BIOL 568 (AMCS 568)

Mathematical Modeling in Physiology and Cell Biology

Instructor: Yoichiro Mori (www.sas.upenn.edu/~ ymori)
Schedule/Classroom: TR 10:30-11:50
Office Hours: TBA
Textbooks: We will use material mostly from the following textbooks:
Mathematical Physiology, James P. Keener and James Sneyd, Springer, 2008.
Stochastic Processes in Cell Biology Paul Bressloff, Springer 2014

Prerequisites: Calculus and linear algebra, together with familiarity with differential equations. Mathematical techniques will be introduced as necessary.

Course Description: Mathematical modeling is increasingly becoming a standard technique in physiology and cell biology. In this class, we will cover some classical models in physiology and cell biology. Half of the course will be devoted to electrophysiology (Hodgkin-Huxley model, action potential propagation and related topics), which has arguably been the most successful area of application of mathematical techniques to biology. We will then consider models of molecular motors and muscle mechanics, of pattern formation and cell polarization. From a mathematical point of view, the course should serve as an introduction in particular to methods in dynamical systems, singular perturbation and asymptotics. A list of tentative topics can be found below.

- Enzyme Kinetics
  - Michaelis Menten kinetics
  - Kinetic proofreading
- Membrane potential and membrane channels
  - Current-voltage relations, equilibrium and resting potential
  - Stochastic channel gating
- Cell volume control
  - Pump-leak models and their mathematical properties

  - Models of transporting epithelia
- Action potential propagation
  - Hodgkin-Huxley and Fitz-Hugh Nagumo reduction.
  - Hodgkin-Huxley PDE model of action potential propagation in an axon
  - Myelination and saltatory conduction
- Cardiac electrophysiology
  - Gap junctions and conduction block
  - Bidomain model and homogenization
  - Arrhythmias and cardiac defibrillation
- Molecular Motors
  - Brownian and polymerization ratchet models
- Muscle Mechanics and Cross-bridge model
- Patten formation
  - Turing instability
  - Wave-pinning and cell polarization

Grading: Grades will be based on homework assignments and a final project. Homework will include both paper-and-pencil and programming assignments.