

# Computational Biology

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.

|  |   |
|--|---|
| <b>Prerequisites:</b>  | <b>2</b>  |
| MATH 0100  | Single Variable Calculus, Part II   |
| or MATH 0170   | Single Variable Calculus, Part II (Accelerated)   |
| BIOL 0200  | The Foundation of Living Systems  |
| <b>General Core Requirements: Biology</b>                      | <b>2</b>  |
| BIOL 0470  | Genetics  |
| BIOL 0280  | Biochemistry  |
| or BIOL 0500   | Cell and Molecular Biology  |
| <b>General Core Requirements: Chemistry</b>                    | <b>1</b>  |
| CHEM 0330  | Equilibrium, Rate, and Structure  |
| or CHEM 0350   | Organic Chemistry I   |
| <b>General Core Requirements: Computer Science</b>             | <b>2-3</b>  |
| 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 <sup>1</sup> |
| 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)                                      |
| <b>General Core Requirements: Probability &amp; Statistics</b> | <b>1</b>  |
| APMA 1650  | Statistical Inference I   |
| OR   |   |
| CSCI 1450  | Advanced Introduction to Probability for Computing and Data Science   |
| OR   |   |
| MATH 1210  | Probability   |
| <b>Comp Bio Core Course Requirements</b>                       | <b>4</b>  |
| 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   |  |
| <b>Capstone Experience</b>   |  |
| 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. |  |
| <b>Total Credits</b>   | <b>12-13</b>   |

## 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.

|  |   |
|--|---|
| <b>Prerequisites</b>   | <b>2</b>  |
| 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)  |
| <b>General Core Course Requirements: Biology</b>                     | <b>2</b>  |
| BIOL 0470  | Genetics (prerequisite BIOL 0200 or equivalent)   |
| BIOL 0280  | Biochemistry  |
| or BIOL 0500   | Cell and Molecular Biology  |
| <b>General Core Requirements: Chemistry</b>                          | <b>1</b>  |
| CHEM 0330  | Equilibrium, Rate, and Structure  |
| or CHEM 0350   | Organic Chemistry I   |
| <b>General Core Requirements: Computer Science</b>                   | <b>3-4</b>  |
| 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 <sup>1</sup> |
| 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         |          |
| <b>Group D</b>   |   |          |
| CSCI 0190  | Accelerated Introduction to Computer Science (and any full-credit computer science course above CSCI 0190.) |          |
| <b>General Core Requirements: Probability &amp; Statistics</b>   |   | <b>1</b> |
| APMA 1650  | Statistical Inference I   |          |
| or CSCI 1450   | Advanced Introduction to Probability for Computing and Data Science   |          |
| or MATH 1210   | Probability   |          |
| <b>General Core Requirements: Computational Biology</b>  |   |          |
| CSCI 1810  | Computational Molecular Biology   | 1        |
| APMA 1080  | Inference in Genomics and Molecular Biology   | 1        |
| <b>Capstone Experience</b>   |   | <b>1</b> |
| 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. |   |          |
| <b>Six Courses in one of the following 3 tracks</b>  |   | <b>6</b> |
| <b>Computer Science Track:</b>   |   |          |
| 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  |          |
| <b>Biological Sciences track</b>   |   |          |
| 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   |              |
| <b>Applied Mathematics &amp; Statistics Track:</b> |  |              |
| 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   |              |
| <b>Total Credits</b>                               |  | <b>18-19</b> |

### 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.