, but the work you turn in must be your own. If, in fact, you do collaborate with fellow students, be sure to include their names at the top of your homework paper. You should read the department's Academic Honesty policy for rules regarding collaboration (available on the course Moodle site).

Diversity, Inclusion and Equity Statement: Students should view this classroom as an inclusive space and safe haven for the free exchange of ideas. As your instructor one of my primary goals is to assure that the background, perspective and beliefs of each student are respected and appreciated regardless of race, ethnicity, gender, social class, sexual orientation, religion, political affiliation, ability level or learning style. Accordingly, I am committed to creating an atmosphere conducive to learning that respects diversity and inclusion and further promotes equity by removing educational barriers. As we work together to build this community of scholars, consider the following actionable points:

- Be open and receptive to the views of others.
- Feel free to share your own unique experiences.
- Honor and be enriched by the uniqueness of your classmates.
- View your classmates as respected resources of information and knowledge.
- Appreciate the opportunity to learn from classmates who may possess skill sets and perspectives that complement your own.

Privacy Statement: Moodle contains student information that is protected by the Family Educational Right to Privacy Act. Disclosure to unauthorized parties violates federal privacy laws. Courses using Moodle will make student information visible to other students in this class. Please remember that this information is protected by these federal privacy laws and must not be shared with anyone outside the class. Questions can be referred to the Registrar's Office.

Accommodation: My policy – It is important to me that you do well in this class. If you have any disabilities which you feel may interfere with your ability to perform well in this class, please contact me to discuss ways of accommodating them.

Meeting Federal Credit Hour Standards: The student work in this course is in full compliance with the federal definition of a four-credit hour course. **The Federal course credit rule requires a total of 180 hours (12 hours/week) of student work over an approximately 15-week semester for a full unit (four credit hour) course.**