**Computational Biology - Minor**

Computational biology is an interdisciplinary field that develops and applies computational methods to understand biological systems and address societal challenges.

The computational biology minor is a cross-college minor that welcomes students from a diversity of majors. Students come together from disciplines in biology, math, computer science and engineering in interdisciplinary learning settings. The minor curriculum is intentionally designed to provide students overlap with their respective computational and biological expertise while challenging students to integrate core concepts and skills.

The minor teaches students to combine computational thinking and algorithms to tackle complex biological systems and topics like epidemiology, biotechnology, precision medicine & human health, genetics & genomics, environmental systems and scientific research. Students learn:

- Computational biology core concepts and experimental techniques.
- Representing and understanding biological data and patterns.
- Biologically relevant skills in applied math, data science and statistics, and computing.
- Modeling and predicting biological processes and dynamics.
- Biological phenomena under uncertainty with probalistic and statistical analyses.

Visit the Computational Biology Minor webpage (https://www.colorado.edu/biofrontiers/cbiominor/) for the most recent information.

**Requirements**

A prerequisite is Calculus I or equivalent with a C- or better such as provided by MATH 1300/MATH 1310/APPM 1345/APPM 1350. Students must have a minimum cumulative GPA of 2.500 to declare this minor. Students interested in declaring should visit the Computational Biology Minor webpage (https://www.colorado.edu/biofrontiers/cbiominor/) and submit an interest form. A cumulative GPA of 2.000 or better is required in the courses that are used to satisfy the minor. Each individual course that is used to satisfy the minor must be passed with a C- or better.

**Required Courses and Credits**

The minor is divided into three course areas: Skills, BioElectives, and Computing. The common pathways through the minor are: a computing or math background, which fulfills most Skills coursework, or a biology background, which fulfills BioElective coursework. Data & Structure + Bioprocesses course offerings emphasize the integration of Skills and BioElective core concepts. Completion of 8 courses from the three course areas is required for the minor; courses may not double count to satisfy multiple minor requirements. Relevant coursework can be petitioned. Course lists are maintained on the Computational Biology Minor webpage (https://www.colorado.edu/biofrontiers/cbiominor/).

### Skills

**Mathematical Biology**

Choose one:

- CSCI 2897 Calculating Biological Quantities
- APPM 2360 Introduction to Differential Equations with Linear Algebra
- MATH 3430 Ordinary Differential Equations

**Data Science & Statistics**

Choose one:

- MCDB 3450 Biological Data Science (recommended)
- CSCI 3022 Introduction to Data Science with Probability and Statistics (recommended)
- CHEN 3010 Applied Data Analysis
- EBIO 4410 Biological Statistics
- IPHY 3280 Intro to Data Science and Biostatistics
- MATH 3510 Introduction to Probability and Statistics
- PSYC 2111 Psychological Science I: Statistics
- STAT 2600 Introduction to Data Science
- STAT 4000 Statistical Methods and Application I

### Computing

Choose one, two-course sequence:

- APPM 1650 & APPM 3650 Python for Math and Data Science Applications and Algorithms and Data Structures in Python
- CSCI 1300 & CSCI 2270 Computer Science 1: Starting Computing and Computer Science 2: Data Structures
- ASEN 1320 & CSCI 2270 Aerospace Computing and Engineering Applications and Computer Science 2: Data Structures
- CSCI 1200 & INFO 2201 Introduction to Computational Thinking and Programming for Information Science 2
- INFO 1701 & INFO 2201 Programming for Information Science 1 and Programming for Information Science 2

### BioElectives

Choose one (from any biological area): ¹

**Biochemistry**

- BCHM 4611 Principles of Biochemistry
- BCHM 4720 Metabolic Pathways and Human Disease
- BCHM 4740 Biochemistry of Gene Transmission, Expression and Regulation

**Biomedical Engineering**

- BMEN 4117 Anatomy and Physiology for Biomedical Engineering

**Ecology & Evolutionary Biology**

- Petition any upper-division EBIO course focused in biological knowledge and theory, e.g.:
  - EBIO 3040 Conservation Biology
  - EBIO 3080 Evolutionary Biology
  - EBIO 3400 Microbiology

¹ Students must have a minimum cumulative GPA of 2.500 to declare this minor.
Environmental Studies
- ENVS 3040 Conservation Biology
- ENVS 4185 Geomicrobiology

Integrative Physiology
- IPHY 3410 Human Anatomy
- IPHY 3430 Human Physiology

Molecular & Cellular Biology
- MCDB 3135 Molecular Biology
- MCDB 3145 Cell Biology
- MCDB 3150 Biology of the Cancer Cell
- MCDB 3160 Infectious Disease
- MCDB 3501 Structural Methods for Biological Macromolecules
- MCDB 3650 The Brain - From Molecules to Behavior

Data & Structure + Bioprocesses
- Data & Structure
  - CSCI 3352 Biological Networks
  - MCDB 4520 Bioinformatics and Genomics
- Bioprocesses
  - CSCI 4118 Software Engineering for Scientists
  - CSCI 4314 Dynamic Models in Biology
  - CSCI 4444 Algorithms and Data Structures for Analyzing DNA
  - CSCI 4897 Computational and Mathematical Modeling of Infectious Diseases
  - APPM 4370 Computational Neuroscience
  - APPM 4390 Modeling in Mathematical Biology
  - BCHM 4631 Computational Genomics Lab
  - EBIO 4290 Phylogenetics and Comparative Biology
  - EBIO 4420 Computational Biology
  - EBIO 4700 Quantitative Genetics
  - MCDB 4312 Quantitative Optical Imaging
  - PHYS 4560 Introduction to Biophysics

Total Credit Hours 24-30

1 BioElectives have prerequisite lectures or labs prior to enrollment, and we list the approximate number of them for students on the Computational Biology Minor webpage (https://www.colorado.edu/biofrontiers/cbiominor/). If a biological area of interest is not (fully) represented above, please contact CBIOminor@colorado.edu to petition BioElectives.

Learning Outcomes
- Effectively identify and communicate Computational Biology topics and applications to specialists and non-specialists.
- Reframe and evaluate biological research questions in the context of computational theory and techniques.
- Contextualize data and modeling problems based on biological principles and the scientific discovery process.
- Collect and access biological data sources to study Computational Biology challenges.