Biological Physics
Physics 405
Prof. R. Superfine, rsuper@physics.unc.edu, 345 Chapman Hall
Fall 2016, Tuesday & Thursday 1230-1:45, Room 247 Phillips Hall
Syllabus

Course Content:
Biology succeeds in defining architecture, motion, response and replication through the generation of order and force from biochemistry. We will explore the fundamental thermodynamic and physical processes that underlie biological phenomena such as diffusion, entropy at the molecular and system level, electrostatics and hydrophobicity. These will form the basis for an understanding of self assembly and force generation that are responsible for molecular and cellular processes such as DNA replication and repair, intracellular transport and cell division. At the higher level of macromolecular assemblies, molecular machines are responsible for the construction of flagella and cilia, and for the manner in which these structures generate torque and force to propel organisms and fluid flow. We will explore the imaging technologies that have elucidated molecular and cellular structure such as electron, optical and atomic force microscopy. Measuring single molecule forces has been accomplished using atomic force microscopy, laser and magnetic tweezers and fluid flow. The overlying goal of the course is for us to understand the cell as a physical entity, and insist on understanding through principled mathematical models and precision measurements.

Topics:
Background: Molecules, Water, Cell biology
Diffusion, dissipation, drive
Random walks, friction and diffusion
Low Reynold's number world
Friction and dynamics in fluids
Time reversal and dissipation
Entropy, temperature, free energy
Second Law of thermodynamics
Entropic forces at work
Osmotic pressure and flow
Special properties of water
Chemical forces and self assembly
Chemical potential and reactions
Self assembly of amphiphiles and cells
Cooperative transitions in macromolecules
Polymer physics
Thermal, chemical and mechanical switching
Enzymes and molecular machines
Survey of molecular devices in cells
Molecular implementation of mechanical principles
Kinetics of enzymes
Techniques 1: Imaging, electrons, light and probes
Techniques 2: Forces, light, magnets and fluid flow

Texts: The Physical Biology of the Cell (Phillips, Garland 2012) plus supplemental reading from current scientific journals (Physical Review Letters, Science, Nature, PNAS, etc.) and texts on hold in library, especially Molecular Driving Forces (Dill, 2003) and Mechanics of Motor Proteins and the Cytoskeleton (Howard 2001).

Grading:	Homework	30%
	Project	15%
	Midterm(s) 1(.5)	30%
	Final	25%

Class: The course work will make use of the textbook and literature from scientific journals. Presentations will regularly be in Powerpoint and be available for download from the course website.
Homework: There will be approximately 5 homework assignments during the semester to further your studying.
Course Project: Students will complete a targeted study on material of interest to them. Wide latitude will be given to the topics that can be covered. Each student will identify a topic and a bibliography for the project by week 6 of the class. For undergraduates, this project will consist of the comparison of two published papers in the field of study. Graduate students will be expected to do a significant project that will include the identification of key issues in the field, and review an appropriate range of the literature in the field. This project will be considered as a significant fraction of the homework assignment.
Midterm: 1 exam will cover the quantitative aspects of the course material, as well as essay questions probing deeper understanding of concepts. We may have mini-quizzes to guide the reading.
FINAL: A final exam will be given that will be cumulative and follow the same format as the exam.
Friday 12pm December 9th , 12-3pm.
Note – NO EXCEPTIONS. DO NOT BUY PLANE TICKETS LEAVING DECEMBER 8th