Contemporary PBSB: Cells, systems, and quantitative methods V2.0

Course content and organization are designed to prepare students for twenty-first century research in the function, analysis, modeling, and understanding of living systems at each of several scales, from the molecular through the cellular to the organ system and organism. Multiscale and translational examples develop conceptual skills necessary to design meaningful experiments, derive insight from journal reports, work within the group structure now essential for contemporary research, and communicate new developments and related findings to today's peers and future students. Structural and developmental concepts are covered as they illuminate function.

Each module consists of multiple weeks. Typical weeks for modules CPBSB1 through 5 include two in-depth lecture-conferences that combine careful presentation of core material with student participation, and conclude with either a computational analysis and/or model, or a relevant illuminating article from the literature. The final module, CPBSB6, introduces new instructional modalities and perspectives designed to instill skills essential for researchers.

Days and times: Mondays and Wednesdays 1 to 3 PM; Fridays 3 to 5 PM ***except as noted***
Room: LC-504, 1300 York Avenue
Quarters I and II
14 weeks September 3 – December 13, 2013, starting *Tuesday*, September 3.
This is the first term of a one-year modular course required of all first-year students in the PBSB Program. The entire course or selected modules are open to students of other programs with the permission of the course director; class limit 20 students.

CPBSB 1: Membranes and cells (MAC)
Four weeks September 3 – September 27, 2013; Daniel Gardner

Week 1: Membranes and compartments
Tuesday, Sept. 3, 11 AM – 1 PM: Cell membranes and phospholipids –Andersen
Thursday, Sept. 5***, 11 AM – 1 PM:*** Compartments, electrolytes, osmosis – Andersen
Friday, Sept. 6: Journal Club – Gardner

Week 2: Membrane potentials and action potentials
Monday, Sept. 9, noon – 2 PM: Membrane potentials and action potentials – Gardner
Wednesday, Sept. 11: Hodgkin-Huxley models and beyond – Gardner
Friday, Sept. 13: Introduction to analysis of living systems – Banfelder

Weeks 3 and 4: Membrane protein structure and function
Monday, Sept. 16: Protein structure/function and modification – Boudker
Wednesday, Sept. 18 ***in rooms L/M, 2nd floor***: Channels, transporters, and pumps – Palmer
Friday, Sept. 20: Computer lab HH modeling – Banfelder, Victor

Monday, Sept. 23: Channeling transporters, transporting channels – Accardi
Wednesday, Sept. 25: Neuromuscular transmission – Dittman
Friday, Sept. 27: Module evaluation/exam

CPBSB 2: Control and communication in bodies and brains (CCBB)
Five weeks September 30 – November 1, 2013; B. Grafstein

Week 5: Neurons and brain networks I
Monday, Sept. 30: CNS synapses & plasticity – Gardner
Wednesday, Oct. 2: Nerve cell properties, brain structure, sensory coding – Grafstein
Friday, Oct. 4: Student pair-presentations: Sensory organ transduction – Grafstein

Week 6: Neurons and brain networks II
Monday, Oct. 7: Neuronal system properties – Aksay
Wednesday, Oct. 9: Neuronal wiring in development and regeneration – Grafstein
Friday, Oct. 11: Computational exercise – Aksay, Banfelder

Week 7: Neural mechanisms and pathways for vision
Monday, Oct. 14: Vision – Nirenberg
Wednesday, Oct. 16: Central visual pathways – Gardner
Friday, Oct. 18: Computational lab: vision – Victor, Gardner

Week 8: I do, I remember
Monday, Oct. 21: Motor systems – Grafstein
Wednesday, Oct. 23: Memory & learning – Prusky
Friday, Oct. 25: no class (Departmental retreat)

Week 9: Immune system
Monday, Oct. 28: Mast cells as a communication medium – Silver
Wednesday, Oct. 30: Student presentations: Nervous system topics I (7 students) – Grafstein
Friday, Nov. 1: Student presentations: Nervous system topics II (7 students) – Grafstein

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CPBSB 3: Protein function signaling and synthesis (PFSAS)

Five weeks November 4 – December 13, 2013; Olga Boudker
(note Thanksgiving break November 25 – 29)

Week 10: Enzyme kinetics and function
Monday, Nov. 4: Enzyme kinetics – Nimigean
Wednesday, Nov. 6: Kinases/Phosphatases – Huang
Friday, Nov. 8: Protein viewing and modeling I (lab) – Banfelder

Week 11: Sequences and signaling I
Monday, Nov. 11: Protein sequence alignments (lab) – Skrabanek
Wednesday, Nov. 13: Adrenergic signaling – Rosenblatt
Friday, Nov. 15: Protein viewing and modeling II (lab) – Banfelder

Week 12: Signaling II
Monday, Nov. 18: Molecular mechanisms of G protein signaling – Weinstein
Wednesday, Nov. 20: Ca2+ signaling – Dittman
Friday, Nov. 22: Journal Club – Boudker

Week 13: Transcription and translation
Monday, Dec. 2: Transcription – Skrabanek
Wednesday, Dec. 4: Transcription factors – Nibu
Friday, Dec. 6: MAPK network modeling (lab) – Banfelder

Week 14: Transcription factors
Monday, Dec. 9: Translation – Blanchard
Wednesday, Dec. 11: Journal Club – Boudker
Friday, Dec. 13: Module evaluation/exam

Contemporary PBSB: Cells, systems, and quantitative methods
Quarters III and IV
15 weeks January 21 – May 9, 2014, starting *Tuesday*, January 21 at 11:30 AM.
This is the second term of a one-year modular course required of all first-year students in the PBSB Program. The entire course or selected modules are open to students of other programs with the permission of the course director; class limit 20 students.
Co-requisite for PBSB students: ***Quantitative Understanding in Biology; Banfelder***

CPBSB 4: Action and mechanical work from biochemical energy (∆G)
Six weeks January 21 – Feb. 28; Trine Krogh-Madsen

Week 1: Voluntary skeletal muscle
Tuesday, Jan. 21, 11:30 AM: Skeletal muscle contraction I – Krogh-Madsen
Wednesday, Jan. 22: Skeletal muscle contraction II – Krogh-Madsen
Friday, Jan. 24: Computer lab: Crossbridge dynamics – Krogh-Madsen

Week 2: Regulation and action
Monday, Jan. 27: Smooth muscle contraction – Palmer
Wednesday, Jan. 29: Regulation by the autonomic nervous system – Grafstein
Friday, Jan 31: Journal club – Grafstein

Week 3: Circulatory function and mechanics
Monday, Feb. 3: The heart and vasculatory system – Krogh-Madsen
Wednesday, Feb. 5: Blood pressure and flow – Krogh-Madsen
Friday, Feb. 5: Computer lab: Blood pressure and flow – Krogh-Madsen

Week 4: Heart electrophysiology and contraction
Monday, Feb. 10: Cardiac action potential I – Krogh-Madsen
Wednesday, Feb. 12: No class (Grad Student recruitment days)
Friday, Feb. 14: No class (Grad Student recruitment days)

Week 5: Heart function and dysfunction
Monday, Feb. 17: No class (Presidents Day)
Wednesday, Feb. 19: Cardiac AP II: Propagation, re-entry, arrhythmia – Krogh-Madsen
Friday, Feb. 21: Computer lab: Cardiac action potential model – Krogh-Madsen

Week 6: Control of and by the heart
Monday, Feb. 24: Cardiomyocyte calcium dynamics– Krogh-Madsen
Wednesday, Feb. 26: Journal club/computer lab – Krogh-Madsen
Friday, Feb 28: Module evaluation/exam

CPBSB 5: Introduction to Computational Systems Biology (CSB)
Six weeks March 3 – April 18; Olivier Elemento et al
(note Spring break March 31 – April 4)

Week 7: Systems biology and Big Data
Monday, March 3: Genome, transcriptome, epigenome, regulation. Systems biology and high-throughput methods to interrogate cells: Microarray, Sequencing, Proteomics, Protein Interactions, Imaging & spatial information – Elemento
Wednesday, March 5: NGS basics, ChIP-seq, RNA-seq, biases, normalization –Rätsch
Friday, March 7: Computer lab: Basic deep-sequencing visualization and manipulation, short read alignments – Skrabanek

Week 8: Biological perturbations

Monday, March 10: Genome sequencing, genotyping, mutation detection with introduction to Bayesian approaches – Lee/Berger
Wednesday, Mar. 12: Uncovering the effect of mutations on phenotypes: genotype-phenotype association, GWAS, eQTL. Parameter estimation and linear regression, feature selection, application, mixed models – Mezey
Friday, March 14: Computer lab: sequence analysis (annotation), NGS analysis using Galaxy – Skrabanek

Week 9: Modeling transcriptional and posttranscriptional regulation
Monday, March 17: Transcriptome sequencing (RNA-seq), quantifying expression, differential analysis, techniques for characterizing transcriptome (noncoding RNAs, assembly, isoform discovery, gene fusion – Rätsch/Leslie
Wednesday, Mar. 19: Clustering techniques, PCA, Pathway analysis, GSEA, network analysis, Cytoscape visualization – Elemento/Leslie
Friday, March 14: Computer lab: clustering, heatmaps in R – Elemento

Week 10: Identifying and modeling correlations in biological data
Monday, March 24: LASSO regression/elastic net and application to gene expression, motif discovery (REDUCE) – Leslie
Wednesday, Mar. 26: Information theory, application to motif analysis, gene network analysis – Elemento
Friday, March 28: Journal club – Elemento

Week 11: Machine learning in biology
Monday, April 7: Supervised Learning, SVMs + Kernels, cancer applications – Rätsch
Wednesday, April 9: Unsupervised clustering of high-dimensional data (k-means, hierarchical, etc), HMMs for chromatin segmentation, Expectation Maximization – Leslie
Friday, April 11: Computer lab: expression quantification, differential testing, SVM, R – Leslie

Week 12: Dynamical systems in biology
Monday, April 14: Mathematical modeling of pathways including MAPK pathway, single cell measurements and analysis – Altan-Bonnet
Wednesday, April 16: Dynamical systems, ODE, dynamical Bayesian networks – Altan-Bonnet
Friday, April 18: Computer lab and exam: Modeling the MAPK pathway in Matlab – Altan-Bonnet, Elemento

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CPBSB 6: Physiology of Systems and Diseases
Four weeks April 21 – May 16; Daniel Gardner and Olaf S. Andersen

Weeks 13 to 16
Each week covers one major topic that links across scales to provide translational, longitudinal, or systemic synthesis.

Formats vary week to week, but include one or more of lecture/conferences, problem-based learning sessions, or journal clubs. Some weeks have a translational focus on the underlying physiology, biophysics, or systems biology, whereas others follow a major investigative thread through successive questions, techniques, and reports. This approach synthesizes lecture, discussion, journal club, and problem-based learning modalities. A major goal is understanding what questions are appropriate to ask, given existing techniques, and what questions require inventing or adopting new but feasible techniques. Each week additionally demonstrates how ideas and tools learned in the five preceding modules promote problem solving.

Week 13: Current controversy in biomedicine: what is the normal function of presenillin?
Monday, April 21: Thesis – A. Accardi

Wednesday, April 23: Antithesis – A. Accardi
Friday, April 25: Surely not synthesis – A. Accardi

Week 14: Molecular timing for signal shaping
Monday, April 28: Macroscopic timing at the synapse – D. Gardner
Wednesday, April 30: Microscopic timing at the synapse – D. Gardner
Friday, May 2: The invention of the electrophysiological microscope – D. Gardner

Week 15: Medical detective work
Monday, May 5; Wednesday, May 7; Friday, May 9 – O.S. Andersen

Week 16: A tour of the kidney, with a side trip to the pituitary
Monday, May 12 and Wednesday, May 14 – L.G. Palmer
Friday, May 16 CPBSB6 exam and module evaluation