Instructor:
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Time and Location

Lecture:
Tuesday/Thursday 2-4pm
Math Sciences 5217

Office Hours:
Young Hall 3044A
Time to be determined

Overview:
One might wonder at the phrase theoretical biological physics. Certainly theoretical efforts in this field differ from fundamental theory in physics in that we will not attempt to develop an overarching theory of living systems from first principles. The role of historical contingency inherent in evolution alone precludes this approach and, more importantly, our rapidly developing understanding of the both the stuff and dynamics of life suggests much more restricted goals at this stage of a young sub-discipline of physics. Nevertheless, there appear to be important unifying principles in biology that can be quantitatively analyzed using a combination of statistical physics, continuum mechanics, and hydrodynamics. In this course, we will examine a few cases in which the application of physics to living systems can produce quantitative predictions. Three themes that we will repeatedly encounter are low energy deformations of elastic structures, dynamics in water, and the role of equilibrium (and sometimes non-equilibrium) noise.

Topics to be covered:
As time permits we will address the following.

1. Filamentous structures and the architecture of cells
   Mechanics and statistical mechanics of one-dimensional structures applied to F-actin, microtubules, and other biopolymers.

2. Biological membranes: Structure, self-assembly, and mechanics
   Self-assembly of membranes, energetics of membrane deformation, ion channels and pores in membranes
3. Water, water everywhere: Hydrodynamics at low Reynolds number and electrostatics in salty water
   Basic hydrodynamics and electrostatics with applications to filaments (see 1) and membranes (see 2).

   How do nerves work? How can biology make use of electric circuits when immersed in a conductive fluid?

5. Diffusion: On small and large scales
   Diffusion to capture, chemoreceptors, and an application to the foraging behavior of E. coli. Diffusion in crowded environments and depletion forces. Diffusion in a more abstract sense: Population biology and evolution.

Texts:
There is no required text for the class. I recommend that you look at some of the following:

   A good general reference.

   Another general reference

   A specialized text on neurons

   A nice and simple introduction to diffusion in biology.

Grading:
There will be no exams for the course. I intend to assign about six homework assignments. Solutions will be posted on my website.