

CiCN Curriculum

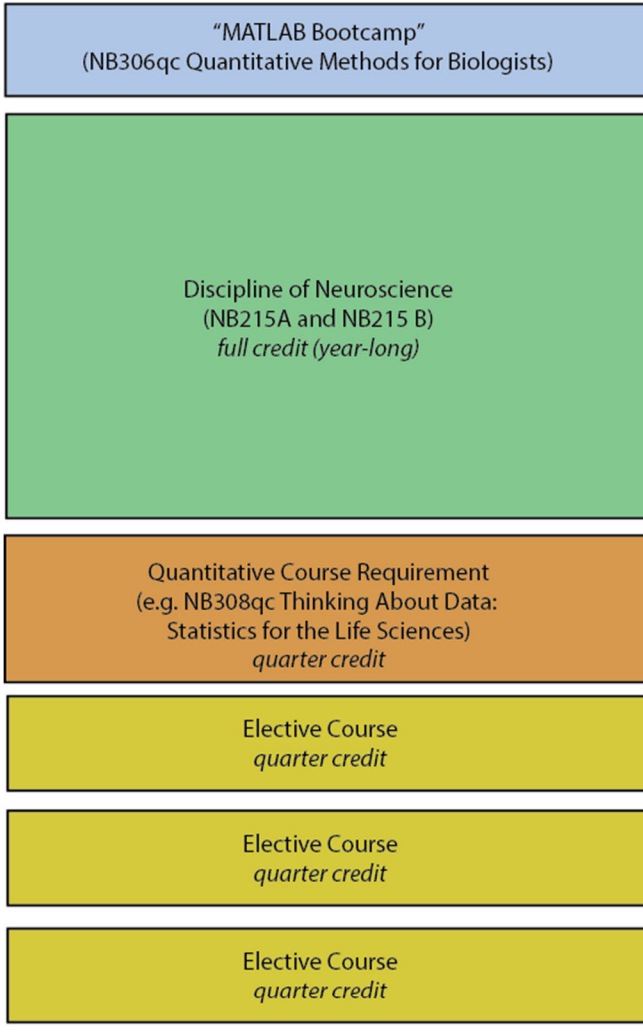
To earn the CiCN, students are required to complete computational coursework beyond the core PiN curriculum that consists of a foundational computational course and four quarters' equivalence of advanced computational elective courses (see curriculum outline below). Students will consult with the CiCN Directors to select appropriate elective courses given their individual backgrounds and training goals (see list of electives below). Courses have been selected based on their importance to the development of technical and theoretical understanding of computational principles that will serve students as they pursue their thesis research. Students may identify courses beyond the scope of this list that would be appropriate for their training and will be able to count those courses towards their electives requirement pending approval by the CiCN Directors.

The computational coursework comprising the curriculum requirement for the CiCN completely satisfies the elective requirements for the PiN curriculum and amounts to one additional half course beyond what is required of all PiN students. This design ensures that CiCN students are immersed in advanced computational coursework without being burdened by excessive coursework beyond the PiN requirements; however, students are not limited to this coursework and will be encouraged to take additional courses beyond the prescribed requirements as appropriate to students' individual training goals and background. For the foundational computational course, CiCN students are required to take either MCB131: Computational Neuroscience, taught by Dr. Haim Sompolinsky, or PSY1401/NEURO1401: Computational Cognitive Neuroscience, taught by Dr. Sam Gershman. Both courses provide a strong computational foundation, but they differ in their emphasis on biophysical vs. cognitive concepts, respectively:

- MCB131 (Computational Neuroscience, Sompolinsky): This course follows trends in modern brain theory, focusing on local neuronal circuits as basic computational modules. It explores the relation between network architecture, dynamics, and function, and introduces tools from information theory, statistical inference, and learning theory for the study of experience-dependent neural codes. Specific topics include computational principles of early sensory systems; adaptation and gain control in vision, dynamics of recurrent networks; feature selectivity in cortical circuits; memory; learning and synaptic plasticity; and noise and chaos in neuronal systems.
- PSY1401/NEURO1401 (Computational Cognitive Neuroscience: Building Models of the Brain, Gershman): "What I cannot create, I do not understand." This course applies Richard Feynman's dictum to the brain, by teaching students how to simulate brain function with computer programs. Special emphasis will be placed on how neurobiological mechanisms give rise to cognitive processes like learning, memory, attention, decision-making, and object perception. Students will learn how to understand experimental data through the lens of computational models, and ultimately how to build their own models.

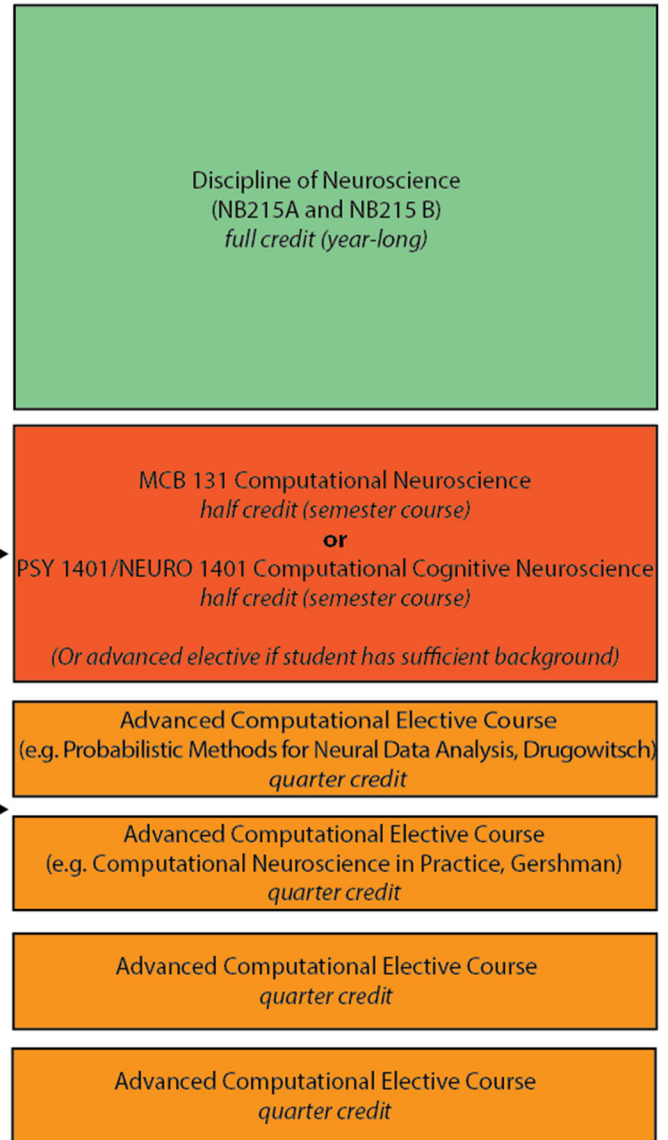
Curriculum Overview for CiCN:

PiN Curriculum



PiN + Computational Neuroscience Certificate

(Test out of NB306qc, opportunity to TA in course)



Notes on course requirements:

- Students may fulfill their 4 quarters of advanced computational electives with quarter courses (partial semester courses) or half courses (full semester, equals 2 quarters)
- Computational coursework satisfies the elective requirement for PiN (indicated by arrows)

Possible Advanced Computational Electives:

Quarter Electives (partial semester)

TBD Computational Neuroscience in Practice (Gershman, planned 2020-21)

*The purpose of this course is to introduce experimental neuroscientists to practical applications of computational models. Students will work on individual research projects throughout the semester, learning to apply specific computational models to their experimental data. The course is geared towards advanced graduate students who have already collected data as part of their PhD research, but it will be open to all students; those who don't have data to analyze can use publicly accessible data sets. The topics covered will vary depending on the students' research projects, but some fundamentals (parameter estimation, model comparison, model checking) will be consistently reviewed. **Seminar-style course, may be taken up to 2x for credit.*

TBD Probabilistic Methods for Neural Data Analysis (Drugowitsch, planned Spring 2020)

This course will provide students with an overview of past and recent probabilistic methods for modeling cell-level, single neuron and population activity, covering linear and generalized linear models, dimensionality reduction, and state space models. It is designed to promote a modular building-block perspective of these methods, such that students can adapt and extend existing methods to their own needs.

Half Courses (full semester)

BMI 707 Deep Learning for Biomedical Data

BST 263 Applied Machine Learning

****MCB 131** Computational Neuroscience (**Sompolinsky**)

****PSY 1401/NEURO 1401** Computational Cognitive Neuroscience: Building Models of the Brain (**Gershman**)

APMTH 108 Nonlinear Dynamical Systems

APMTH 115 Mathematical Modeling

APMTH 120 Applied Linear Algebra and Big Data

APMTH 121 Introduction to Optimization: Models and Methods

APMTH 203 Introduction to Disordered Systems and Stochastic Processes

APMTH 207 Advanced Scientific Computing: Stochastic Methods for Data Analysis, Inference, & Optimization

APMTH 216 Inverse Problems in Science and Engineering

APMTH 221 Advanced Optimization

APMTH 226 Neural Computation

APMTH 231 Decision Theory

COMPSCI 181 Machine Learning

COMPSCI 182 Artificial Intelligence

COMPSCI 228 Computational Learning Theory

COMPSCI 281 Advanced Machine Learning

COMPSCI 282R (Fall) Topics in Machine Learning: Deep Bayesian Models

COMPSCI 282R (Spring) Machine Learning: Advances in Uncertainty Quant. Prediction, Lg-Scale Methods

MATH 118R Dynamical Systems

NEURO 230 Visual Recognition: Computational and Biophysical Perspective

PSY 1406 Biological and Artificial Visual Systems: How Humans and Machines Represent the Visual World

STAT 171 Introduction to Stochastic Processes

STAT 220 Bayesian Data Analysis

STAT 221 Statistical Computing and Learning

STAT 234 Sequential Decision Making

STAT 244 Linear and Generalized Linear Models (**STAT 149** is possible alternative)

MIT Courses

9.110J Nonlinear Control System Design

9.520 Statistical Learning Theory and Applications

9.523 Aspects of a Computation Theory of Intelligence

9.660J Computational Cognitive Science