

Course Syllabus: Introduction to Biophysics 33-441 / 03-439, Fall 2019

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Consultation Hours: Thursdays, 9:00 – 10:00 or by appointment (Theresa Gabrielli, 8-8367)

Course Web site: <http://www.cmu.edu/smsl/teaching/IntroBioPhys.html>

Course Meeting Times: 15:00 – 16:20 Tuesdays & Thursdays

First day of class: Tuesday, Aug. 27, 2019

Student Goals: This intermediate level course is primarily offered to Physics and Biology undergrads (junior/senior) and provides a modern view of molecular and cellular biology *as seen from the perspective of physics*, and quantified through the analytical tools of physics. This course will *not* review experimental biophysical techniques (which are covered, e.g., in 03-871). Rather, physicists will learn what sets “bio” apart from the remainder of the Physics world and how the apparent dilemma that the existence of life represents to classical thermodynamics is reconciled. They also will learn the nomenclature used in molecular biology. In turn, biologists will obtain (a glimpse of) what quantitative tools can achieve beyond the mere collecting and archiving of facts in a universe of observations: By devising models, non-obvious quantitative predictions are derived which can be experimentally tested and may lead to threads that connect vastly different, apparently unrelated phenomena. One major goal is then to merge the two areas, physics and biology, in a unified perspective.

Upon completion of the course, students will have gained an understanding of how biological systems overcome the apparent contradiction that the creation of ordered structures is opposed by basic thermodynamics. They will be able to perform basic calculations of the strengths of physical interactions within cells and will understand how these interactions shape cellular structure. Furthermore, they will have obtained a basic understanding of how cellular systems exploit thermal energy, which is usually associated with the creation of disorder, to help form the organized supramolecular structures necessary to maintain life.

Prerequisites: 03-121 and 33-107, -112 or -132

Text: “Biological Physics – Energy, Information, Life”, Phil Nelson, WH Freeman, NY 2008, ISBN 0-7167-9897-2

This text will form a backbone for the course schedule, but will not rigorously be followed throughout. It holds a wealth of in-depth discussions and is highly recommended.

Further Reading: “*Molecular and Cellular Biophysics*”, M.B. Jackson, Cambridge Univ. Press 2006; “*Physical Biology of the Cell*”, R. Phillips *et al.*, Garland Science 2008.

Grading: problem sets (40%), in-class exams (2 x 15%), final exam (30%), grades will be posted on Canvas (<https://canvas.cmu.edu/courses/>)

Schedule:

- How order is created and maintained in an entropy-driven world
- The biology toolbox: Molecular building blocks of life
- The physics toolbox: Molecular interactions and forces in biology
- Thermal disorder and the probabilistic facts of life
- Macromolecular conformation
- Dancing molecules: Random walks, diffusion, friction and dissipation
- Thermodynamics of biosystems: entropy, temperature and free energy
- Chemical forces and molecular self-assembly