Contemporary PBSB: Cells, systems, and quantitative methods V5.0

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 many modules 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 an illuminating article from the literature. Other modules introduce new instructional modalities and perspectives designed to instill skills essential for researchers, while providing insights into scales or approaches central to contemporary research.

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: PBSB.9000.01-Contemporary PBSB 1-3
15 weeks: August 29, 2016 – December 9, 2016.
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 individual 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: August 29, 2016 – September 23, 2016; Daniel Gardner

This module introduces rigorous, essential fundamentals of membranes, cells, and membrane proteins. It also uses the relation between experimentally-derived data and mathematical and computational models and analyses as an introduction to how biophysicists think. Such a view is fundamental to understanding contemporary PBSB research, no matter the level, techniques, or system.

Week 1: Membranes and compartments
Tuesday, Aug. 30 @1 PM: Cell membranes, structure and function –Andersen
Wednesday, August 31: Compartments and electrolytes – Andersen
Friday, Sept. 2: Journal Club – Gardner

Week 2: Membrane potentials and action potentials
Tuesday, Sept. 6 @1 PM: Membrane potentials and action potentials – Gardner
Wednesday, Sept. 7: Hodgkin-Huxley models and beyond – Gardner
Friday, Sept. 9: Channels, transporters, and pumps – Palmer

Weeks 3 and 4: Membrane protein structure and function
Monday, Sept. 12: Protein structure/function and modification – Boudker
Wednesday, Sept. 14: Introduction to analysis of living systems (osmotic balance computer lab) – Krogh-Madsen
Friday, Sept. 16: Channeling transporters, transporting channels – Accardi

Monday, Sept. 19: Computer lab Hodgkin-Huxley modeling – Gardner, Victor
Wednesday, Sept. 21: Neuromuscular transmission – Dittman
Friday, Sept. 23: Module evaluation/exam

CPBSB 2: Protein function signaling and synthesis (PFSAS)
Five weeks: September 26, 2016 – October 28, 2016; Olga Boudker

Module 2 combines lectures on aspects of cellular signaling coupled to guided independent work by students, teamed in pairs. Individual research papers will be assigned to student pairs in advance, during the week of Sept. 19.

Week 5:
Monday, Sept. 26: Signaling at membranes – Dittman
Wednesday, Sept 28: Thinking about science: the grant proposal/review process – Boudker
Friday, Sept. 30: Protein viewing and modeling I (lab) – Khelashvili

Week 6:
Monday, Oct. 3: Thermodynamics and signaling – Boudker
Wednesday, Oct. 5: Two-on-one student meetings with advising faculty
Friday, Oct. 7: Protein viewing and modeling II (lab) –Khelashvili

Week 7:
Monday, Oct. 10: Ion channel signaling - TBD
Wednesday, Oct. 12: Student oral presentations of project Aims I
Friday, Oct. 14: Student oral presentations of project Aims II

Week 8:
Monday, Oct. 17: Transcription – Skrabanek
Wednesday, Oct. 19: Protein multiple sequence alignments (lab) – Skrabanek
Friday, Oct. 21: Departmental Retreat; no class

Week 9:
Monday, Oct 24: GPCR signaling - TBD
Wednesday, Oct 26: Regulatory network modeling – Khelashvili
Friday, Oct 28: Mock NIH study section (Extended class)

Final proposals due Friday, Nov 4

CPBSB 3: Control and communication in bodies and brains (CCBB)
Six weeks: October 31, 2016 – December 9, 2016; Bernice Grafstein
(note Thanksgiving break November 24 – 25)

CPBSB3 will give a working introduction to the concepts underlying the nervous system, and the ongoing study of it, with examples drawn from molecular, cellular, and systems levels. At the same time, it again uses student research and presentations, along with student critiques, as a principal modality, thus developing skills essential to contemporary research.

Week 10: Neurons and brain networks I
Monday, Oct 31: Organization of the nervous system I: basic structure, development, sensory coding – Grafstein
Wednesday, Nov 2: CNS synapses & plasticity – Gardner
Friday, Nov 4: Neuronal system dynamics: negative feedback – Aksay

Week 11: Neurons and brain networks II
Monday, Nov 7: Neuronal system dynamics: positive feedback – Aksay
Wednesday, Nov 9: Organization of the nervous system II: Vision – retina to V1 – Grafstein
Friday, Nov 11: Student pair-presentations: Sensory organ transduction – Grafstein

Week 12: Neural and chemical pathways

Monday, Nov 14:	Vision – Nirenberg
Wednesday, Nov 16:	Mast cells as a communication medium – Silver
Friday, Nov 18:	Organization of the nervous system III: Central visual pathways – Gardner

Week 13: Standing up

Monday, Nov 21:	Organization of the nervous system IV: spinal cord; reflex activity – Grafstein
Wednesday, Nov 23:	Thanksgiving break, no class
Friday, Nov 25:	Thanksgiving break, no class

Week 14: Using the brain

Monday, Nov 28:	Organization of the nervous system V: cerebral cortex; sensory-motor coordination – Grafstein
Wednesday, Nov 30:	Memory & learning – Prusky
Friday, Dec 2:	Computational lab: vision – Victor, Gardner

Week 15: Rewiring the nervous system

Monday, Dec 5:	Organization of the nervous system VI: structural plasticity – Grafstein
Wednesday, Dec 7:	Student presentations: Nervous system topics I (7 students) – Grafstein
Friday, Dec 9:	Student presentations: Nervous system topics II (7 students) – Grafstein

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Quarters III and IV: PBSB.9001.03-Contemporary PBSB 4-6
17 weeks January 23 – May 26, 2017.
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***

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
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CPBSB 4: Action and mechanical work from biochemical energy (∆G)
Five weeks January 23 – Feb 24; Trine Krogh-Madsen

Week 1: Heart electrophysiology and regulation

Monday, Jan. 23:	The autonomic nervous system – Grafstein
Wednesday, Jan. 25:	Cardiac action potential – Krogh-Madsen
Friday, Jan 27:	Computer lab: Cardiac action potential – Krogh-Madsen

Week 2: Regulation and action of the circulatory system

Monday, Jan. 30:	Heart and vasculature – Krogh-Madsen
Wednesday, Feb. 1:	Journal club – Krogh-Madsen
Friday, Feb. 3:	Computer lab: Blood pressure and flow – Krogh-Madsen

Week 3: Skeletal and smooth muscle

Monday, Feb. 6:	Skeletal muscle contraction – Gardner
Wednesday, Feb. 8:	Smooth muscle contraction – Palmer
Friday, Feb. 10:	Computer lab: Crossbridge dynamics – Krogh-Madsen

Week 4: Cardiac dysfunction and arrhythmias

Monday, Feb. 13:	Propagation, reentry, arrhythmias – Krogh-Madsen
Wednesday, Feb. 15:	Precision modeling – Krogh-Madsen
Friday, Feb. 17:	Journal club – Krogh-Madsen

Week 5: Cardiac disease models

Monday, Feb. 20:	*No class (Presidents Day)*
Wednesday, Feb. 22:	iPSCs and zebrafish – Quach/Ortega/Krogh-Madsen
Friday, Feb 24:	Journal club – Krogh-Madsen

CPBSB 5: Introduction to Computational Systems Biology (CSB)
Six weeks Feb 27 – April 15; Olivier Elemento et al
(note Spring break March 20 – 24)

Week 6: Systems biology and Big Data

Monday, Feb 27:	Genome, transcriptome, epigenome, regulation. Systems biology and high-throughput methods to interrogate cells: Microarray, Sequencing, Proteomics, Protein Interactions, Imaging & spatial information – Elemento
Wednesday, March 1:	NGS basics, ChIP-seq, RNA-seq, biases, normalization –Rätsch
Friday, March 3:	Computer lab: Basic deep-sequencing visualization and manipulation, short read alignments – Skrabanek

Week 7: Biological perturbations

Monday, March 6:	Genome sequencing, genotyping, mutation detection with introduction to Bayesian approaches – Lee/Berger
Wednesday, Mar. 8:	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 10:	Computer lab: sequence analysis (annotation), NGS analysis using Galaxy – Skrabanek

Week 8: Modeling transcriptional and posttranscriptional regulation

Monday, March 13:	Transcriptome sequencing (RNA-seq), quantifying expression, differential analysis, techniques for characterizing transcriptome (noncoding RNAs, assembly, isoform discovery, gene fusion – Rätsch/Leslie
Wednesday, Mar. 15:	Clustering techniques, PCA, Pathway analysis, GSEA, network analysis, Cytoscape visualization – Elemento/Leslie
Friday, March 17:	Computer lab: clustering, heatmaps in R – Elemento

Week 9: Identifying and modeling correlations in biological data

Monday, March 27:	LASSO regression/elastic net and application to gene expression, motif discovery (REDUCE) – Leslie
Wednesday, Mar. 29:	Information theory, application to motif analysis, gene network analysis – Elemento
Friday, March 31:	Journal club – Elemento

Week 10: Machine learning in biology

Monday, April 3:	Supervised Learning, SVMs + Kernels, cancer applications – Rätsch
Wednesday, April 5:	Unsupervised clustering of high-dimensional data (k-means, hierarchical, etc), HMMs for chromatin segmentation, Expectation Maximization – Leslie
Friday, April 7:	Computer lab: expression quantification, differential testing, SVM, R – Leslie

Week 11: Dynamical systems in biology

Monday, April 10:	Mathematical modeling of pathways including MAPK pathway, single cell measurements and analysis – Altan-Bonnet
Wednesday, April 12:	Dynamical systems, ODE, dynamical Bayesian networks – Altan-Bonnet
Friday, April 14:	Computer lab and exam: Modeling the MAPK pathway in Matlab – Altan-Bonnet, Elemento

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CPBSB 6: Physiology of Systems and Diseases
Six weeks April 17 – May 26; Daniel Gardner and Olaf S. Andersen

Each week of weeks 12 to 17 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. Each week additionally demonstrates how ideas and tools learned in the five preceding modules—and in QBio—promote problem solving.

We're doing this with a major goal in view. The goal is for you to understand what questions are appropriate to ask and important to ask. Also, questions need techniques and data to be resolved, so one needs to consider if current techniques are adequate, or it's important to develop a new technique, or adopt a feasible one used for another purpose.

Week 12: A tour of the kidney, with a side trip to the pituitary
Monday, April 17; Wednesday, April 19; Friday, April 21 – L.G. Palmer

Week 13: Molecular timing for signal shaping
Monday, April 24: Macroscopic timing at the synapse – D. Gardner
Wednesday, April 26: Microscopic timing at the synapse – D. Gardner
Friday, April 28: The invention of the electrophysiological microscope – D. Gardner

Week 14: Current controversy in biomedicine: what is the normal function of presenillin?
Monday, May 1: Thesis – A. Accardi
Wednesday, May 3: Antithesis – A. Accardi
Friday, May 5: Surely not synthesis – A. Accardi

Week 15: Medical detective work
Monday, May 8, Wednesday, May 10, Friday, May 12 – O.S. Andersen

Week 16: Seeing the retina in multiple ways
Monday, May 15, Wednesday, May 17, Friday, May 19 – E. Rodriguez-Boulan

Week 17: Falsity and Inference
Monday, May 22: What is truth? – D. Gardner
Wednesday, May 24: Are you there? Can you let us know if you are? – D. Gardner
Friday, May 26: CPBSB6 exam and module evaluation