Evolutionary Systems Biology of Cancer

This course will introduce the basics of mathematical modeling and computation in biology. Only basic mathematical knowledge (Calculus at high-school or college level) is required.

Three hours a week, one quarter term (January 25 - March 15)

Mondays 3:30 pm - 6:30 pm, ZRC 1970

Class 1: January 25, 2010.

Introduction to Mathematical Modeling in Biology. We will study introductory models in biology, and cover the basic principles of constructing mathematical models. How do we quantitatively describe a biological system? How do we know which systems are amenable to mathematical modeling, and what kinds of questions can we answer with these techniques?

Class 2: February 1, 2010.

Classic Models in Ecology and Evolutionary Biology. We introduce basic exponential and logistic models of population growth, epidemiological models of disease spread, models of natural selection. We introduce an example of simple probabilistic model of population growth to motivate the next lecture.

Class 3: February 8, 2010.

Introduction to Basic Probability. We cover the basics of conditional

probabilities, Bayes' Rule and basic probability distributions. We study basic stochastic processes that are often used in modeling biological populations.

Class 4: February 15, 2010.

Introduction to Biostatistics: Estimation, hypothesis testing and confidence intervals. Specific data analysis examples using contingency tables, regression and analysis of variance. Study design will be covered with discussion of power and sample size calculations.

Class 5: February 22, 2010.

Introduction to Cancer Genomics Data Analysis. DNA copy number changes, gene expression, mutations and integrated analysis, with worked examples.

Class 6: March 1, 2010.

Probabilistic Models in Biology. We discuss various models of population growth, birth-death models such as Wright-Fisher and Moran processes.

Class 7: March 8, 2010.

Evolutionary Models in Cancer (I). We introduce basic probabilistic models of cancer cell populations, including Moran models of stem cell compartments, birth-death models of exponentially growing tumor populations, Wright-Fisher models. We introduce an example of two-type model of sensitive and resistant cancer cells, and some compartment

models of the hematopoietic system.

Class 8: March 15, 2010.

Evolutionary Models in Cancer (II). Part 1. Analytical tools for exploring our models. We use the models discussed in the previous discussion to calculate various quantities such as the probability of developing resistance in an exponentially growing tumor. Part 2. Simulation tools for exploring our models. Many models are too complex to obtain analytical estimates for the quantities we are interested. We introduce basic stochastic computer simulation methods to explore these complex models.