Center for Computational Molecular Biology

The prime intellectual mission of Brown University's Center for Computational Molecular Biology (CCMB) (https://www.brown.edu/academics/computational-molecular-biology/) is to promote the development, implementation and application of analytical and computational methods to foundational questions in the biological and medical sciences. The research programs of the Core Faculty in CCMB lie fundamentally at the intersection of computer science, evolutionary biology, mathematics, and molecular and cellular biology.

Biological questions that currently unite the CCMB Core and Associate Faculty are: How do genotypes and genes interact to produce phenotypes, and how does this happen from womb to tomb? What drives the formation, maintenance and evolutionary transformations of communities of organisms over time? Quantitative questions that currently unite the CCMB faculty are: how can we design powerful algorithms to make sense of the sea of data produced in the genomic era? What principles are required for a theoretical framework to completely model cellular systems?

The research challenges at the heart of CCMB are a rich source of mathematical problems motivated by the complex nature of genomes, disease processes and evolutionary relationships. These challenges are both multi-scale (with units of interest ranging from molecules to communities of organisms) and large-scale (data-intensive, due to advances in sequencing technologies). Thus, CCMB rounds out the broader landscape of research in methodological development at Brown University by partnering with and complementing the Data Science Initiative (https://www.brown.edu/initiatives/data-science/) and the Brown Center for Biomedical Informatics. (https://www.brown.edu/academics/medical/about-us/research/centers-institutes-and-programs/biomedical-informatics/)

In addition to these research interests, CCMB Faculty members are actively involved in the operation of Brown's NIH-funded COBRE Center for the Computational Biology of Human Disease (https://www.brown.edu/research/projects/computational-biology-of-human-disease/), and administer both an undergraduate concentration (https://www.brown.edu/academics/computational-molecular-biology/courses-study/)and an interdisciplinary doctoral program (https://www.brown.edu/academics/computational-molecular-biology/courses-study/) in Computational Biology. This is a short video about our Ph.D. program in Computational Biology (https://www.youtube.com/watch/?v=p3zBdW-ENtU).

Computational Biology Concentration Requirements

Computational biology involves the analysis and discovery of biological phenomena using computational tools, and the algorithmic design and analysis of such tools. The field is widely defined and includes foundations in computer science, applied mathematics, statistics, biochemistry, molecular biology, genetics, ecology, evolution, anatomy, neuroscience, and visualization.

Students may pursue a Bachelor of Arts or a Bachelor of Science. Students pursuing the ScB have the option of electing a concentration in Computational Biology with one of three focus areas: Computer Sciences, Biological Sciences, or Applied Mathematics & Statistics. Both programs require a senior capstone experience that pairs students and faculty in creative research collaborations.

Standard program for the A.B. degree

Please see the bottom of the page for more information regarding the University Writing Requirement, the Capstone Experience, and the Computational Biology Honors Program.

Prerequisites:		2
MATH 0100	Single Variable Calculus, Part II	
or MATH 0170	Single Variable Calculus, Part II (Accelerated)	
BIOL 0200	The Foundation of Living Systems	
General Core Requirements: Biology		**2**
BIOL 0470	Genetics	
BIOL 0280	Biochemistry	
or BIOL 0500	Cell and Molecular Biology	
General Core Requirements: Chemistry		**1**
CHEM 0330	Equilibrium, Rate, and Structure	
or CHEM 0350	Organic Chemistry I	
General Core Requirements: Computer Science		**2-3**
Choose one of the following groupings of introductory courses:		
Group A		
CSCI 0111 & CSCI 0112 & CSCI 0200	Computing Foundations: Data and Computing Foundations: Program Organization and Program Design with Data Structures and Algorithms [1]	
Group B		
CSCI 0150 & CSCI 0200	Introduction to Object-Oriented Programming and Computer Science and Program Design with Data Structures and Algorithms	
Group C		
CSCI 0170 & CSCI 0200	Computer Science: An Integrated Introduction and Program Design with Data Structures and Algorithms	
Group D		
CSCI 0190	Accelerated Introduction to Computer Science (and any full-credit computer science course above CSCI 0190)	
General Core Requirements: Probability & Statistics		**1**
APMA 1650	Statistical Inference I	
OR		
CSCI 1450	Advanced Introduction to Probability for Computing and Data Science	
OR		
MATH 1210	Probability	
Comp Bio Core Course Requirements		**4**
CSCI 1810	Computational Molecular Biology	
APMA 1080	Inference in Genomics and Molecular Biology	
AND two of the following:		
APMA 1660	Statistical Inference II	
APMA 1690	Computational Probability and Statistics	
BIOL 1430	Foundations of Population Genetics	
BIOL 1435	Computational Methods for Studying Demographic History with Molecular Data	
BIOL 1465	Human Population Genomics	
BIOL 1555	Methods in Informatics and Data Science for Health	
CSCI 1420	Machine Learning	
CSCI 1470	Deep Learning	
CSCI 1820	Algorithmic Foundations of Computational Biology	
Additional course with Director approval		
Capstone Experience		

Students enrolled in the computational biology concentration will complete a research project in their senior year under faculty supervision (i.e: BIOL 1950/1960, CSCI 1970, APMA 1970). The themes of such projects evolve with the field and the technology, but should represent a synthesis of the various specialties of the program. The requirements are either one semester of reading and research with a CCMB Faculty member or approved advisor, or a 2000-level Computational Biology course.

Total Credits	12-13

Standard program for the Sc.B. degree

Please see the bottom of the page for more information regarding the University Writing Requirement, the Capstone Experience, and the Computational Biology Honors Program.

Prerequisites		2
MATH 0100	Single Variable Calculus, Part II (or equivalent)	
or MATH 0170	Single Variable Calculus, Part II (Accelerated)	
BIOL 0200	The Foundation of Living Systems (or equivalent)	

General Core Course Requirements: Biology		2
BIOL 0470	Genetics (prerequisite BIOL 0200 or equivalent)	
BIOL 0280	Biochemistry	
or BIOL 0500	Cell and Molecular Biology	

General Core Requirements: Chemisty		1
CHEM 0330	Equilibrium, Rate, and Structure	
or CHEM 0350	Organic Chemistry I	

General Core Requirements: Computer Science		3-4
CSCI 0220	Introduction to Discrete Structures and Probability	

AND complete one of the following groupings of introductory courses:

Group A		
CSCI 0111 & CSCI 0112 & CSCI 0200	Computing Foundations: Data and Computing Foundations: Program Organization and Program Design with Data Structures and Algorithms [1]	
Group B		
CSCI 0150 & CSCI 0200	Introduction to Object-Oriented Programming and Computer Science and Program Design with Data Structures and Algorithms	
Group C		
CSCI 0170 & CSCI 0200	Computer Science: An Integrated Introduction and Program Design with Data Structures and Algorithms	
Group D		
CSCI 0190	Accelerated Introduction to Computer Science (and any full-credit computer science course above CSCI 0190.)	

General Core Requirements: Probability & Statistics		1
APMA 1650	Statistical Inference I	
or CSCI 1450	Advanced Introduction to Probability for Computing and Data Science	
or MATH 1210	Probability	

General Core Requirements: Computational Biology		
CSCI 1810	Computational Molecular Biology	1
APMA 1080	Inference in Genomics and Molecular Biology	1

Capstone Experience		1

Students enrolled in the computational biology concentration will complete a research project in their senior year under faculty supervision (i.e: BIOL 1950/1960, CSCI 1970, APMA 1970). The themes of such projects evolve with the field and the technology, but should represent a synthesis of the various specialties of the program. The requirements are either one semester of reading and research with a CCMB Faculty member or approved advisor, or a 2000-level Computational Biology course.

Six Courses in one of the following 3 tracks		6
Computer Science Track:		
Three of the following:		
CSCI 1230	Introduction to Computer Graphics	
CSCI 1270	Database Management Systems	
CSCI 1410	Artificial Intelligence	
CSCI 1420	Machine Learning	
CSCI 1470	Deep Learning	
CSCI 1550	Probabilistic Methods in Computer Science	
CSCI 1570	Design and Analysis of Algorithms	
or other Computer Science courses approved by the concentration advisor.		
AND three of the following:		
APMA 1660	Statistical Inference II	
APMA 1690	Computational Probability and Statistics	
BIOL 1430	Foundations of Population Genetics	
BIOL 1435	Computational Methods for Studying Demographic History with Molecular Data	
BIOL 1465	Human Population Genomics	
CSCI 0320 & CSCI 0330	Introduction to Software Engineering and Introduction to Computer Systems	
CSCI 1820	Algorithmic Foundations of Computational Biology	
PHP 2620	Statistical Methods in Bioinformatics, I	
Biological Sciences track		
At least four courses comprising a coherent theme in one of the following areas: Biochemistry, Ecology, Evolution, or Neurobiology.		
AND two courses from the following:		
APMA 1660	Statistical Inference II	
APMA 1690	Computational Probability and Statistics	
BIOL 1430	Foundations of Population Genetics	
BIOL 1435	Computational Methods for Studying Demographic History with Molecular Data	
BIOL 1465	Human Population Genomics	
CSCI 1420	Machine Learning	
CSCI 1470	Deep Learning	
CSCI 1820	Algorithmic Foundations of Computational Biology	
PHP 2620	Statistical Methods in Bioinformatics, I	
Applied Mathematics & Statistics Track:		
At least three courses from the following:		
APMA 1660	Statistical Inference II	
APMA 1690	Computational Probability and Statistics	
CSCI 1410	Artificial Intelligence	
APMA 0330 & APMA 0340	Methods of Applied Mathematics I and Methods of Applied Mathematics II	
APMA 0350 & APMA 0360	Applied Ordinary Differential Equations and Applied Partial Differential Equations I	
At least three of the following:		
APMA 1070	Quantitative Models of Biological Systems	
BIOL 1430	Foundations of Population Genetics	

BIOL 1435	Computational Methods for Studying Demographic History with Molecular Data	
BIOL 1465	Human Population Genomics	
CSCI 1420	Machine Learning	
CSCI 1470	Deep Learning	
CSCI 1820	Algorithmic Foundations of Computational Biology	
PHP 2620	Statistical Methods in Bioinformatics, I	
Total Credits		**18-19**

University Writing Requirement:

As part of Brown's writing requirement, all students must demonstrate that they have worked on their writing both in their general studies and their concentration. There are a number of ways for Computational Biology concentrators to fulfill these requirements:

- Enrolling in an independent study: CSCI 1970, BIOL 1950, APMA 1970
- Writing an Honors Thesis
- Taking a "WRIT" course in the final two years

Capstone Experience:

Students enrolled in the computational biology concentration will complete a research project in their senior year under faculty supervision. The themes of such projects evolve with the field and the technology, but should represent a synthesis of the various specialties of the program. The requirements are either one semester of reading and research with a CCMB Faculty member or approved advisor, or a 2000-level Computational Biology course.

Honors:

 In order to be considered a candidate for honors, students will be expected to maintain an outstanding record, with no "C's" in concentration courses and with a minimum of an "A-" average in concentration courses. In addition, students should take at least one semester, and are strongly encouraged to take 2 semesters, of reading and research with a CCMB faculty member or approved advisor. Students must submit to a public defense of their theses to be open to the CCMB community.

- Students seeking honors are advised to choose a Thesis Advisor prior to the end of their Junior year
- Students must complete the Registration form for Comp Bio and submit it to CCMB@BROWN.EDU

Any deviation from these rules must be approved by the director of undergraduate studies, in consultation with the student's advisor.

Computational Biology Graduate Program

The Center for Computational Molecular Biology (CCMB) offers Ph.D. degrees in Computational Biology to train the next generation of scientists to perform cutting edge research in the multidisciplinary field of Computational Biology. During the course of their Ph.D. studies students will develop and apply novel computational, mathematical , and statistical techniques to problems in the life sciences. Students in this program must achieve mastery in three areas - computational science, molecular biology, and probability and statistical inference - through a common core of studies that spans and integrates these areas.

The Ph.D. program in Computational Biology draws on course offerings from the disciplines of the Center's Core faculty members. These areas are Applied Mathematics (APMA), Computer Science (CS), the Division of Biology and Medicine (BioMed), Brown Center for Biomedical Informatics (BCBI), and the School of Public Health/Biostats (SPH). Our faculty and Director of Graduate Studies (DGS) work with each student to develop the best plan of coursework and research rotations to meet the student's goals in their research focus and satisfy the University's requirements for graduation.

Applicants should state a preference for at least one of these areas in their personal statement or elsewhere in their application. In addition, students interested in the intersection of Applied Mathematics and Computational Biology are encouraged to apply directly to the Applied Mathematics Ph.D. program (http://www.brown.edu/academics/applied-mathematics/graduate/), and also to contact relevant CCMB faculty members (https://www.brown.edu/academics/computational-molecular-biology/about/people/faculty-and-staff/).

Our PhD program assumes the following prerequisites: mathematics through intermediate calculus, linear algebra and discrete mathematics, demonstrated programming skill, and at least one undergraduate course in chemistry and in molecular biology. Exceptional strengths in one area may compensate for limited background in other areas, but some proficiency across the disciplines must be evident for admission.

- Ph.D. Program Overview & Handbook (https://www.brown.edu/academics/computational-molecular-biology/sites/brown.edu.academics.computational-molecular-biology/files/uploads/Comp%20Bio%20Ph.D.%20Program%20requirements%20%26%20handbook_1.pdf) (pdf file)
- FAQ (http://brown.edu/academics/computational-molecular-biology/frequently-asked-questions/)

The application process to the CCMB graduate program is run through the Graduate School (http://www.brown.edu/academics/gradschool/)