Quantitative Understanding in Biology Course Syllabus – Q3-Q4 2014

Tuesday, January 21, 2014 – Thursday, June 05, 2014
Tuesdays, 4:00 pm – 5:30 pm, Thursdays, 4:00 pm – 5:30 pm
Location: Physiology Department Conference Room (1300 York Avenue); 5th Floor, Room LC-504
Midterm Exam: Thursday, March 20th (4:00 pm – 7:00 pm)
Final Exam: Thursday, June 5th (4:00 pm – 7:00 pm)
Course Director: Jason Banfelder (jrb2004@med.cornell.edu)
Teaching Assistants: Michael LeVine (mil2037@med.cornell.edu) and German Sabio (ges2021@med.cornell.edu)
This course will be fully graded: (Honors, High Pass, Low Pass, Fail)
Course web site: http://physiology.med.cornell.edu/people/banfelder/qbio

This course will prepare students to apply quantitative techniques to the analysis of experimental data and the modeling of biological systems. To emphasize both practical and theoretical skills, the course will involve several hands-on workshops, and the completion of several projects by the students will be required. Topics include: practical aspects of data formatting and management; graphical, mathematical and verbal communication of quantitative concepts (including videotaping of students' lectures); a review of statistics, with emphasis on the selection of appropriate statistical tests, the use of modern software packages, the interpretation of results, and the design of experiments; the formulation, evaluation, and analysis of mathematical models of biological function, with an emphasis on linear and non-linear regression, determination of model parameters, and the critical comparison of alternative models with regard to over-parameterization. In order to enable quantitative modeling in biological arenas such as gene networks, neural function, enzyme kinetics, cardiac dynamics, and signaling pathways, the formal components will introduce (and demystify) ordinary differential equations and basic principles of non-linear dynamics. Additional special topics will also be presented and their application will be illustrated with ongoing research in the laboratories of PBSB faculty.

Module I: Statistics

Quantifying a Sample Distribution; Biological Diversity; Probability Density Functions and the Normal Distribution; Confidence Intervals; P-Values; Large Datasets, Data Mining, and Multiple Hypothesis Testing; Experimental Design for Behavioral Neuroscience; Applications to Analysis of High-Throughput Sequencing Data; Principal Component Analysis

Module II: Model Parameter Estimation

Correlation and Linear Regression; Fitting Model Parameters to Experimental Data; Quantitative Comparison of Models; Principal Components Analysis; Model and Simulation Based Statistics; More Applications to Analysis of High-Throughput Sequencing Data

Module III: Linear Difference Equations and Linear Algebra

Introduction to Dynamical Systems; Linear Algebra Review; Eigenvalues and Eigenvectors Demystified; Markov Models and Evolution; Ion Channels

Module IV: Dynamical Systems

Modeling Biochemical Systems with ODEs; Numerical Evaluation of ODE Models; Quantitative Understanding of Enzyme Kinetics and Cooperatively; Control Theory and the Stability of Dynamical Systems; Eigenvalues and Eigenvectors Revisited; Non-Linear Systems; Networks and Memory; Fourier Analysis and the Human Auditory System