Syllabus

Physics 220/01 (Medical and Biological Physics)

Spring 2017

Instructor: Professor Brad Antanaitis (Dr. A)

Office: Room 024 Hugel Hall of Science (Hours and other useful information are posted on a bulletin board right outside my door. This information is also available on the Physics 220 Moodle site.)

Lab: Room 021 Hugel Hall of Science (located right across the hall from my office) 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.)

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: http://microsite.garlandscience@garland.com.

Supplementary References: These are available on a sign-out basis from the instructor, from the library or, in many cases, can still be purchased:

1. **Biological Physics: Energy, Information, Life** (Updated 1st Edition), Philip Nelson, 2008.
2. **Introductory Biophysics**, Hallett, Speight and Stinson, 1977.
3. **The Physics of Proteins: An Introduction to Biological Physics and Molecular Biophysics**, Hans Frauenfelder (Shirley S. Chan and Winnie S. Chan, eds.), 2010.
4. **36 Lectures in Biology**, S. E. Luria, 1975.
5. **Medical Physics -** Selected Reprints, ed. R. K. Hobbie, AAPT, 1986.
6. **Mathematical Models in the Social and Biological Sciences,** E. Beltrami, 1993.
7. **Applied Biophysics: A Molecular Approach for Physical Scientists**, Tom Waigh, 2007.

8. **Fractals in Chemistry, Geochemistry and Biophysics** – **An Introduction**, K. S. Birdi, 1993.
9. **Mathematical Techniques for Biology & Medicine**, W. Simon, 1986.
10. **Physical Biology of the Cell**, R. Phillips, J. Kondev, J. Theriot, 2009.
11. **Consider a Spherical Cow: A Course in Environmental Problem Solving**, J. Harte, 1985.
12. **Physics with Illustrative Examples from Medicine and Biology** – vols. 1-3, F. M. H. Villars and G. B. Benedek, 2000. Excellent resource is, once again, in print!
13. **Intermediate Physics for Medicine and Biology**,4rth edition, Russell K. Hobbie and Bradley J. Roth, 2007
14. **Fractals and Chaos: Simplified for the Life Sciences**, Larry S. Liebovitch, 1998.
15. **Physics in Biology and Medicine**, 2nd ed., Paul Davidovits, 2001.
16. **Biomedical Applications of Introductory Physics**, 2nd ed., Paul Davidovits, 2001.

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 Samantha Miller-Brown, a mathematics major.

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%

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 9 (Electrostatics for Salty Solutions); Midterm Exam

(Week 9) Spring Break

(Week 10) Chapter 12 (The Mathematics of Water)

(Week 11) Chapter 13 (A Statistical View of Biological Dynamics)

(Week 12) Chapter 15 (Rate Equations and Dynamics in the Cell)

(Week 13) Chapter 17 (Biological Electricity)

(Week 14) Chapter 20 (Biological Patterns: Order in Space and time)

(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).

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.

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.