BIOLOGICAL SCIENCES (BA)

College of Arts and Sciences

Program Website (https://as.cornell.edu/major_minor_gradfield/biological-sciences/)

CIP: 26.0101 | **HEGIS:** 0401.00 | **NYSED:** 05451

Program Description

The biological sciences major is available to students enrolled in either the College of Agriculture and Life Sciences or the College of Arts and Sciences. Students pursuing the Bachelor of Science (BS) must meet College of Agriculture and Life Sciences Graduation Requirements. Students pursuing the Bachelor of Arts (BA) must meet College of Arts & Sciences Graduation Requirements.

Students majoring in biology and society may not double major in biological sciences. Students majoring in nutritional sciences may double major in biological sciences but can not choose human nutrition as their concentration. The program's curriculum, academic advising, and undergraduate research components are coordinated for students in both colleges by the Office of Undergraduate Biology located in 216 Stimson Hall (607-255-5233, bioadvising@cornell.edu) (biology.cornell.edu) (https://biology.cornell.edu)/).

Students majoring in biological sciences take a set of courses in six core areas of biology. Students complete the Introductory Biology Cluster consisting of the Investigative Biology Laboratory and two courses from three foundational areas of biology: Introductory Biology: Comparative Physiology; Introductory Biology: Cell and Developmental Biology; and Introductory Biology: Ecology and the Environment. Completion of the Introductory Biology Cluster satisfies the Introductory Biology requirement for application to medical, dental and veterinary school. Students take required courses in three additional core areas of biology: Introduction to Evolution and Diversity, Genetics and Genomics, and Biochemistry and Molecular Biology. Introduction to Evolution and Diversity is taken in the first or second year. Both Genetics and Genomics, and Biochemistry and Molecular Biology are typically taken in the second or third years. Students should complete all coursework for the six core areas prior to their fourth year.

Whenever possible, students should complete the Introductory Biology Cluster, Introduction to Evolution and Diversity, general and organic chemistry, and mathematics sequences by the end of their second year. Additionally, majors are required to complete one of 13 concentrations within the biological sciences major.

Students are expected to work closely with their faculty advisor and professional academic advisors in the Office of Undergraduate Biology to design a suitable academic course plan. By completion of the sophomore year, all students who intend to major in biological sciences must declare the major and a concentration. Students may change their concentration at any time by notifying the OUB.

Students are responsible for meeting degree requirements and should regularly monitor their progress in the major to assess the likelihood of achieving at a level that is necessary for their academic and personal goals. While a grade of D- or higher counts toward the major, students who receive a C- or lower in core courses are encouraged to meet with an advisor in the Office of Undergraduate Biology. This will provide an opportunity to discuss their options and determine if the major aligns with their goals and interests.

Program Information

- Instruction Mode: In Person
- Location: Ithaca, NY
- Minimum Credits for Degree: 120

Program Requirements

The requirements for the biological sciences major are listed below. Students are responsible for understanding the degree requirements for the major and for planning their courses of study accordingly. Requirements 1–10 must be taken for a letter grade (grades of D- or better count toward major requirements). Once matriculated, students are required to complete all coursework in the six core areas of biology (numbers 1-3, 8–10 below) at Cornell or during an approved Study Abroad semester. Students must take all courses for the concentration for letter grade unless the course is offered S/U only. Exceptions need to be approved by the student's faculty advisor via the biological sciences petition.

- All requirements need to be taken for letter grade unless the course is offered S/U only. Exceptions may be approved via the biological sciences petition.
- A grade of D- or better must be obtained to count course for major.
- 42-50 credits of foundation requirements.
- 12-17 credits of concentration requirements.

Foundation Requirements

Introductory Biology Cluster: (6 Credits)

Code	Title	Hours
Take two courses in the three following subject areas:		
Cell Biology		
BIOMG 1350	Introductory Biology: Cell and Developmental Biology	
Physiology		
BIOG 1440	Introductory Biology: Comparative Physiology	
or BIOG 1445	Introduction to Comparative Anatomy and Physiology, Individualized Instruction	
Ecology		
BIOSM 1610	Ecology and the Marine Environment	
or BIOSM 1610	Ecology and the Marine Environment	

Investigative Laboratory: (2-3 Credits)

Code	Title	Hours
Select one of the following:		
BIOG 1500	Investigative Biology Laboratory	
or BIOSM 15	Investigative Marine Biology Laboratory	

Evolutionary Biology and Diversity: (4-5 Credits)

Code	Title	Hours
Select one of the following:		
BIOEE 1780	An Introduction to Evolutionary Biology and Diversity	

BIOEE 1781	Introduction to Evolution and Diversity
BIOSM 1780	Evolution and Marine Diversity

General Chemistry: (4-8 Credits)

Code	Title	Hours
Select one of the following options:		
Option 1		
CHEM 2070 & CHEM 2071	General Chemistry I and General Chemistry I Laboratory	
CHEM 2080 & CHEM 2081	General Chemistry II and General Chemistry II Laboratory	
Option 2		
CHEM 2150	Honors General and Inorganic Chemistry	

Note

CHEM 2150 Honors General and Inorganic Chemistry is intended for students who have earned a score of 5 on the CEEB AP Chemistry exam, or have equivalent preparation (to be determined by the Chemistry Department). Students who have earned a score of 5 on the CEEB AP Chemistry exam will receive credit for CHEM 2070 or CHEM 2090 Engineering General Chemistry. Students taking CHEM 2070 General Chemistry I or CHEM 2090 Engineering General Chemistry will forfeit AP credit. Students taking CHEM 2150 Honors General and Inorganic Chemistry will retain AP credit. Students may also receive credit for CHEM 2070 General Chemistry I by passing the Cornell Advanced Study Exam (CASE) given during orientation in August and January. See chemistry.cornell.edu (https://chemistry.cornell.edu/) for further information. Cornell advises medical schools that Chemistry AP credit, together with completion of CHEM 2150 Honors General and Inorganic Chemistry, is the equivalent of 8 credits of introductory chemistry, such as CHEM 2070 General Chemistry I - CHEM 2080 General Chemistry II.

Mathematics: (7-8 Credits)

One course in calculus I (4 credits):

Code	Title	Hours
MATH 1106	Modeling with Calculus for the Life Sciences	4
MATH 1110	Calculus I [1,2]	4

1 Students must earn a score of 4 or 5 on the AP Mathematics AB to receive credit for Calc I.
Students must earn a score of 4 or 5 on the AP Mathematics BC exam to receive credit for Calc I and Calc II.

2 or equivalent.

One additional course selected from categories a, b, or c (3-4 credits).

While any course listed for a, b, or c will fulfill the second mathematics requirement, students are strongly encouraged to complete a statistics course to fulfill the second mathematics requirement or in addition to taking a course from either b or c.

Students planning on concentrating in Biochemistry should be aware that a course in Physical Chemistry required for the concentration has a pre-requisite of MATH 1120 Calculus II.

A. One Course in Statistics

These are the only approved courses to meet the statistics requirement for the biological sciences major. STSCI 2150 or BTRY 3010 are preferred because of biological applications utilized in the courses.

Code	Title	Hours
AEM 2100	Introductory Statistics	4
BTRY 3010	Statistics I	4
ECON 3130	Probability and Statistics	4
MATH 1710	Statistical Theory and Application in the Real World	4
PSYCH 2500	Statistics and Research Design	3
SOC 3010	Statistics for Sociological Research	4
STSCI 2150	Introductory Statistics for Biology	4

* Students can apply AP Statistics with a score of 5 toward the major. (Will show as STSCI 2100 with an S grade on transcript) Students are not permitted to use Cornell's STSCI 2100 course to count toward the major.

B. A second semester of calculus

Code	Title	Hours
MATH 1120	Calculus II [1]	4
MATH 1910	Calculus for Engineers [2]	4

1 Students must earn a score of 4 or 5 on the AP Mathematics BC exam to receive credit for Calc I and Calc II.

2 or equivalent or higher-level.

C. A course in finite mathematics

Code	Title	Hours
MATH 1105	Finite Mathematics for the Life and Social Sciences	3

Organic Chemistry: (3-6 Credits)

Code	Title	Hours
Select one of the following:		3-6
CHEM 1570	Introduction to Organic and Biological Chemistry	
CHEM 3570 & CHEM 3580	Organic Chemistry for the Life Sciences and Organic Chemistry for the Life Sciences	
CHEM 3570 & CHEM 2510	Organic Chemistry for the Life Sciences and Introduction to Experimental Organic Chemistry	
CHEM 3590 & CHEM 3600	Honors Organic Chemistry I and Honors Organic Chemistry II	

Note

CHEM 1570 is not allowed for students concentrating in Biochemistry or Molecular and Cell Biology. Additionally CHEM 2510 Introduction to Experimental Organic Chemistry is required for students concentrating in Biochemistry. Finally, some medical, dental, and veterinary schools, as well as some masters and PhD programs expect students to take a full year of organic chemistry and/or an organic chemistry laboratory. Please refer to Cornell Career Services (http://career.cornell.edu/) for more information.

Physics: (8 Credits)

Code	Title	Hours
Select one of the following:		8
PHYS 1101 & PHYS 1102	General Physics I and General Physics II	

PHYS 2207 & PHYS 2208	Fundamentals of Physics I and Fundamentals of Physics II
PHYS 1112 & PHYS 1110 & PHYS 2213	Physics I: Mechanics and Heat and Introduction to Experimental Physics and Physics II: Electromagnetism [1]

[1] (or PHYS 1112 Physics I: Mechanics and Heat and PHYS 1110 Introduction to Experimental Physics beginning fall 2021)

Note
Students can mix and match Part I and Part II of Physics sequences and can consult with an OUB advisor if they have questions.

Genetics and Genomics: (5 Credits)

Code	Title	Hours
BIOMG 2800 & BIOMG 2801	Lectures in Genetics and Genomics and Laboratory in Genetics and Genomics	5

Note
If students have not taken BIOMG 1350 or Biochemistry (BIOMG 3300, BIOMG 3310, BIOMG 3320, BIOMG 3350) previously, it is recommended that students take BIOMG 2800 as a prerequisite for BIOMG 2801. It is strongly encouraged that these two course requirements be taken prior to senior year.

Biochemistry and Molecular Biology: (4-5 Credits)

Code	Title	Hours
Select one of the following:		4-5
BIOMG 3300	Principles of Biochemistry, Individualized Instruction	
BIOMG 3310 & BIOMG 3320	Principles of Biochemistry: Proteins and Metabolism and Principles of Biochemistry: Molecular Biology [1]	
BIOMG 3350	Principles of Biochemistry: Proteins, Metabolism, and Molecular Biology [2]	

[1] BIOMG 3310 and BIOMG 3320 can be taken in either order.

[2] BIOMG 3350 is not allowed for students concentrating in Biochemistry or Molecular and Cell Biology.

Concentration: (12-17 Credits)
Students accepted into the biological sciences major must complete a concentration. Students may change their concentration at any time as long as they can meet the requirements by their graduation date. Students must notify OUB if they wish to change their concentration. Whereas the core requirements of the biological sciences curriculum provide the common foundation deemed essential for all majors, the role of the concentration is to provide a focus in a particular area of biology. The concentration requirement can be met by taking 12 to 17 credit hours of courses chosen by the student in accordance with the requirements for the concentration and in consultation with his or her faculty advisor. Concentrations in particular subject areas are designed by faculty members specializing in the subject. Typically, the concentration consists of one or more courses that provide foundation in the subject and a list of courses from that area or related areas, the majority of which are at an advanced level (3000 or higher). Because biology is an experimental science, most concentrations require one or more laboratory courses.

The laboratory requirement in some concentrations can be met by participation in the independent research course (BIOG 4990).

Note:
- Advanced placement biology credits are not accepted for substitution or placement out of any introductory biology cluster course.
- Although not required for the biological sciences major, a course in statistics is recommended for all students. STSCI 2150 and BTRY 3010 are preferred course choices.
- Core courses noted in numbers 1–9 above cannot count toward the concentration requirements.
- External transfer students must see the Director of Advising in the Office of Undergraduate Biology to determine the transferability of courses into the biological sciences major and subsequent courses that must be completed.

Animal Physiology

In addition to the concentration requirements outlined below, all students must complete the Biological Sciences foundation requirements:

- Biological Sciences Foundation Requirements (p. 1)

The Animal Physiology concentration provides an excellent foundation in basic physiological mechanisms in the first year of study, and offers a wide selection of specialty interests in the second year of study. Two lecture courses, Cellular Physiology and Principles of Animal Physiology, form the foundation. Seven additional credit hours selected from a wide choice of physiology courses (of which 4 credit hours must be a laboratory) fulfill the requirements of the concentration. Most of our graduates go on to medical, dental or veterinary schools. Many decide to spend a life in research and go on to pursue Masters and/or Ph.D. degrees.

Animal physiology is housed in the Department of Biomedical Sciences in the Cornell College of Veterinary Medicine because of the obvious connections between physiology, anatomy, pharmacology, pathology, medicine, surgery and the creation of new knowledge through biomedical research. The facilities for student laboratories are excellent.

In addition to formal course work, there are many opportunities for undergraduates to become active researchers through campus-wide programs, among them the Honors Program in Biological Sciences and Independent Studies in Physiology. It is not uncommon for undergraduates to spend one summer or more in Ithaca participating in research full-time. And it is not unusual for undergraduate physiology students to present their research at scientific meetings and to share (or lead) authorship in the professional literature.

The research interests and activity of more than 30 members of the faculty can be broadly grouped into Behavioral Physiology, Cell and Molecular Physiology, Cancer Biology, Stem Cell Biology, Developmental Biology, Genomics, Organ and System Physiology, Neurobiology, Pathology, and Zoology. Students may do research in virtually every field of biomedical investigation, from isolating and cloning new membrane transport proteins to searching for new hormones, to tracing the molecular cables of communication within and between cells, to determining blood flow to specific tissues during situations of rest and exercise, to tracking the development of neural connections, to discovering how the immune system recognizes foreign but not native proteins, and to unraveling the complexities of reproduction and the development of the fetus. Research is done at the whole animal, organ, tissue, cellular and subcellular level.

Career plans take our graduates to medical, veterinary, and other professional schools. Some graduates of the Animal Physiology concentration pursue advanced degrees in fields such as anatomy, animal science, biophysics, molecular and cell biology, neurobiology, physiology, pharmacology, and zoology. There is an increasing demand for graduates with an Animal Physiology concentration, and our graduates have found employment in museums, pharmaceutical companies, public-relations firms, publishing houses, agricultural technology companies, and in research laboratories at private, university, state, and federal institutions. The 21st century has been designated the Century of Biology in anticipation of heretofore unimaginable vistas promised by the merging of biology and technology.

Animal Physiology Requirements

- All requirements must be taken for letter grade unless the course is offered S/U only. Exceptions to the grading option and any course substitutions must be approved via the biological sciences petition (https://qafederation.ngwebsolutions.com/sp/startSSO.ping?PartnerIdpId=https://shibidp.cit.cornell.edu/idp/shibboleth&TargetResource=https%3A%2F%2Fdynamicforms.ngwebsolutions.com%2FSubmit%2FStart%2F889d159c-0bfd-489f-b1dc-ebbbabcdac94). Students are encouraged to discuss exceptions and course substitutions with their faculty advisor prior to submitting petition.
- A grade of D- or better must be obtained to count course for major.
- A minimum of 13 credits of concentration requirements.

Required Courses

Code	Title	Hours
Required Courses		
BIOAP 3110	Principles of Animal Physiology	3
BIOAP 3160	Cellular Physiology	3
Lecture & Lab [1]		**7**
Lecture [2]		
ANSC 2400	Biology of Reproduction	
ANSC 3410	Biology of the Mammary Gland in Health and Disease ((crosslisted))	
ANSC 4270	Fundamentals of Endocrinology ((crosslisted))	
BIOAP 2140	Sex Ed: Understanding Human Reproduction	
BIOAP 4140	Principles of Pharmacology ((crosslisted))	
BIOMG 3850	Developmental Biology	
BIOMG 4000	Genomics: Technology, Data, and Applications	
BIOMG 4390	Molecular Basis of Disease	
BIOMS 4150	Essential Immunology	
BIONB 3220	Hormones and Behavior ((crosslisted))	
BIONB 3920	Drugs and the Brain	
NS 3310	Human Nutrition and Nutrient Metabolism	
Laboratory (minimum 4 credits) [2]		
BIOAP 4130	Histology: The Biology of the Tissues ((crosslisted))	
BIOAP 3190	Laboratory in Physiology ((crosslisted))	
BIOMG 4400	Laboratory in Biochemistry and Molecular Biology	
BIONB 4300	Experimental Molecular Neurobiology	

[1] A minimum of 7 credit hours selected from the following lecture and laboratory courses, of which at least 4 credit hours must be a laboratory course.

[2] New courses are occasionally added to the Cornell catalog that may be used to satisfy Concentration requirements. Students are encouraged to discuss these possibilities with their academic advisors of the staff of the OUB.

Biochemistry

In addition to the concentration requirements outlined below, all students must complete the Biological Sciences foundation requirements:

- Biological Sciences Foundation Requirements (p. 1)

The diversity of biochemistry is illustrated by the breadth of the research interests of the faculty associated with the Biochemistry concentration. These interests range from biophysics and biophysical chemistry through molecular and cellular biology. A biochemist must have an excellent grounding in the physical sciences as well as in biology. Students in this concentration are encouraged to enroll in the more rigorous course sequences in chemistry and physics and to take at least three semesters of mathematics. Courses at the advanced level are open to upper-class students as well as graduate students, and a one-credit seminar course in an area of biochemistry is offered each semester.

Biochemistry is an experimental science and students are encouraged to carry out independent research projects under faculty supervision. By performing research, a student gains a deeper understanding of an area as well as an appreciation of the experimental scientific process. Faculty members pursue a large variety of projects in their laboratories, using many different techniques. Faculty research interests include regulation of gene expression, genetic engineering, properties of transformed cells, membrane structure and transport, structure and function of proteins and the cytoskeleton, photosynthesis and oxidative phosphorylation, and chromosome structure. Viruses, microbes, yeast, animal cells in culture, and higher plants are used in the research programs of faculty members in biochemistry.

A number of the graduates from the Biochemistry concentration will continue their training in graduate school or in medical or veterinary colleges. Holders of a bachelor's degree in biochemistry are needed in academic, industrial, and government laboratories. Biochemistry is a rapidly evolving discipline that is attracting increasing interest from many industries, including pharmaceutical houses, chemical concerns, and food processors.

Biochemistry Requirements

- All requirements must be taken for letter grade unless the course is offered S/U only. Exceptions to the grading option and any course substitutions must be approved via the biological sciences petition (https://qafederation.ngwebsolutions.com/sp/startSSO.ping?PartnerIdpId=https://shibidp.cit.cornell.edu/idp/shibboleth&TargetResource=https%3A%2F%2Fdynamicforms.ngwebsolutions.com%2FSubmit%2FStart%2F889d159c-0bfd-489f-b1dc-ebbbabcdac94). Students are encouraged to discuss exceptions and course substitutions with their faculty advisor prior to submitting petition.
- A grade of D- or better must be obtained to count course for concentration.
- A minimum of 16 credits of concentration requirements.

Students electing this concentration should be sure to complete CHEM 2070-CHEM 2080 or CHEM 2150 during their first year. Students concentrating in Biochemistry should not take CHEM 1570.

Also note that our concentrators are required to complete an organic chemistry laboratory course (either CHEM 2510 or CHEM 3010).

Code	Title	Hours
Organic Chemistry (Shared with Foundation Requirements)		**6-7**
Select one of the following sequences:		
CHEM 3570 & CHEM 2080	Organic Chemistry for the Life Sciences and General Chemistry II	
CHEM 3590 & CHEM 3600	Honors Organic Chemistry I and Honors Organic Chemistry II	
Organic Chemistry Lab		**2-5**
CHEM 2510	Introduction to Experimental Organic Chemistry	
CHEM 3010	Honors Experimental Chemistry I	
Biochemistry (Shared with Foundation Requirements)		**5**
BIOMG 3310 & BIOMG 3320	Principles of Biochemistry: Proteins and Metabolism and Principles of Biochemistry: Molecular Biology	
BIOMG 3300 & BIOMG 3340	Principles of Biochemistry, Individualized Instruction and Computer Graphics and Molecular Biology	
PCHEM and Cell Biology		**6-8**
CHEM 3870 & BIOMG 4320	Principles of Physical Chemistry and Survey of Cell Biology	
CHEM 3890 & CHEM 3900	Honors Physical Chemistry I and Honors Physical Chemistry II	
Laboratory Course in Biochemistry and Molecular Biology		**4**
BIOMG 4400	Laboratory in Biochemistry and Molecular Biology	
Additional Course [1]		**3**
BIOMG 4380	RNA in Biology and Medicine	
BIOMG 6310	Proteins: Structure, Function and Evolution	
CHEM 3880	Basics of Biophysical Chemistry	
CHEM 4500	Principles of Chemical Biology	
BIOG 4990	Independent Undergraduate Research in Biology (or the equivalent in other departments) [2]	

1 At least one other course with a biochemical or biophysical orientation.

2 With the approval of the advisor, if the research has continued over at least two semesters and includes a substantial biochemical component.

Note

- It is recommended that when selecting first-year level core biological sciences choice courses that one of them be BIOMG 1350 Introductory Biology: Cell and Developmental Biology.
- Students interested in graduate work in biochemistry should take PHYS 2207–PHYS 2208 and should consider taking CHEM 3890–CHEM 3900 and its prerequisites.
- It is recommended that you consult with your advisor when deciding between the Cell Biology / Physical Chemistry option.

Biodiversity and Systematics

In addition to the concentration requirements outlined below, all students must complete the Biological Sciences foundation requirements:

- Biological Sciences Foundation Requirements (p. 1)

Biodiversity refers to the immense variety of life on Earth, encompassing all living organisms from their genes and species to ecosystems and their functions, and interactions between organisms and the environment in which they flourish. Biodiversity involves the study of the variability within species (genetic diversity) and among species (species diversity) of all living and fossil organisms and their environments (ecosystem diversity). Systematics is the scientific study of the diversity of living organisms and of the relationships among them. As such the field spans a broad range of related areas, including phylogeny, evolution, and taxonomy (classification). Systematics involves studies of all kinds of living organisms, including bacteria, fungi, plants, and animals, as well as long-extinct species known only from fossils. Human uses of plants and animals are also investigated by systematists. Therefore, the connection between biodiversity and systematics entails locating ecosystems in a multivariate space defined by the many different ways in which organisms relate to one another. Examples of Biodiversity and Systematics include, among others, Taxonomic diversity (number and relative abundance of taxa defined by an evolutionary classification), Phylogenetic diversity (relationships among taxa based on divergence time), Genetic diversity (aspects of genomic and genetic variability), and Temporal diversity (rates of turnover of species through space or time). Research in Biodiversity and Systematics is performed in the field worldwide (from tropical rain forests to the poles), as well as in the laboratory, where traditional tools as well as those of molecular biology are used. In a few words: Biodiversity is crucial for Earth equilibrium and therefore human survival as well.

The concentration in Biodiversity and Systematics is designed to introduce students interested in the diversity of the living and extinct world to several facets of this eclectic field. The course requirements are drawn from two complementary areas. The courses identified as Group A deal with taxonomic diversity. These courses provide opportunities to learn about the variation that exists within particular groups of organisms, and about the history of diversification in those groups, as reflected in phylogenies that link their species. Courses in Group B build upon the basic ideas presented in many of the Group A courses, and explore the various theoretical and technical underpinnings of systematics. These courses cover such topics as evolution, the fossil record, molecular approaches to studying variation, and phylogenetic theory. Because hands-on familiarity with organisms is an essential part of systematics, participation in two courses that include a laboratory is expected.

Faculty teaching these courses belong to several different departments in the College of Arts and Sciences and the College of Agriculture and Life Sciences. All are involved in original research, and many include undergraduates as well as graduate students in their research programs. The organisms they study encompass the entire tree of life, and the topics on which their research focuses are comparably broad: taxonomy, paleontology/paleobotany, DNA sequence evolution, development, comparative and functional morphology and anatomy, chemical ecology, population genetics, and bacterial physiology, to list a few. Students are strongly encouraged to undertake independent research projects as a part of their training, and many professors are eager to work with students interested in performing research and honors theses in their labs.

The range of career choices for students who specialize in systematics is also extensive. Many students go on to graduate school, where they specialize in studies of a particular group of organisms utilizing many different approaches, and continue their research (and teaching) from a university base or other kind of research unit. Others are based in the world's botanical gardens, zoological parks, and museums, as on-site

curators or as collectors stationed in often exotic locales. New venues for employment are non-profit organizations focusing on biodiversity and environmental conservation. With the increased public awareness of vanishing biodiversity, still others find employment as scientific communicators.

Biodiversity and Systematics Requirements

- All requirements must be taken for letter grade unless the course is offered S/U only. Exceptions to the grading option and any course substitutions must be approved via the biological sciences petition (https://qafederation.ngwebsolutions.com/sp/startSSO.ping?PartnerIdpId=https://shibidp.cit.cornell.edu/idp/shibboleth&TargetResource=https%3A%2F%2Fdynamicforms.ngwebsolutions.com%2FSubmit%2FStart%2F889d159c-0bfd-489f-b1dc-ebbbabcdac94). Students are encouraged to discuss exceptions and course substitutions with their faculty advisor prior to submitting petition.
- A grade of D- or better must be obtained to count course for concentration.
- A minimum of 13 credits of concentration requirements.

A minimum of 13 credits from the following two groups, including at least 7 credits from Group A and 3 credits from Group B and at least two courses with a laboratory component (marked with *). BIOG 4990 Independent Undergraduate Research in Biology, in a relevant field of study and with approval of the faculty advisor, can be used in fulfillment of up to 4 credits in Group A and can count as one laboratory course if it has a laboratory component of 2 or more credits. Students are required to select courses from the list below to complete the concentration; however, if students find another relevant course that is not listed, they may petition the Director of Undergraduate Studies via the biological sciences petition (https://qafederation.ngwebsolutions.com/sp/startSSO.ping?PartnerIdpId=https://shibidp.cit.cornell.edu/idp/shibboleth&TargetResource=https%3A%2F%2Fdynamicforms.ngwebsolutions.com%2FSubmit%2FStart%2F889d159c-0bfd-489f-b1dc-ebbbabcdac94) to use that course for the concentration. Teaching Assistant positions will not count towards concentration credits.

Group A (minimum 7 credits)

Code	Title	Hours
BIOEE 2740	The Vertebrates: Comparative Anatomy, Function, Paleontology, and Evolution *	4
BIOEE 4700	Herpetology, Lectures	3
BIOEE 4750	Ornithology, Lectures *	3
BIOEE 4752	Ornithology, Worldwide Avian Diversity Laboratory	2
BIOEE 4760	Ichthyology: Biology of Fishes, Lectures *	3
BIOMI 2900	General Microbiology Lectures	3-4
BIOMI 2911	General Microbiology Laboratory *	3
BIOMI 3310	(crosslisted)	2
PLSCI 2300	Global Plant Biodiversity and Vegetation (five-credit option counts as lab course) *	3
PLSCI 2410	Introductory Plant Diversity and Evolution *	4
PLSCI 2470	Plants and Cultures around the World *	3
PLSCI 2480	Vascular Plant Systematics *	4
ENTOM 2120	Insect Biology *	4
ENTOM 2150	Spider Biology: Life on a Silken Thread	2
ENTOM 3150	Spider Biology	3
ENTOM 3310	Insect Diversity and Evolution	3
ENTOM 3311	Insect Diversity Laboratory *	1
PLSCI 4300	Mycology	4
PLSCI 3190	Mushrooms of Field and Forest *	2

* laboratory component

Group B (minimum 3 credits)

Code	Title	Hours
BIOEE 4530	Speciation: Genetics, Ecology, and Behavior (crosslisted)	4
BIOEE 4790	Paleobiology (crosslisted)	4
EAS 4795		4
EAS 2250	The Earth System (crosslisted)	4
EAS 2680	Climate and Global Warming	3
EAS 3010	Evolution of the Earth System	4
ENTOM 4610	Model-Based Phylogenetics and Hypothesis Testing	3
PLSCI 4400	Phylogenetic Systematics *	3

* laboratory component

Computational Biology

In addition to the concentration requirements outlined below, all students must complete the Biological Sciences foundation requirements:

- Biological Sciences Foundation Requirements (p. 1)

Computation methods and data mining has become essential to biological research. Technology for collecting high-throughput data, such as genomic technology, mass spectrometry, and MRI imaging, and the development of large-scale databases, such as those for genomes, epidemiology, and compilations of biological information types, have made available unprecedented amounts of detailed information that require computationally intensive methodologies to access and analyze. These data and computational methods are transforming almost all of biological research.

Problems investigated by computational biologists include topics as diverse as the genetics of disease susceptibility; comparing entire genomes to reveal the evolutionary history of life; predicting the structure, motions, and interactions of proteins; designing new therapeutic drugs; modeling the complex signaling mechanisms within cells; predicting how ecosystems will respond to climate change; and designing recovery plans for endangered species. The computational biologist must have skills in mathematics, statistics, machine learning, and the physical sciences as well as in biology. A key goal in training is to develop the ability to relate biological processes to computational models. Cornell faculty work primarily in six subareas of computational biology:

1. computational and statistical genomics,
2. population, comparative, and functional genomics,
3. bioinformatics,
4. proteomics,
5. ecology and evolutionary biology, and
6. statistical and computational methods for modeling biological systems.

Beyond core skills in mathematics, physical sciences and biology, the computational biology concentration requires additional coursework in

mathematics and computer programming, a "bridging" course aimed at connecting biology to computation, and an advanced course where the theoretical/computational component of one aspect of biology is studied. Students should enroll in the more rigorous courses in the physical and mathematical sciences, and may wish to take additional courses in these areas.

Computational biology has applications as broad as biology itself. The problems of interest and the tools available to study them are constantly evolving, so students are encouraged to gain fundamental skills that will serve them throughout their careers. There is great, and increasing, demand for research scientists and technical personnel who can bring mathematical and computational skills to the study of biological problems. This concentration is also an excellent preparation for graduate study in any area of biology or computational biology.

Students are required to select courses from the list below to complete the concentration; however, if students find another relevant course that is not listed, they may petition the Office of Undergraduate Biology (https://qafederation.ngwebsolutions.com/sp/startSSO.ping?PartnerIdpId=https://shibidp.cit.cornell.edu/idp/shibboleth&TargetResource=https%3A%2F%2Fdynamicforms.ngwebsolutions.com%2FSubmit%2FStart%2F889d159c-0bfd-489f-b1dc-ebbbabcdac94).

Computational Biology Requirements

- All requirements must be taken for letter grade unless the course is offered S/U only. Exceptions to the grading option and any course substitutions must be approved via the biological sciences petition (https://qafederation.ngwebsolutions.com/sp/startSSO.ping?PartnerIdpId=https://shibidp.cit.cornell.edu/idp/shibboleth&TargetResource=https%3A%2F%2Fdynamicforms.ngwebsolutions.com%2FSubmit%2FStart%2F889d159c-0bfd-489f-b1dc-ebbbabcdac94). Students are encouraged to discuss exceptions and course substitutions with their faculty advisor prior to submitting petition.
- A grade of D- or better must be obtained to count course for concentration.
- A minimum of 12 credits of concentration requirements

Code	Title	Hours
Computer Programming [1]		
Select one of the following:		2-4
CS 1110	Introduction to Computing: A Design and Development Perspective	
CS 1112	Introduction to Computing: An Engineering and Science Perspective	
CS 2024	C++ Programming	
Mathematics		
Select one of the following:		3-4
BTRY 3080	Probability Models and Inference [2]	
MATH 2210	Linear Algebra	
MATH 2310	Linear Algebra for Data Science	
MATH 2940	Linear Algebra for Engineers	
MATH 4200	Differential Equations and Dynamical Systems	
MATH 4210	Nonlinear Dynamics and Chaos	
MATH 4710	Basic Probability	
MATH 4740	Stochastic Processes	
Bridging Courses [3, 4]		
Select one of the following:		3-4
BIOCB 3620	Dynamic Models and Data in Biology	
BIOCB 4381	Biomedical Data Mining and Modeling	
BIOCB 4810	Population Genetics (crosslisted)	
BIOCB 4830	Quantitative Genomics and Genetics	
BIOCB 4840	Computational Genetics and Genomics (crosslisted)	
BIOCB 4910	Advanced Population Genetics	
BIOEE 3550	Data Analysis and Visualization in Ecology and Environmental Science	
BIOMG 4311	Proteins: Structure, Function and Evolution	
BIOMG 4810	Population Genetics (crosslisted)	
BIOMG 4870	Human Genomics	
BIONB 3300	Introduction to Computational Neuroscience (crosslisted)	
BIONB 4220	Modeling Behavioral Evolution	
BIONB 4740	Neural Dynamics of Learning, Memory and Decision Making	
BME 3110	Cellular Systems Biology	
ENTOM 4610	Model-Based Phylogenetics and Hypothesis Testing	
NTRES 3100	Applied Population Ecology	
NTRES 4100	Advanced Conservation Biology: Concepts and Techniques	
NTRES 4120	Wildlife Population Analysis: Techniques and Models	
PLSCI 4000	Concepts and Techniques in Computational Biology	
PLSCI 4400	Phylogenetic Systematics	
STSCI 3740	Data Mining and Machine Learning	
d. Advanced Courses [4, 5]		
Select one of the following:		3-4
BIOCB 3620	Dynamic Models and Data in Biology	
BIOCB 4381	Biomedical Data Mining and Modeling	
BIOMI 4300	Computational Approaches for Microbial Systems	
BTRY 3080	Probability Models and Inference (crosslisted)	
BTRY 4090	Theory of Statistics (crosslisted)	
CS 2110	Object-Oriented Programming and Data Structures (crosslisted)	
CS 4210	Numerical Analysis and Differential Equations (crosslisted)	
CS 4220	Numerical Analysis: Linear and Nonlinear Problems (crosslisted)	
CS 3780	Introduction to Machine Learning	
MATH 4200	Differential Equations and Dynamical Systems	
MATH 4210	Nonlinear Dynamics and Chaos	
MATH 4710	Basic Probability	
MATH 4740	Stochastic Processes	
ORIE 3500	Eng Probability and Statistics: Modeling and Data Science II [2]	
ORIE 3510	Stochastic Processes for Decision-Making (crosslisted)	

[1] AP credit in computer science can be used to satisfy part (a) One course in computer programming.

[2] Students who use BTRY 3080 to fulfill the additional mathematics requirement should not use ORIE 3500 Eng Probability and Statistics: Modeling and Data Science II to fulfill the requirement for an advanced course.
[3] A course in mathematical modeling applied to biology.
[4] Many of the "bridging" and "advanced" courses listed above are offered only in alternate years or irregularly, and many have one or more prerequisites that are not required for the biological sciences major or this concentration. Students therefore need to plan well in advance how they will satisfy these requirements, and verify when course offerings will occur.
[5] or an additional "bridging" course numbered 4000 or above.

Note:

- It is strongly recommended that students in this concentration use PHYS 2207/PHYS 2208 to satisfy the core physics requirement.
- It is strongly recommended that students complete the core organic chemistry requirement using the CHEM 1570 option, and that the time saved be used to take either CS 2110 or a second mathematics course from the list above.
- One course may not be used to satisfy two different requirements simultaneously. For example, BTRY 3080 can be used to satisfy either requirement (b) or requirement (d), but not both.
- BIOG 49** courses (4990, independent study, TA, undergrad seminar) cannot be used towards the computational biology concentration.

Ecology and Evolutionary Biology

In addition to the concentration requirements outlined below, all students must complete the Biological Sciences foundation requirements:

- Biological Sciences Foundation Requirements (p. 1)

Ecologists study the interactions between organisms and their environments, and the consequences of those interactions for individuals, populations, communities, and ecosystems. Evolutionary biologists study the history of organisms and the processes that have resulted in adaptation, phenotypic variation, and biotic diversity. Ecology and evolutionary biology are interdependent fields that both rely on a deep understanding of the diversity of organisms, their physiology and anatomy, and how they are modified through natural selection, which is why biodiversity/organismal biology is the third pillar of our curriculum.

Learning in the Ecology and Evolutionary Biology (E&EB) concentration is not confined to the classroom and lab. In Field Ecology, for example, students spend one afternoon each week in the fields, forests, and ponds of the area, investigating animals and plants by observation and experiment. Many of our courses (e.g. Field Ecology, Ichthyology, Ornithology, Limnology, Stream Ecology) include field trips and short field-based student projects. E&EB students can also earn credit for off-campus field courses, such as courses at Shoals Marine Lab and through the Organization for Tropical Studies. Hands-on laboratory work is a basic feature of many courses. Quantitative methods are used in laboratory and field research and in theoretical studies, and molecular biology has become crucial in all areas of ecology and evolutionary biology.

Research in Ecology and Evolutionary Biology at Cornell has greatly enhanced our understanding of natural ecosystems, and how ecosystems are changing in response to the major global challenges in the Anthropocene: climate change, biodiversity loss, emerging infectious diseases, and providing food for an ever-increasing human population. Students have many opportunities to participate in original field- and lab-based research, either as a member of a research team or independently under the guidance of a faculty member. In addition, students can receive credit for research in E&EB through BIOG 2990 Introduction to Research Methods in Biology and BIOG 4990 Independent Undergraduate Research in Biology.

Graduates from this concentration have entered a wide variety of careers. Many go on to graduate school in ecology or evolutionary biology. Others take jobs with government agencies doing conservation work, management, or environmental education, or with non-governmental organizations such as The Nature Conservancy or World Wildlife Fund. Students have also used their backgrounds to enter careers in environmental law, journalism, medicine, and business.

Ecology and Evolutionary Biology Requirements

- All requirements must be taken for letter grade unless the course is offered S/U only. Exceptions to the grading option and any course substitutions must be approved via the biological sciences petition (https://qafederation.ngwebsolutions.com/sp/startSSO.ping?PartnerIdpId=https://shibidp.cit.cornell.edu/idp/shibboleth&TargetResource=https%3A%2F%2Fdynamicforms.ngwebsolutions.com%2FSubmit%2FStart%2F889d159c-0bfd-489f-b1dc-ebbbabcdac94). Students are encouraged to discuss exceptions and course substitutions with their faculty advisor prior to submitting petition.
- A grade of D- or better must be obtained to count the course for concentration.
- A minimum of 13 credits of concentration requirements.

In addition to BIOEE 1780 An Introduction to Evolutionary Biology and Diversity (A Biological Sciences major requirement), Ecology and Evolutionary Biology concentrators must take BIOEE 1610 Introductory Biology: Ecology and the Environment or BIOSM 1610 Ecology and the Marine Environment as one of the courses used to fulfill the core course requirement for the Biology major. The E&EB curriculum is organized into three categories, representing the Ecology, Evolutionary Biology, and Biodiversity pillars of the program. In addition, courses are categorized as:

1. Core courses (Advanced Fundamentals), which provide a broad exposure to several sub-disciplines within one field or comprehensively cover one core discipline,
2. Electives (specialized) courses, which allow specialization in various subfields, and
3. Field and Laboratory courses.

To meet E&EB concentration requirements, students must take:

- at least one Core course in Ecology
- at least one Core course in Evolutionary Biology
- at least one Core course in Biodiversity (Organismal Biology)
- at least one course that provides field or laboratory experience.
- additional courses of any category to meet specific interests and career plans up to at least 13 credits total

Note

BIOG 4990 can be used for up to three of the total 13 credits, with the approval of the faculty advisor, and if the research has a substantial ecology, evolutionary biology, or biodiversity/organismal biology component. It cannot be used to fulfill the field/lab requirement. Students can receive credit for research in E&EB through BIOG 2990 Introduction to

Research Methods in Biology and BIOG 4990 Independent Undergraduate Research in Biology.

Core Courses (Advanced Fundamentals)

Code	Title	Hours
Ecology		
Select one of the following:		3-4
BIOEE 3610	Advanced Ecology	
BIOEE 4460	Plant Behavior and Biotic Interactions, Lecture (crosslisted)	
BIOEE 4550	Insect Ecology (crosslisted)	
BIOEE 4560	Stream Ecology (crosslisted)	
BIOEE 4570	Limnology: Ecology of Lakes, Lectures	
BIOEE 4660	Physiological Ecology, Lectures	
BIOEE 4780	Ecosystem Biology and Global Change	
NTRES 3100	Applied Population Ecology	
Evolutionary Biology		
Select one of the following:		
BIOEE 4530	Speciation: Genetics, Ecology, and Behavior (Select one of the following:)	
BIOEE 4800	Ecological Genetics	
BIOMG 4610	Development and Evolution	
ENTOM 4610	Model-Based Phylogenetics and Hypothesis Testing	
Biodiversity		
Select one of the following:		3-4
BIOEE 2740	The Vertebrates: Comparative Anatomy, Function, Paleontology, and Evolution	
BIOEE 3730	Biodiversity and Biology of the Marine Invertebrates	
BIOEE 4700 & 4701	Herpetology, Lectures and	
BIOEE 4750	Ornithology, Lectures	
BIOEE 4752	Ornithology, Worldwide Avian Diversity Laboratory	
BIOEE 4760	Ichthyology: Biology of Fishes, Lectures	
BIOEE 4762	The Biology, Evolution, and Lives of Fishes	
ENTOM 3310	Insect Diversity and Evolution	
PLSCI 2480	Vascular Plant Systematics	
PLSCI 4300	Mycology	
PLSCI 6300	Mycology	

Electives (Specialized) Courses

Code	Title	Hours
BIOEE 1130	The Art and Science of Birds	2
BIOEE 1150	Techniques of Avian Specimen Preparation	2
BIOEE 1540	Introductory Oceanography	3
BIOEE 1640	FWS: Topics in Ecology and Evolutionary Biology	3
BIOEE 2001	Bringing Specimens to Life: Using Natural History Collections to Engage Communities in Sci Outreach	3
BIOEE 2233	Field Lectures in Biodiversity and Evolution	1
BIOEE 2525	Ecology and Conservation of Wildlife in the Neotropics	2
BIOEE 2527	Neotropical Wildlife Biology	1
BIOEE 3250	Evolutionary Medicine	3
BIOEE 3550	Data Analysis and Visualization in Ecology and Environmental Science	3
BIOEE 3690	Chemical Ecology (crosslisted)	3
BIOEE 4000	Ecology and Evolution of Infectious Diseases (crosslisted)	4
BIOEE 4690	Food, Agriculture, and Society (crosslisted)	3
EAS 4795		4
BIOEE 6000	Ecology and Evolution of Infectious Diseases (crosslisted)	4
BIOEE 6550	Data Analysis and Visualization in Ecology and Environmental Science	3
EAS 4790	Paleobiology (crosslisted)	4
NTRES 2830	DNA, Genes and Genetic Diversity	4
NTRES 3110	Fish Ecology, Conservation, and Management	3
NTRES 4100	Advanced Conservation Biology: Concepts and Techniques	4
PLSCI 2300	Global Plant Biodiversity and Vegetation	3
PLSCI 2410	Introductory Plant Diversity and Evolution	3
PLSCI 3440	Evolutionary Plant Biology	3
PLSCI 4400	Phylogenetic Systematics	3
PLSCI 4220	Comparative Plant Development: Evo-Devo	2
PLSCI 4730	Ecology of Agricultural Systems	4

Field and Laboratory Courses

Code	Title	Hours
Select one of the following:		
BIOEE 1560	Introductory Oceanography with Laboratory	
BIOEE 2150	Advanced Techniques of Avian Specimen Preparation	
BIOEE 2526	Ecology and Conservation of Wildlife in the Neotropics II	
BIOEE 2740	The Vertebrates: Comparative Anatomy, Function, Paleontology, and Evolution	
BIOEE 3610	Advanced Ecology	
BIOEE 3611	Field Ecology	
BIOEE 3780	Digital Morphology through CT	
BIOEE 4461	Plant Behavior and Biotic Interactions, Laboratory (crosslisted)	
BIOEE 4571	Limnology: Ecology of Lakes, Laboratory	
BIOEE 4661	Physiological Ecology, Laboratory	
BIOEE 4701		
BIOEE 4751	Ornithology, Laboratory	
BIOEE 4761	Ichthyology: Biology of Fishes, Laboratory	
EAS 4795		
ENTOM 3310	Insect Diversity and Evolution	
ENTOM 3311	Insect Diversity Laboratory	
NTRES 3400	Molecular Tools for Ecology, Conservation, and Natural Resource Management	
PLSCI 2301	Field Lab in Global Plant Biodiversity and Vegetation	
PLSCI 2410	Introductory Plant Diversity and Evolution	
PLSCI 3190	Mushrooms of Field and Forest	

Note

Students can fulfill their field and laboratory course requirements with a diversity of off-campus opportunities, including:

1. Courses at the Shoals Marine Laboratory (BIOSM).
2. Courses offered by the Organization for Tropical Studies (OTS) Undergraduate Semester Abroad Program (3 credits each for Fundamentals in Tropical Biology and Field Research in Tropical Biology for a total of 6 credits).
3. Any other field course, with approval from their academic advisor and the Ecology and Evolutionary Biology Director of Undergraduate Studies.

General Biology

In addition to the concentration requirements outlined below, all students must complete the Biological Sciences foundation requirements:

- Biological Sciences Foundation Requirements (p. 1)

The General Biology concentration provides an opportunity for students who wish to explore several biological disciplines instead of concentrating on only one specific area of biology for in-depth study. Students obtain a breadth of knowledge by taking coursework from at least three different concentrations and are exposed to advanced topics by taking a minimum of two upper-level courses. Laboratory coursework beyond the core course required for the major must also be completed.

General Biology is a particularly good choice for students whose interests lie within more than one established concentration. It also is an appropriate program for students who are not ready to select one focused area for study, by providing guidelines for students who are trying to identify an area of interest. Students in the General Biology concentration are advised by faculty in any of the biology departments. The flexibility of the concentration allows virtually endless combinations of courses to satisfy the requirements, limited only by the scope of the student's interests and creativity in designing a course of study.

This concentration provides a suitable background for students who desire to continue their studies in human or veterinary medicine, or in graduate-level study in biology (most likely in the area the student focuses on for advanced study). It is also ideal preparation for careers in teaching, business, or law requiring broad knowledge of the field of biology.

General Biology Requirements

- All requirements must be taken for letter grade unless the course is offered S/U only. Exceptions to the grading option must be approved via the biological sciences petition (https://qafederation.ngwebsolutions.com/sp/startSSO.ping?PartnerIdpId=https://shibidp.cit.cornell.edu/idp/shibboleth&TargetResource=https%3A%2F%2Fdynamicforms.ngwebsolutions.com%2FSubmit%2FStart%2F889d159c-0bfd-489f-b1dc-ebbbabcdac94). Exceptions ay be submitted for consideration but are not a guaranteed approval.
- A grade of D- or better must be obtained to count course for concentration.
- A minimum of 13 credits of concentration requirements.

The concentration in general biology requires a minimum of 13 credit hours in addition to courses counted toward requirements 1–9 of the biological sciences major. These 13 credits must include:

1. A total of three courses selected from three different concentrations in the biological sciences major. Only those courses specifically listed as fulfilling a concentration requirement are permitted. Foundation courses are not permitted except if a student takes BIOG 1440 and BIOMG 1350 to fulfill the introductory biology cluster requirements they can then use BIOEE 1610 for Category A as part of the EEB concentration. See note below for course substitutions.
2. A biology laboratory or field course or a biology course with a laboratory or field component. BIOG 1500, BIOMG 2801, CHEM 2510 and BIOEE 1560 do not fulfill this requirement. Many courses may be used, including but not limited to: BIOG 4990, BIOAP 4130, BIOEE 2740, BIOMI 2911, BIOMG 4400, BIONB 3240, Students should seek approval from their faculty advisor for the course they plan to use to fulfill this requirement.
3. A minimum of two upper-level (3000 and above) courses of 2 or more credits, listed as satisfying one of the other 12 concentrations. Course must have significant biology content. See note below for course substitutions.

Note

In general, students must select courses that qualify for the other 12 concentrations to fulfill the General Biology requirements. However, students can discuss other majors-level courses with significant biology content with their faculty advisor. If a course is deemed appropriate given the student's interests or goals, with their faculty advisor's approval the student can submit a biological sciences petition (https://qafederation.ngwebsolutions.com/sp/startSSO.ping?PartnerIdpId=https://shibidp.cit.cornell.edu/idp/shibboleth&TargetResource=https%3A%2F%2Fdynamicforms.ngwebsolutions.com%2FSubmit%2FStart%2F889d159c-0bfd-489f-b1dc-ebbbabcdac94) to apply the course toward any of the General Biology requirements. Final approval of this petition from the Director of Undergraduate Studies is required.

Only 1000-level courses that are currently approved for other concentrations can be used toward fulfilling requirements. BIOG 2990 and BIOG 4980 are not acceptable for meeting any requirements. BIOG 4990 (minimum of 2 credits, but no more than 3 credits) may count as one of the upper-level courses and may count as the laboratory course with approval of faculty advisor, but it cannot count for category A as a course representing a concentration. No more than 3 credits of BIOG 4990 can count toward the required 13 credits.

Students who complete CHEM 3570 , CHEM 3580 and CHEM 2510 cannot use CHEM 3580 to fulfill any of the General Biology concentration requirements.

Students who fulfill the Organic Chemistry requirement by completing CHEM 3570 and CHEM 2510 may not use CHEM 2510 to satisfy any General Biology concentration requirement.

CHEM 2510 Introduction to Experimental Organic Chemistry and BIOEE 1560 Introductory Oceanography with Laboratory, may count as a concentration course (category A) and toward the overall 13 credits, but do not count toward the General Biology laboratory requirement (category B).

It is possible to use a single course to fulfill more than one requirement. For example, BIOAP 4130 could count in all three areas: as a course in the Animal Physiology Concentration, as an upper-level course, and as a course with a lab.

Genetics, Genomics and Development

In addition to the concentration requirements outlined below, all students must complete the Biological Sciences foundation requirements:

- Biological Sciences Foundation Requirements (p. 1)

The fields of Genetics, Genomics and Development seek to understand the mechanisms used by living organisms to preserve biological information and transmit it to the next generation. Central to these questions is the study of DNA and its organization into genes and genomes. Advances in molecular biology have provided many tools for the analysis of gene function, as well as for the understanding of how mutations affect biological processes and cause disease. Genetic engineering methods to manipulate gene function also constitute important research tools in biology. Work in several disciplines within Genetics is contributing to increase our understanding of how the information encrypted in DNA is decoded to influence cellular processes (Regulation of Gene Expression) and form complete organisms (Developmental and Stem Cell Biology), as well as to appreciate how genetic variation leads to evolutionary changes within populations (Evolutionary and Population Genetics). In the last few years, improvements in DNA sequencing technologies have allowed geneticists to expand the scope of their studies, shifting from the study of individual genes to the analysis of whole genomes. Research in this expanding area of Genomics is providing unprecedented views of the organization and functional elements of our genomes. Additionally, whole genome-sequencing and computational genomics methods have opened exciting venues for the diagnosis of congenital human disorders and genetic predisposition to disease.

The Genetics, Genomics and Development (GGD) concentration requires at least 13 credits chosen from any of the courses indicated below. Courses have been classified into broad areas for guidance purposes. Students can choose courses in one or several of these areas to satisfy their concentration requirements. Many of these courses explore current research topics and new technologies, exposing students to the latest discoveries and primary literature.

Students are strongly encouraged to perform undergraduate research in a professor's laboratory to gain practical experience. There are a large number of laboratories on campus that perform research related to the areas of Genetics, Genomics and Development in a variety of model organisms. Research areas currently pursued at Cornell include:

- Genetic studies in baker's yeast, fruit flies, plants, mice, and other model organisms aimed at understanding cell cycle control & cancer, signal transduction, DNA replication, DNA repair, chromosome segregation, gene expression and viral life cycles.
- Functional and computational genomic analyses aimed at understanding gene regulation and the genetics of complex traits in both model organisms and in humans.
- Studies to unravel the mechanisms that mediate reproduction and fertilization, promote cell differentiation and morphogenesis during embryonic development, and regulate stem cell pluripotency and tissue regeneration in adult organisms. Research on these topics uses a variety of model organisms such as fruit flies, nematodes, planaria, plants, chicken and mice, with the ultimate goal of uncovering the genetic factors that influence congenital birth defects, human disease and longevity.
- Research aimed to understanding genetic variation and molecular evolution within and across different populations, including model organisms and humans.

Instruction in the fields of Genetics, Genomics and Development prepares students for a variety of professional careers. Some of Cornell's GGD graduating students continue their education in graduate, medical or veterinary schools. Others pursue professions in biotech, pharmacological or agricultural industries, education, scientific publishing or health/science law & policy. The growing capabilities of genome sequencing and prenatal diagnosis are expected to increase the demand for professionals trained to interpret genomic information, develop clinical protocols for the diagnosis of genetic diseases and provide genetic counseling.

Genetics, Genomics and Development Requirements

- All requirements must be taken for letter grade unless the course is offered S/U only. Exceptions to the grading option and any course substitutions must be approved via the biological sciences petition (https://qafederation.ngwebsolutions.com/sp/startSSO.ping?PartnerIdpId=https://shibidp.cit.cornell.edu/idp/shibboleth&TargetResource=https%3A%2F%2Fdynamicforms.ngwebsolutions.com%2FSubmit%2FStart%2F889d159c-0bfd-489f-b1dc-ebbbabcdac94). Students are encouraged to discuss exceptions and course substitutions with their faculty advisor prior to submitting petition.
- A grade of D- or better must be obtained to count course for concentration.
- A minimum of 13 credits of concentration requirements. Students are required to complete a minimum of 13 credits, usually chosen from the following courses:

Genetics

Code	Title	Hours
BIOMG 3800	Advanced Genetics and Genomics	3
BIOMG 4880	Cancer Biology and Metabolism	3
BIOMG 6870	Tricks of the trade in molecular genetic research	3
BIOMI 4850	Bacterial Genetics	2-3
BIONB 3950	Molecular and Genetic Approaches to Neuroscience	3
PLSCI 3430	Molecular Biology and Genetic Engineering of Plants	2

Genomics

Code	Title	Hours
BIOMG 3800	Advanced Genetics and Genomics	3
BIOMG 4000	Genomics: Technology, Data, and Applications	3
BIOMG 4870	Human Genomics	3
BIOCB 4830	Quantitative Genomics and Genetics	4

Note

Students planning to pursue studies in Genomics after graduation are encouraged to learn computer programming and statistical analysis (including Python, MATLAB and R environments). Some introductory courses covering these topics are: STSCI 2150 (R), BTRY 3010 (R), BIOG 1500 (R), CS 1110 (Python), CS 1133 (Pyth Credit for these courses should not be counted towards the GGD concentration requirements, but can be used to satisfy college distribution requirements.

Developmental and Stem Cell Biology

Code	Title	Hours
BIOMG 3850	Developmental Biology	3
BIOMG 4610	Development and Evolution	3
BIOMG 6870	Tricks of the trade in molecular genetic research	3
PLSCI 4220	Comparative Plant Development: Evo-Devo	2

Evolutionary and Population Genetics

Code	Title	Hours
BIOEE 4530	Speciation: Genetics, Ecology, and Behavior (crosslisted)	4
BIOMG 4610	Development and Evolution	3
BIOMG 4810	Population Genetics (crosslisted)	4
BIOMG 4870	Human Genomics	3
BIOCB 4830	Quantitative Genomics and Genetics	4
NTRES 3400	Molecular Tools for Ecology, Conservation, and Natural Resource Management	3

Molecular Biology

Code	Title	Hours
BIOMG 4380	RNA in Biology and Medicine	3
BIOMG 4390	Molecular Basis of Disease	3
BIOMG 6330	DNA Biology	3
BIOMG 6390	The Nucleus	3

Methods in Genetics, Genomics and Development

Code	Title	Hours
BIOMG 4000	Genomics: Technology, Data, and Applications	3
BIOMG 6870	Tricks of the trade in molecular genetic research	3
BIOCB 4830	Quantitative Genomics and Genetics	4
NTRES 3400	Molecular Tools for Ecology, Conservation, and Natural Resource Management	3
PLSCI 3430	Molecular Biology and Genetic Engineering of Plants	2

Laboratory Experience

Students seeking laboratory experience in the areas of Genetics, Genomics and Development are encouraged to participate in Undergraduate Research through enrollment in BIOG 4990.

- BIOG 4990 Independent Undergraduate Research in Biology A maximum of 3 credits can be applied to fulfill the concentration requirements with approval from the faculty advisor. Research project must be in the areas of Genetics, Genomics and/or Development.
- BIOMG 4400 Laboratory in Biochemistry and Molecular Biology

Note

Up to 3 credits for this concentration may be chosen from other biological sciences courses upon approval. Students seeking approval for courses not listed above should petition (https://qafederation.ngwebsolutions.com/sp/startSSO.ping?PartnerIdpId=https://shibidp.cit.cornell.edu/idp/shibboleth&TargetResource=https%3A%2F%2Fdynamicforms.ngwebsolutions.com%2FSubmit%2FStart%2F889d159c-0bfd-489f-b1dc-ebbbabcdac94)to the Director of Undergraduate Studies (https://biology.cornell.edu/about/directors-undergraduate-study/) for the GGD concentration.

Human Nutrition

In addition to the concentration requirements outlined below, all students must complete the Biological Sciences foundation requirements:

- Biological Sciences Foundation Requirements (p. 1)

Nutritional Sciences draws upon several disciplines, including biological sciences, to understand the relationships between food, nutrients, and human health. The concentration in Human Nutrition offers Biological Sciences majors courses concerned with the nature and biochemical function of essential and non-essential nutrients, nutrient requirements, the role of nutrients in gene expression, and the role of diet in both risk of chronic disease and treatment of existing disease states.

The Human Nutrition concentration requires one core course, NS 3310 Human Nutrition and Nutrient Metabolism (Spring, 4 cr), as well as at least 9 credits selected from a list of didactic NS courses related to the nature and biochemical function of essential and non-essential nutrients, nutrient requirements, the role of nutrients in gene expression, and the role of diet in both risk of chronic disease and treatment of existing disease states.

Students in this concentration are encouraged to complete a diverse set of advanced courses affording a perspective on current knowledge of nutrient requirements and function and how this knowledge can be put to use. Faculty advisors work with individual students to develop a curriculum that fits the students' interests.

As part of their program, students are also encouraged to obtain laboratory experience either through coursework or research. Faculty in Nutritional Sciences are engaged in a wide variety of research activities, including nutritional regulation of gene expression, nutrient function, and regulation of nutritional status, employing diverse approaches such as cell culture, animal experimentation, and human metabolism studies.

Students completing the concentration in Human Nutrition most often choose to continue their education in medical or graduate school, and pursue careers in the applied aspects of nutrition or in laboratory-based or epidemiological research.

For additional information about the Division of Nutritional Sciences and its academic and research opportunities, see the Division of Nutritional Sciences (https://courses.cornell.edu/preview_entity.php?catoid=60&ent_oid=14991) section or contact the Division of Nutritional Sciences Student Services Office, B36 Kinzelberg Hall, dnsstudentservices@cornell.edu.

Human Nutrition Requirements

- All requirements need to be taken for letter grade unless the course is offered S/U only. Exceptions to the grading option need to be approved by the student's faculty advisor via the biological sciences petition (https://qafederation.ngwebsolutions.com/sp/startSSO.ping?PartnerIdpId=https://shibidp.cit.cornell.edu/idp/shibboleth&TargetResource=https%3A%2F%2Fdynamicforms.ngwebsolutions.com%2FSubmit%2FStart%2F889d159c-0bfd-489f-b1dc-ebbbabcdac94).
- A grade of D- or better must be obtained to count course for concentration.
- A minimum of 13 credits of concentration requirements.
- Students are required to take NS 3310 Human Nutrition and Nutrient Metabolism.

In addition to the above requirement, students must also take 9 credits of coursework in the Biological Aspects of Nutrition category, from the following list:

Code	Title	Hours
NS 3060	Nutrition and Global Health	3
NS 3150	Obesity and the Regulation of Body Weight (crosslisted)	3
NS 3320	Methods in Nutritional Sciences	3
NS 3410	Human Anatomy and Physiology	4
NS 3420	Human Anatomy and Physiology Laboratory	2
NS 3450	Introduction to Physiochemical and Biological Aspects of Foods	3
NS 4140	Maternal and Child Nutrition and Health	3
NS 4200	Diet and the Microbiome	3
NS 4210	Precision Nutrition and Health	3
NS 4300	Proteins, Transcripts, and Metabolism: Big Data in Molecular Nutrition	3
NS 4330	Nutrition and the Brain	3
NS 4410	Nutrition and Disease	4
NS 4430	Applied Anatomy and Physiology	2
NS 5510	Nutrition Assessment	3
NS 6310	Micronutrients: Function, Homeostasis, and Assessment	2-4
NS 6320	Regulation of Macronutrient Metabolism	4

Notes

- Only courses on the list above may be used.
- Students must pass a course with a "D-" or higher for it to count toward the requirement.
- Independent study credits cannot be used toward the 13 credit minimum.
- For students in the College of Agriculture and Life Sciences, credits in NS courses count toward the required CALS credits. For students in the College of Arts and Sciences, up to three NS courses may be petitioned to count toward A&S credit if those credits fulfill major requirements.
- Students in the Human Nutrition concentration of the Biological Sciences major in CALS may not also major in Nutritional Sciences. To double major in Biological Sciences and Nutritional Sciences, students must choose a different Biological Sciences concentration.

Marine Biology

In addition to the concentration requirements outlined below, all students must complete the Biological Sciences foundation requirements:

- Biological Sciences Foundation Requirements (p. 1)

General Goals of the Concentration in Marine Biology

About 70% of the planet's surface consists of estuarine, coastal, and pelagic ocean environments. Students who choose the Concentration in Marine Biology will learn about the biology, evolution and ecology of organisms that inhabit these environments and the ecological processes linking them. Marine biology draws from a range of disciplines including organismal biology, marine microbiology, ocean biogeochemistry, and biological oceanography. These disciplines consider adaptation of marine organisms to their environment, their interactions with other organisms, and ultimately the consequences and feedbacks of these interactions upon the environment. Marine habitats are sensitive barometers to anthropogenic perturbations today and global climatic perturbations over evolutionary history.

Students will take an **introductory class** related to the marine environment as a foundation for further courses in marine biology and ecology. Next, students will choose courses from **Group A** that provide foundations in marine biology, including *an appreciation for the diversity of marine organisms, their anatomy and physiology, their ecological interactions, evolution, and adaptations to the marine environment*. Secondly, students will choose courses from **Group B** that *provide advanced knowledge of biological and ecological dynamics of marine ecosystems, biogeochemistry, and current threats and problems related to marine organisms (e.g., climate change*). Students are required to take a total of 15 credits, consisting of one **introductory course** and 12 credits combined from **Groups A and B**, with at least one course from each group.

Fieldwork is a central part of marine biology education, and most marine biologists are actively engaged in field research. Hence, a significant field component is required for the marine biology concentration. This requirement may be fulfilled by courses at Shoals Marine Laboratory; field courses through the Department of Earth and Atmospheric Sciences; or approved independent study (e.g., BIOG 4990), volunteer work, or internships involving a marine field work component with faculty at Cornell or elsewhere with approval (e.g., during winter or spring breaks, weekends during semester, etc.). The Marine Biology Director of Undergraduate Studies must approve the field component – please contact Dr. Ian Hewson: hewson@cornell.edu.

Students graduating with the Marine Biology Concentration will find careers in areas including but not limited to: graduate studies in marine biology, fisheries and oceanography leading to positions in academic institutions, museums, aquariums and government agencies; aquaculture and marine resources management; natural products chemistry and pharmaceuticals; environmental or maritime law; and veterinary science.

Courses for the Concentration in Marine Biology

- All requirements must be taken for letter grade unless the course is offered S/U only. Exceptions to the grading option and any course substitutions must be approved via the biological sciences petition (https://qafederation.ngwebsolutions.com/sp/startSSO.ping?PartnerIdpId=https://shibidp.cit.cornell.edu/idp/shibboleth&TargetResource=https%3A%2F%2Fdynamicforms.ngwebsolutions.com%2FSubmit%2FStart%2F889d159c-0bfd-489f-b1dc-ebbbabcdac94). Students are encouraged to discuss exceptions and course substitutions with their faculty advisor prior to submitting petition.
- A grade of D- or better must be obtained to count course for concentration.
- A minimum of 15 credits of concentration requirements.

Students are required to take a total of 15 credits, consisting of one **introductory course** and 12 credits combined from **Groups A** and **B**, with at least one course from each group. BIOSM 1610, BIOSM 1780 **or** BIOEE 1610 (Spring Semester Only) may also count as Group A course if BIOEE 1540 is taken as an introductory course. Courses that fulfill the field requirement have an asterisk (*).

Note regarding BIOSM 1610, BIOSM 1500, BIOSM 1780, and BIOEE 1610 (Spring Semester):

BIOSM 1610, BIOSM 1500 and BIOSM 1780 are equivalent courses to BIOEE 1610 , BIOSM 1500 and BIOEE 1780, and count for the Introductory Biology Cluster, Investigative Biology Laboratory and Evolution Biology & Diversity requirements for the Biological Sciences Major. If BIOSM 1610, BIOSM 1500 and/or BIOSM 1780 are taken to fulfill Biology Major requirements, they are ineligible to count towards the 15 credits required for the Concentration in Marine Biology but may be used to satisfy an Introductory Course. The spring semester BIOEE 1610 may count as an Introductory Course for the concentration but may not be counted towards the 15 credits required for the concentration

Introductory Courses (select 1)

Code	Title	Hours
BIOEE 1540	Introductory Oceanography	3
BIOEE 1560	Introductory Oceanography with Laboratory (crosslisted)	4
BIOEE 1610	Introductory Biology: Ecology and the Environment (crosslisted)	3-4
BIOSM 1500	Investigative Marine Biology Laboratory (see note above)	3
BIOSM 1610	Ecology and the Marine Environment (see note above) *	3

* fulfills the field requirement

Total 12 credits from Groups A and B

Group A - Organismal Biology and Foundations (select at least 1)

Code	Title	Hours
BIOAP 3300	Fish Physiology (crosslisted)	3
BIOEE 2740	The Vertebrates: Comparative Anatomy, Function, Paleontology, and Evolution	4
BIOEE 3730	Biodiversity and Biology of the Marine Invertebrates	3
BIOEE 4760	Ichthyology: Biology of Fishes, Lectures	3
BIOMI 3500	Marine Microbes and Disease in a Changing Ocean (crosslisted)	3
BIOSM 1780	Evolution and Marine Diversity (see note above) *	4
BIOSM 3210	Anatomy and Function of Marine Vertebrates *	3
BIOSM 3330	Marine Parasitology and Disease	3
BIOSM 3450	Marine Mammal Biology	3
BIOSM 4650	Shark Biology and Conservation	3
EAS 3555	Marine Microbes and Disease in a Changing Ocean (crosslisted)	3

* fulfills the field requirement

Group B - Advanced Topics

Code	Title	Hours
BIOEE 4570	Limnology: Ecology of Lakes, Lectures	3
BIOEE 4571	Limnology: Ecology of Lakes, Laboratory	2
BIOEE 4790	Paleobiology	4
BIOSM 2800	Sustainable Fisheries	3
BIOSM 3750	Marine Ecosystem Research and Management	3
NTRES 3110	Fish Ecology, Conservation, and Management	3
NTRES 3111	Fish Ecology Laboratory	1

Microbiology

In addition to the concentration requirements outlined below, all students must complete the Biological Sciences foundation requirements:

- Biological Sciences Foundation Requirements (p. 1)

Microbiology is the study of organisms that are too small to be seen with the unaided eye: Bacteria and Archaea, viruses, and unicellular eukaryotes. Microorganisms thrive in every corner of the world, from Antarctic ice (< 0 degrees C) to deep-sea thermal vents (> 100 degrees C); from the gastrointestinal tracts and skin of animals to the root nodules of leguminous plants; from sewage treatment plants to pristine lakes and streams. To study microbiology is to pursue the breadth of biology, as microorganisms provide experimental material for understanding physiology; cell structure and function; biochemistry; molecular biology; photosynthesis; ecology; evolution; genetics; development; and even simple behavioral responses and "memory." Studies with microorganisms continue to lay the foundation for molecular genetics, recombinant DNA research, biotechnology, environmental sciences, human health and many areas of biochemistry.

The Microbiology concentration provides excellent preparation for graduate study in many areas of biological science, as well as for professional study in medical, veterinary, or dental school. Graduates with bachelor's degrees can pursue careers in biotechnology or industrial microbiology, environmental microbiology, clinical microbiology, food microbiology, or pharmaceutical microbiology, and can also work as technicians in university, government, industrial, or hospital research laboratories.

Microbiology Requirements

- All requirements must be taken for letter grade unless the course is offered S/U only. Exceptions to the grading option and any course substitutions must be approved via the biological sciences petition (https://qafederation.ngwebsolutions.com/sp/startSSO.ping?PartnerIdpId=https://shibidp.cit.cornell.edu/idp/shibboleth&TargetResource=https%3A%2F%2Fdynamicforms.ngwebsolutions.com%2FSubmit%2FStart%2F889d159c-0bfd-489f-b1dc-ebbbabcdac94). Students are encouraged to discuss exceptions and course substitutions with their faculty advisor prior to submitting petition.
- A grade of D- or better must be obtained to count course for concentration.
- A minimum of 13 credits of concentration requirements.

Classes required of all students

The concentration in microbiology requires a minimum of 13 credit hours in addition to the biological sciences major requirements.

All students participating in the concentration must take an Introductory Lecture Course (BIOMI 2900) as well as an Introductory Laboratory (BIOMI 2911) which provides training in basic laboratory skills used by microbiologists.

[**Note**: although BIOMI 2900 has a 4 credit option, students in the concentration may only apply 3 credits of BIOMI 2900 towards satisfying the concentration requirements.]

- BIOMI 2900 General Microbiology Lectures (3 credits)
- BIOMI 2911 General Microbiology Laboratory (3 credits)

Other Credits

Students may fulfill the additional 7 credit hours of classes using any of the courses from the approved list below:

The additional 7 credit hours of classes include courses in environmental microbiology, microbial physiology, bacterial diversity, bacterial genetics, microbe-host interactions, virology, marine microbiology, applied microbiology and genomics. The remaining credit requirements must be fulfilled using any of the courses from the approved list below.

Code	Title	Hours
BIOMI 2600	Microbiology of Human Contagious Diseases	3
BIOMI 2950	Biology of Infectious Disease: From Molecules to Ecosystems	3
BIOMI 3210	The Gut Microbiome	3
BIOMI 3500	Marine Microbes and Disease in a Changing Ocean (crosslisted)	3
BIOMI 4040	Pathogenic Bacteriology (crosslisted)	2-3
BIOMI 4090	Principles of Virology (crosslisted)	3
BIOMI 4200	Core Concepts in Molecular Bacteriology	3
BIOMI 4300	Computational Approaches for Microbial Systems	3
BIOMI 4310	Medical Parasitology (crosslisted)	2
BIOMI 4850	Bacterial Genetics	2-3
BIOMI 6200	Core Concepts in Molecular Bacteriology	3
BIOMI 6300	Computational Approaches for Microbial Systems	3
BIOMS 4340	Cellular and Molecular Microbial Pathogenesis: The Host Pathogen Interplay	3
CEE 4510	Microbiology for Environmental Engineering	3
FDSC 3940	Applied and Food Microbiology (crosslisted)	3
FDSC 3950	Food Microbiology Laboratory	3
FDSC 4260	We Are What We Eat: Linking Food With Intestinal Functionality and Microbiome	3
NS 4200	Diet and the Microbiome	3
PLSCI 4300	Mycology	3
PLSCI 5700	Symbioses: Evolution and Ecology	3
VIEN 4650	Wine Microbiology	3

Molecular and Cell Biology

In addition to the concentration requirements outlined below, all students must complete the Biological Sciences foundation requirements:

- Biological Sciences Foundation Requirements (p. 1)

Molecular and cell biologists are interested in a broad range of problems relating to the structure and activities of microbial, plant, and animal cells, and the molecular mechanisms by which these activities are carried out. Recent technological advances in molecular biology, including high-throughput DNA sequencing and high resolution electron microscopy, have radically transformed the fields of molecular and cellular biology, enabling fascinating insights into such fundamental questions as: how cells regulate gene expression in response to changing environmental and developmental states; how cancer cells differ from normal cells; the assembly of cellular elements; cell-cell interactions; and the fine structure of cells. Cell culture techniques are an important aspect of research in this field, and yeast, insect, avian, plant, and mammalian cells are under active study at Cornell. Faculty in several units are carrying out research in molecular and cell biology. These faculty members are distributed among several departments in the Colleges of Arts and Sciences, Agriculture and Life Sciences, and Veterinary Medicine.

Students interested in the Molecular and Cell Biology concentration should enroll in the more rigorous courses in physical sciences and be well prepared in mathematics. As large datasets become a more common property of experiments in this field, a strong understanding of statistics is particularly encouraged. Genetics and biochemistry are of prime importance in molecular and cell biology. In fact, there is no sharp division between biochemistry, genetics, and cell biology. Molecular and cell biology may be considered as the application of biochemical and genetic approaches to the solution of problems at the molecular and cellular levels.

The Molecular and Cell Biology concentration requires a laboratory course in molecular biology, a cell biology survey course, a course in biochemistry, and at least six credits chosen from a list of advanced courses ranging from aspects RNA or DNA biology, to bacterial genetics, to plant anatomy. Students are also encouraged to gain an appreciation for leading edge research by carrying out independent research projects. Although it is not required, students are also encouraged to take a physical chemistry course sequence.

Molecular and cell biology is a dynamic field. Students graduating with a concentration in molecular and cell biology at Cornell usually continue their education in graduate, medical, or veterinary schools. The demand for research scientists interested in this field is high, not only in academic institutions but also in industrial and government laboratories as well. Technical positions for bachelor's-level graduates are also prevalent.

Molecular and Cell Biology Requirements

- All requirements must be taken for letter grade unless the course is offered S/U only. Exceptions to the grading option and any course substitutions must be approved via the biological sciences petition. Students are encouraged to discuss exceptions and course substitutions with their faculty advisor prior to submitting petition.
- A grade of D- or better must be obtained to count course for concentration.
- A minimum of 14 credits of concentration requirements.

Students electing this concentration should be sure to complete CHEM 2070/CHEM 2071-CHEM 2080/CHEM 2081 or CHEM 2150 during their first year. Students concentrating in Molecular and Cell Biology should not take CHEM 1570 Introduction to Organic and Biological Chemistry.

Code	Title	Hours
Organic Chemistry (Shared with Foundation Requirements)		
Select one of the following options:		
CHEM 3570 & CHEM 3580	Organic Chemistry for the Life Sciences and Organic Chemistry for the Life Sciences	
CHEM 3590 & CHEM 3600	Honors Organic Chemistry I and Honors Organic Chemistry II	
Biochemistry (Shared with Foundation Requirements)		
Select one of the following options:		5
BIOMG 3310 & BIOMG 3320	Principles of Biochemistry: Proteins and Metabolism and Principles of Biochemistry: Molecular Biology	
BIOMG 3300 & BIOMG 3340	Principles of Biochemistry, Individualized Instruction and Computer Graphics and Molecular Biology	

Cell Biology	
BIOMG 4320	Survey of Cell Biology
A Laboratory Course in Molecular Biology	
BIOMG 4400	Laboratory in Biochemistry and Molecular Biology
or BIONB 43	Experimental Molecular Neurobiology
Additional Credits [1]	
Any BIOMG course at the 3000 level or above [2]	
BIOG 4990	Independent Undergraduate Research in Biology [3]
BIOMS 4150	Essential Immunology
BIOMS 4250	Applied Immunology
BIOMI 4090	Principles of Virology
BIOMI 4850	Bacterial Genetics
BIONB 3950	Molecular and Genetic Approaches to Neuroscience
PLSCI 3420	Plant Physiology, Lectures
PLSCI 3430	Molecular Biology and Genetic Engineering of Plants
PLSCI 4220	Comparative Plant Development: Evo-Devo
PLSCI 4540	Plant Cell Biology
PLSCI 4620	Plant Biochemistry

1 The 6 additional hours should include at least two 2-credit or above courses from the following list (Note: graduate-level BIOMG courses and related courses in other departments are acceptable with permission of your advisor).

2 Except BIOMG 4980 , BIOMG 4981 , and BIOMG 4982.

3 Can be used for up to three of these credits, with the approval of the advisor, if the research has a substantial molecular or cell biology component.

Note

* It is recommended that when selecting first-year level core biology choice courses that one of them be BIOMG 1350 Introductory Biology: Cell and Developmental Biology.

Neurobiology and Behavior

In addition to the concentration requirements outlined below, all students must complete the Biological Sciences foundation requirements:

- Biological Sciences Foundation Requirements (p. 1)

The concentration in Neurobiology and Behavior covers a broad range of topics, all concerned in some way with how animals (including humans) behave and what neural mechanisms underlie their behavior. Students are required to take the two introductory courses, one in behavior (fall) and one in neuroscience (spring), in any order. After taking these courses, each student has a choice of many different upper-level courses for further exploration of areas of special interest, including social evolution, behavioral neurobiology, animal communication, animal cognition, computational and systems neuroscience, neuropharmacology, chemical ecology, motor systems, brain evolution, motivation, and cell and molecular neuroscience.

Neurobiology and behavior is a synthesis of many disciplines, including physiology, anatomy, ecology, evolution, genetics, biochemistry, physics and mathematics. The course requirements beyond the required two-course introductory sequence are left unspecified, so that courses may be selected from a wide range of possibilities, depending on your interests. These include one upper-level neurobiology and behavior course, 3000 level or above of at least 3 credits plus one or two other BIONB courses from the wide variety of course offerings. Credit for classes outside of the BIONB offerings is permitted but, it is at the discretion of the faculty advisor and it should reflect coursework that is cross-disciplinary with the concentration. Students are encouraged to get hands-on experience in a research lab or the field, and/or take one of the advanced laboratory courses or topic seminars during their senior year. Faculty advisers help students plan their courses of study in light of their interests and goals.

The variety of courses offered in this concentration reflects the breadth of research interests of its faculty. These interests span field and laboratory studies. They include such diverse topics as animal communication, plant behavior, sensory systems, systems and computational neuroscience, behavioral genetics, cellular neurophysiology, and neuropharmacology ("drugs and the brain").

Most students in the Neurobiology and Behavior concentration proceed to further study in graduate, medical, or veterinary school. Still others enter the work force immediately following graduation in the areas of research, business, and teaching.

Neurobiology and Behavior Requirements

- All requirements must be taken for letter grade unless the course is offered S/U only. Exceptions to the grading option need to be approved by the student's faculty advisor via the biological sciences petition (https://qafederation.ngwebsolutions.com/sp/startSSO.ping?PartnerIdpId=https://shibidp.cit.cornell.edu/idp/shibboleth&TargetResource=https%3A%2F%2Fdynamicforms.ngwebsolutions.com%2FSubmit%2FStart%2F889d159c-0bfd-489f-b1dc-ebbbabcdac94).
- A grade of D- or better must be obtained to count course for concentration.
- A minimum of 15 credits of concentration requirements.

Required Courses

Code	Title	Hours
BIONB 2210	Neurobiology and Behavior I: Introduction to Behavior (with 1 credit discussion section)	4
BIONB 2220	Neurobiology and Behavior II: Introduction to Neuroscience (with 1 credit discussion section)	4
BIONB 3000-4999		3
Additional NBB Courses [1]		4

1 Additional courses can include other 3000 or 4000 level NBB courses including "Topics" courses (BIONB 4200), independent study (BIOG 4990) or (BIOG 4970), up to 4 credits, with advisor approval, BIONB 3215, ENTOM 3755, PSYCH 3020, PSYCH 4230, and PSYCH 4260/PSYCH 6260 to equal a total of 15 credits for the concentration.

Note

Students who declare the concentration in Neurobiology and Behavior (NBB) after taking BIONB 2210 or BIONB 2220 for only 3 credits must still take the 1-credit discussion section in BIONB 2210 and BIONB 2220. To arrange this, the student should consult the course directors.

Recommendations

The faculty of NBB strongly advises students concentrating in NBB to: (1) gain laboratory or field experience in neurobiology or behavior by

taking at least one laboratory course or field biology course, or by doing independent research for course credit (BIOG 4990); (2) take at least one special topics (BIONB 4200) discussion course on a subject of interest in the junior or senior year.

Examples of laboratory-based and field-based courses are as follows:

Animal behavior and behavioral ecology:

Code	Title	Hours
BIONB 4461	Plant Behavior and Biotic Interactions, Laboratory (crosslisted)	1
BIOEE 3730	Biodiversity and Biology of the Marine Invertebrates	3
ENTOM 3150	Spider Biology	3
ENTOM 3311	Insect Diversity Laboratory	1

Neurobiology and animal physiology:

Code	Title	Hours
BIONB 3240	Behavioral Neuroscience Laboratory (crosslisted)	3
BIONB 4300	Experimental Molecular Neurobiology	4
BIONB 4910	Principles of Neurophysiology (crosslisted)	4
BIOAP 3190	Laboratory in Physiology (crosslisted)	4
ENTOM 4830	Insect Physiology	4

Field biology courses offered at Shoals Marine Lab:

Code	Title	Hours
BIOSM 3450	Marine Mammal Biology	3
BIOSM 3210	Anatomy and Function of Marine Vertebrates	3
BIOSM 3740	Field Ornithology	3
BIOSM 4650	Shark Biology and Conservation	3

Plant Biology

In addition to the concentration requirements outlined below, all students must complete the Biological Sciences foundation requirements:

- Biological Sciences Foundation Requirements (p. 1)

Plants are essential as they are the primary producers and almost everything we eat is derived from them either directly or indirectly. As Earth population is expanding while the climate continuous to change, plant science is critical to save Earth and could help to save millions of lives. The Plant Biology Concentration is designed for students who are interested in gaining a greater understanding of the structure, classification, evolution, ecology, function, development, and molecular biology of plants. It is applicable to areas that encompass either wild or cultivated/agricultural plants, or both.

Experience in working with the plants themselves is essential to obtain a grasp of the theoretical aspects of plant science. For this reason, there is a strong emphasis on laboratory work in plant biology courses. Through formal courses and independent studies, students learn skills that prepare them to address relevant questions in plant biology such as: bioprospecting of plant secondary products as potential pharmaceuticals, plant biodiversity, evolution and phylogenetic relationships among plants including agriculturally important species, adaptation of plants to climate change and environmental stress, competition among plants for limiting resources (light and nutrients), and how plants can be manipulated to make them more useful for humans (biofuels, production of specific compounds). In addition, many laboratories are engaged in basic research addressing our most fundamental understanding of plant biology at all levels of biological organization. Students are strongly encouraged to undertake independent research projects as a part of their training, and many professors are eager to work with students interested in performing research and honors theses in their labs. For both the Plant Evolutionary Biology and Plant Biotechnology options, BIOG 4990 Independent Undergraduate Research in Biology (or the equivalent in other departments) for research in the plant sciences can be used towards the required number of credits (up to 3 credits) with the approval of the faculty advisor.

The University maintains growth chamber facilities, research greenhouses, a teaching conservatory, the fifth larger US university herbarium, and field laboratories necessary for plant research. In addition to wild and managed land areas, which play a strategic part in the study of plants at Cornell, the local countryside offers diverse habitats for plant growth. The natural environment is used in research and teaching programs.

Many students who pursue the Plant Biology concentration are interested in continuing their education beyond the bachelor's degree which include Masters, PhD and MD postgraduate degrees. Because the tools of research in both fundamental and applied aspects of plant science are basically the same, a concentration in plant biology provides a strong background for graduate study in either area.

Holders of a bachelor's degree may be employed as teachers, research assistants, or technicians in public and private institutions. Employment opportunities in teaching and research are increased by advanced study.

The concentration offers two options: (a) Plant Evolutionary Biology and (b) Plant Biotechnology. Option (a) focuses on plant evolution, adaptation and interactions with the environment. Students are required to take introductory plant biology and plant physiology courses and a minimum of six additional credits from a group of courses covering plant anatomy, plant cell biology, development, ecology, taxonomy, and evolution. Option (b) is primarily for students who wish to specialize in the molecular biology of plants and its agricultural applications. It centers on the Molecular Biology and Genetic Engineering of Plants and Plant Physiology courses. Students should take at least seven credits of other courses in plants and biotechnology. Students are required to select courses from the list provided in the courses of study to complete the concentration; however, if students find another relevant course that is not listed, they may petition the Director of Undergraduate Studies via the biological sciences petition to use that course for the concentration. Teaching Assistant positions will not count towards concentration credits.

Plant Biology Requirements

- All requirements must be taken for letter grade unless the course is offered S/U only. Exceptions to the grading option and any course substitutions must be approved via the biological sciences petition (https://qafederation.ngwebsolutions.com/sp/startSSO.ping?PartnerIdpId=https://shibidp.cit.cornell.edu/idp/shibboleth&TargetResource=https%3A%2F%2Fdynamicforms.ngwebsolutions.com%2FSubmit%2FStart%2F889d159c-0bfd-489f-b1dc-ebbbabcdac94). Students are encouraged to discuss exceptions and course substitutions with their faculty advisor prior to submitting petition.

- A grade of D- or better must be obtained to count course for concentration.
- A minimum of 13 credits of concentration requirements.

Students choose one area of study from the following two options:

Option (a) Plant Evolutionary Biology

Code	Title	Hours
Students are required to take:		
PLSCI 2410	Introductory Plant Diversity and Evolution	3
PLSCI 3420	Plant Physiology, Lectures	3
PLSCI 3421	Plant Physiology, Laboratory	1
Students should then choose, with the aid of their faculty advisor, a minimum of three of the following courses for a total of at least 6 additional credits, to round out their botanical training:		6
BIOEE 4460	Plant Behavior and Biotic Interactions, Lecture (crosslisted)	
BIOEE 4461	Plant Behavior and Biotic Interactions, Laboratory (crosslisted)	
BIOG 4990	Independent Undergraduate Research in Biology (up to 3 credits, with the approval of the faculty advisor)	
PLSCI 2300	Global Plant Biodiversity and Vegetation	
PLSCI 2400	Green World, Blue Planet	
PLSCI 2430	Ecology and Evolution of Plants	
PLSCI 2470	Plants and Cultures around the World	
PLSCI 2480	Vascular Plant Systematics	
PLSCI 3430	Molecular Biology and Genetic Engineering of Plants	
PLSCI 3431	Laboratory in Molecular Biology and Genetic Engineering of Plants	
PLSCI 3440	Evolutionary Plant Biology	
PLSCI 3450	Basic Plant Anatomy	
PLSCI 4220	Comparative Plant Development: Evo-Devo	
PLSCI 4400	Phylogenetic Systematics	
PLSCI 4540	Plant Cell Biology	
PLSCI 4620	Plant Biochemistry	
PLSCI 4990	Independent Undergraduate Research in Plant Science [1]	
PLSCI 6831	Concepts and Techniques in Plant Biology	
PLSCI 6841	Plant Form and Function: Anatomy, Cell Biology, and Development	

[1] For research in the plant sciences (up to 3 credits, with the approval of the faculty advisor).

Option (b) Plant Biotechnology

Code	Title	Hours
Option (b) Plant Biotechnology		
Required Courses		
PLSCI 3430	Molecular Biology and Genetic Engineering of Plants	2
PLSCI 3431	Laboratory in Molecular Biology and Genetic Engineering of Plants	2
PLSCI 3420	Plant Physiology, Lectures	3
Select a minimum of seven additional credits from the following list to enhance botanical training, with guidance from a faculty advisor:		**7**
BIOEE 4460	Plant Behavior and Biotic Interactions, Lecture (crosslisted)	3
BIOEE 4461	Plant Behavior and Biotic Interactions, Laboratory (crosslisted)	1
BIOG 4990	Independent Undergraduate Research in Biology (up to 3 credits, with the approval of the faculty advisor)	1-8
PLSCI 2250	Plant Genetics	4
PLSCI 3421	Plant Physiology, Laboratory	1
PLSCI 4030	Genetic Improvement of Crop Plants	3
PLSCI 4070	Nutritional Quality Improvement of Food Crops	2
PLSCI 4080	Methods of Plant Breeding Laboratory	2
PLSCI 4220	Comparative Plant Development: Evo-Devo	2
PLSCI 4540	Plant Cell Biology	4
PLSCI 4620	Plant Biochemistry	3
PLSCI 6841	Plant Form and Function: Anatomy, Cell Biology, and Development	3

University Graduation Requirements Requirements for All Students

In order to receive a Cornell degree, a student must satisfy academic and non-academic requirements.

Academic Requirements

A student's college determines degree requirements such as residency, number of credits, distribution of credits, and grade averages. It is the student's responsibility to be aware of the specific major, degree, distribution, college, and graduation requirements for completing their chosen program of study. See the individual requirements listed by each college or school or contact the college registrar's office (https://registrar.cornell.edu/service-resources/college-registrar-directory/) for more information.

Non-academic Requirements

Conduct Matters. Students must satisfy any outstanding sanctions, penalties or remedies imposed or agreed to under the Student Code of Conduct (Code) or Policy 6.4. Where a formal complaint under the Code or Policy 6.4 is pending, the University will withhold awarding a degree otherwise earned until the adjudication process set forth in those procedures is complete, including the satisfaction of any sanctions, penalties or remedies imposed.

Financial Obligations. Outstanding financial obligations will not impact the awarding of a degree otherwise earned or a student's ability to access their official transcript. However, the University may withhold issuing a diploma until any outstanding financial obligations owing to the University are satisfied.

Additional Requirements for Undergraduate Students

The University has two requirements for graduation that must be fulfilled by all undergraduate students: the swim requirement, and completion of two physical education courses. For additional information about

fulfilling University Graduation Requirements, see the Physical Education website (https://scl.cornell.edu/pe/).

Physical Education

All incoming undergraduate students are required to take two credits (two courses) of Physical Education prior to graduation. It is recommended they complete the two courses during their first year at Cornell. Credit in Physical Education may be earned by participating in courses offered by the Department of Athletics and Physical Education (https://courses.cornell.edu/preview_program.php?catoid=60&poid=30232) and Cornell Outdoor Education, by being a registered participant on a varsity athletic team, or performing in the marching band.

Students with medical concerns should contact the Office of Student Disability Services (http://sds.cornell.edu/).

Swim Requirement

The Faculty Advisory Committee on Athletics and Physical Education has established a basic swimming and water safety competency requirement for all undergraduate students. Normally, the requirement is taken during the Fall Orientation process at Helen Newman Hall or Teagle Hall pools. The requirement consists of the following: jump or step feet-first into the deep end of the pool, float or tread for one minute, turn around in a full circle, swim 25 yards using any stroke(s) of choice without touching the bottom or holding on to the sides (there is no time limit) and exit from the water. Students who do not complete the swim requirement during their first year, during a PE swim class or during orientation subsequent years, will have to pay a $100 fee. Any student who cannot meet this requirement must register for PE 1100 Beginning Swimming as their physical education course before electives can be chosen.

If a student does not pass the swim requirement in their first Beginning Swimming PE class, then the student must take a second Beginning Swimming PE class (PE 1100 or PE 1101). Successful completion of two Beginning Swimming classes (based on attendance requirements) with the instructor's recommendation will fulfill the University's swim requirement.

Students unable to meet the swim requirement because of medical reasons should contact the Office of Student Disability Services (http://sds.cornell.edu/). When a waiver is granted by the Faculty Committee on Physical Education, an alternate requirement is imposed. The alternate requirement substitute is set by the Director of Physical Education.

College of Arts and Sciences Graduation Requirements

Undergraduate Degrees

Graduation Requirements for the Bachelor of Arts Degree

Credit Requirement: 120 academic credits are required, 100 of which must be taken in the College of Arts & Sciences. 100 credits in Arts & Sciences is a minimum number, as is the 120 credit total. A minimum of 80 credits must be in courses for which a letter grade was received. AP, IB, CASE and A-Level credits count toward the 120 total credits but not toward the 100 A&S credits. Transfer credits for non-transfer students cannot count towards the 100 A&S credits. (See list of courses (https://as.cornell.edu/registrar/courses-that-dont-count/) that do not count as academic credit.)

Residency Requirement: eight full-time semesters in residence (in person) are expected to complete degree requirements with a minimum of six full-time semesters being required. External transfer students must complete a minimum of four full-time residence semesters.

First-year Writing Seminar (FWS) Requirement: two courses are required. A 5 on either the AP English Composition or Literature exam, or a 7 on the IB HL English Literature or Language exam will count towards one of these seminars. First-year students should take an FWS during their first semester at Cornell and are required to complete two by the end of their sophomore year.

Foreign Language Requirement: a student must either pass an intermediate Cornell language course at the 2000-level or above (Option 1) or complete at least 11 credits in a single foreign language at Cornell (Option 2). AP and IB credits cannot complete this requirement, but usually indicate that a student can place into a higher level course. Note: Native speakers of a foreign language may be exempted from this requirement. For a list of language offerings and placement, see Language Study at Cornell.

Distribution Requirement: Must take a minimum of 8 courses of at least 3 credits to fulfill 10 distribution categories. How an individual course is categorized is indicated with the appropriate abbreviation in its course description. It is important to recognize that only courses with the proper designation in the catalog can be used toward fulfilling the distribution requirements in Arts and Sciences. Unless otherwise specified, variable credit courses, including independent study courses, may not be used for distribution credit.

Arts & Sciences Distribution Requirement Categories:

- Arts, Literature, and Culture (ALC-AS)
- Biological Sciences (BIO-AS)
- Ethics and the Mind (ETM-AS)
- Global Citizenship (GLC-AS)
- Historical Analysis (HST-AS)
- Physical Sciences (PHS-AS)
- Social Difference (SCD-AS)
- Social Sciences (SSC-AS)
- Statistics and Data Science (SDS-AS)
- Symbolic and Mathematical Reasoning (SMR-AS)

Distribution Requirement Definitions

Arts, Literature, and Culture (ALC-AS)

Courses in this area examine arts, literature, and culture in various contexts. Students gain insights into the interplay of individual or collaborative creativity and social practice, and understand the complexities of the expression of the human condition. Topics include the analysis of artworks and literary texts, and the belief systems of social groups, cultures, and civilizations; they also focus on artistic expression itself (in creative writing, performing arts, and media such as film and video).

Biological Sciences (BIO-AS)

Courses in this area focus on understanding a wide range of life forms, from single cells to plants, animals, and their ecosystems. Topics include the molecular and biochemical makeup of life, the sub-cellular, cellular and organismal structures of life, and the evolutionary relatedness of all life forms. Students learn to describe how organisms are connected to each other and to their physical environment. Many courses address how genetic information is expressed from DNA, and how this expression leads to complex function and behavior.

Ethics and the Mind (ETM-AS)

Courses in this area investigate the human mind and its capacities, ranging from cognitive faculties shared by humans and animals such as perception, to language and abstract reasoning, to the ability to form and justify ethical values. Courses investigating the mind may use the methodologies of psychology, linguistics, or philosophy. Those focusing on ethics explore ways of reflecting on questions that concern the nature of justice, the good life, or human values in general. Many courses combine these topics and methodologies.

Global Citizenship (GLC-AS)
Courses in this area examine the history, culture, politics, religion, and social relations of peoples in different parts of the world, as well as their interactions. They encourage students to think broadly about the global community and their place within it, beyond the boundaries of their particular national or cultural group, and cultivate skills of intercultural engagement that are vital to their role as global citizens. These courses introduce students to global challenges such as war and peace, social and economic inequalities, international migration, and environmental sustainability, and encourage students to think critically about international responses to these challenges.

Historical Analysis (HST-AS)
Courses in this area train students in the analysis of documentary, material, and oral evidence about social phenomena, institutions, events and ideas of the past. Students learn to evaluate and critically assess differing analyses and interpretations of former times so that they may acquire a better understanding of the origins and evolution of the present. Questions addressed in HA courses include why and under what circumstances changes have occurred in how people have interacted with one another and with the environments in which they live.

Physical Sciences (PHS-AS)
Courses satisfying this requirement provide an appreciation of how science generates and categorizes enduring knowledge of our physical world. This includes the physics, chemistry, and technology involved, of everything from light to atoms, DNA molecules, Earth science, our Solar system, and to the Cosmos. These courses expose students to both the process and some of the substance of science. By learning the universal aspects of scientific enquiry, students will be better equipped to form opinions on scientific issues that affect the world.

Social Difference (SCD-AS)
Courses in this area examine social differences relevant to the human experience. Social categories include class, race, ethnicity, indigeneity, nationality, language, religion, gender, sexuality, and ability as objects of study. Students develop a deeper understanding of these categories and their intersections. Topics may include: how hierarchies in power and status shape social differences; how social, economic and political systems can impact the interpretation of social differences; and how differences attributed to various groups are explained.

Social Sciences (SSC-AS)
Courses in this area examine social, economic, political, psychological, demographic, linguistic, and relational processes. Topics include understanding how different social contexts, for example neighborhoods, families, markets, networks, or political organizations, shape social life. Students learn to identify, describe, and explain the causes and consequences of social phenomena using quantitative and/or qualitative evidence based on systematic observation of the social world. They also learn to link evidence to theory through rigorous and transparent reasoning, and/or reflect critically on the concepts through which people make sense of the social world.

Statistics and Data Science (SDS-AS)
Courses in this area develop data literacy, essential to be an informed citizen in today's world. Students learn and apply statistical and computational techniques to effectively collect, visualize, analyze and interpret data, and present conclusions. Applications span a wide variety of contexts: providing a better understanding of the communities in which we live, guiding and enriching our lives, and driving forward scientific inquiry. Students gain an appreciation of how to ask the right questions, and how statistics can depend on the context, assumptions, and limitations of data.

Symbolic and Mathematical Reasoning (SMR-AS)
Courses satisfying this requirement help students develop the skills to solve problems through understanding abstract, logical relationships. Such skills include mathematical analysis of patterns and phenomena, modeling natural and technological systems, and creating algorithms essential to computation. These courses explore specific quantitative and symbolic methods, strategies for applying logical reasoning in diverse areas, and the intrinsic elegance of mathematics.

Major Requirement: students must complete the requirements for at least one major in A&S. See individual major listings for major requirements.

Physical Education Requirement: completion of the university requirement of two PE courses and passing the swim test. Note: physical education credit is not academic credit and does not count toward the 120 credits needed to graduate.

Policies on Applying Cornell and Non-Cornell Courses and Credits to Distribution Requirements

Restrictions on Applying AP/Test Credit and Courses from Other Institutions to the Distribution Requirements

- Students may not apply AP/test credit or transfer credit from another institution to the distribution requirements.
- Students who transfer to the college from another institution are under the above rules for advanced placement credit, but are eligible to have credit for post–high school course work taken during regular full-time semesters (not summer terms) at their previous institution count toward all distribution requirements. Transfer students receive a detailed credit evaluation when they are accepted for admission.

Restrictions on Applying Cornell Courses to the Distribution Requirements

- First-year writing seminars and ENGL 2880 Expository Writing or ENGL 2890 taken to satisfy a first-year writing seminar requirement may not count toward any other college or major requirement.
- Only courses with the proper designation in the Courses of Study can be used toward fulfilling the distribution requirements in Arts and Sciences.
- Students may not petition to change the category of any given course, nor may any faculty member change the category of a course for an individual student. Faculty members wishing to change the category for a course in which they are the primary instructor must petition the Educational Policy Committee for a change in category. If granted, the new category must be applied to the course as a whole and not for an individual student.

Courses That May Fulfill More Than One Requirement

- A course may fulfill more than one college requirement in any of the following situations:
- A course may be used to fulfill distribution and a major requirement (except if prohibited by one of the restrictions noted on applying AP/test credit, transfer credit, and Cornell courses to distribution requirements).
- A course may satisfy a maximum of two distribution categories. Students can only double-count distribution requirements on a maximum of two courses.
- A one-semester course in foreign literature (not language) or culture that is acceptable for certifying option 1 in that language may also be applied to the relevant distribution requirement.
- Courses may count toward any other requirement except first-year writing seminars.

Credit Requirement

Credits and Courses: Students must earn a minimum of 120 academic credits (which may include AP/test credits). Of the 120, a minimum of 100 must be from courses taken in the College of Arts and Sciences at Cornell.

Courses that do not count toward the 120 credits required for the degree. The College of Arts and Sciences does not grant credit toward the degree for every course offered by the university. Courses in military training, service as a teaching assistant, physical education, remedial or developmental training, precalculus mathematics, supplemental science and mathematics, offered by the Learning Strategies Center, and English as a second language are among those for which degree credit is not awarded. Students can view the list of courses that do not count for academic credit here (https://as.cornell.edu/registrar/courses-that-dont-count/).

Other cases in which a course may not receive credit include the following:

- A course identified as a prerequisite for a subsequent course may not be taken for credit once a student completes that subsequent course.
- A repeated course. (For more information, see "Repeating courses," below.)
- A "forbidden overlap," that is, a course with material that significantly overlaps with material in a course a student has already taken. Students should consult the list of Forbidden Overlaps for more information.

Courses that count toward the 100 required Arts and Sciences credits may include liberal arts courses approved for study abroad during a semester or academic year of full-time study (not summer abroad study), courses taken in certain off-campus Cornell residential programs, and a maximum of three courses that majors may accept from other colleges at Cornell as fulfilling major requirements. A&S courses taken in Cornell's summer session may count towards the 100 A&S credits.

Courses that do not count toward the 100 required Arts and Sciences credits include credits earned in other colleges at Cornell (except in the cases specifically noted in this section), transfer credits earned in any subject at institutions other than Cornell, and advanced placement/test credits. AP/test credits count as part of the 120 credits required for the degree but not as part of the 100 Arts and Sciences credits and may not be applied to distribution requirements. AP credits are posted on the transcript. If, subsequently, a student takes the course out of which they had placed, the AP credit will be removed because of the overlap in content.

Repeating Courses

Students occasionally need to repeat courses. Some courses, such as independent study, some music and performance courses, and specific topical seminars, in which content is significantly different, do grant credit when the course is taken more than once. For all repeated courses, both grades appear on the transcript and are included in both the term and cumulative GPA. For repeated courses that do not grant credit more than once, only one instance counts toward degree credits and requirements.

Residency Requirement

The College of Arts & Sciences is a residential community and students typically spend eight semesters of full-time study in residence to earn the B.A. degree.

The completion of a fall or spring term as a full-time registered student at Cornell counts as a semester in residence. Summer and winter terms at Cornell, study in Cornell's School of Continuing Education and at other institutions do not count as semesters of residence.

The residency requirement has two components: a minimum number of semesters in residence and a requirement to spend the last full-time semester of study in residence.

Students matriculating into the College of Arts & Sciences as first-year students must have a minimum of six semesters in residence before graduating. First-year matriculants into A&S can count up to two semesters in an approved off-campus program as semesters in residence. Approved off-campus programs include A&S approved study abroad programs, Cornell in Washington, Cornell in Rome, and the Cornell-China & Asia-Pacific Studies (CAPS) Program.

Students who transfer into the College of Arts & Sciences after matriculating in their first-year in another Cornell college (internal transfers) must have a minimum of six semesters in residence, and a minimum of two semesters in the College of Arts and Sciences before graduating. Internal transfers can count up to two semesters in an approved off-campus program as semesters in residence.

Students who transfer into Cornell from another institution (external transfers) must have a minimum of four semesters in residence, and a minimum of two semesters in the College of Arts & Sciences, before graduating. External transfers can count up to one semester in an approved off-campus program as a semester in residence.

In addition to the minimum number of semesters in residence, all students must complete their final full-time semester of study (i.e., the last semester in which at least 9 academic credits are needed to meet graduation requirements) in residence. Students who have fewer than 9 credits to complete degree requirements, and have met the minimum number of semesters residency requirement, may elect to complete their degree requirements during Cornell summer and winter terms registered as an A&S student or at another institution with approved transfer credit. Students cannot meet final degree requirements registered as an extramural student at Cornell.

Exceptions to the residence requirement are not petitionable.

Foreign Language Requirement

The faculty considers competence in a foreign language essential for an educated person. Studying a language other than one's own

helps students understand the dynamics of language, our fundamental intellectual tool, and enables students to understand another culture. The sooner a student acquires this competence, the sooner it will be useful. Hence, work toward the foreign language requirement should be undertaken in the first two years. Students postponing the language requirement for junior and senior years risk not graduating on time. Courses in foreign languages and/or literature are taught in the College of Arts and Sciences by the following departments: Africana Studies and Research Center, Asian Studies, Classics, Comparative Literature, German Studies, Linguistics, Near Eastern Studies, and Romance Studies. For a list of languages and placement see Language Study at Cornell.

The language requirement may be satisfied in one of the following ways:

Option 1 (FLOPI): Passing (a) a non-introductory foreign language course of 3 or more credits at Cornell at the 2000-level or above or (b) any other non-introductory course at the 2000-level or above conducted in a foreign language at Cornell. OR

Option 2: Passing at least 11 credits of study in a single foreign language (taken in the appropriate sequence) at Cornell.

Any exceptions to these rules will be noted elsewhere in individual department descriptions.

Students whose speaking, reading, and writing competence in a language other than English is at the same level we would expect our entering first-year students to have in English (as shown by completing high school in that language or by special examination during their first year here at Cornell) are exempt from the college's language requirement.

Major Requirement

Most departments and programs specify certain prerequisites for admission to the major; they are found on the pages for each department and program available at Degree Programs.

Students may apply for acceptance into the major as soon as they have completed the prerequisites and are confident of their choice. This may be as early as the second semester of their first year, and must be no later than the end of the second semester of sophomore year. A student without a major at the beginning of the junior year is not making satisfactory progress toward the degree and risks not being allowed to continue in the college. Undeclared first-term juniors must file a Late Declaration of Major form with Student Services and may be placed on a leave of absence during their junior year if they have not yet declared a major.

Double Majors

Completion of one major is required for graduation. Some students choose to complete more than one major. No special permission or procedure is required; students simply become accepted into multiple majors and are assigned to an advisor in each department. All completed majors are posted on the official transcript. Students are not allowed to continue their studies past their eighth semester to complete additional majors.

Early and Delayed Graduation

Graduating Early

A student may elect to graduate early if they are able to complete all graduation requirements in fewer than eight semesters.

Students must still satisfy the college's residency requirement as part of the graduation requirements. This residency requirement requires that students who are first-year matriculants into Cornell spend a minimum of six semesters in residence, external transfers must spend a minimum of four. To request an early graduation, students must notify the A&S Registrar's Office in KG 17 Klarman Hall or at as-studentservices@cornell.edu (as-studentservices@cornell.edu?subject=Early%20Graduation%20Request).

The earliest a student can request to graduate early and officially change their graduation date is immediately following the pre-enrollment period for their anticipated final semester. The student should have pre-enrolled in the classes required to meet the graduation requirements by the requested graduation date. The student must then complete Part I in DUST and have Part II completed by their major advisor.

Graduating Late: Ninth Term Enrollment

The Bachelor of Arts degree is expected to be completed in eight terms. If degree requirements cannot be completed in eight terms, students may seek permission to continue their studies. Requests will only be granted for students who have found themselves in emergent circumstances beyond their control which have prevented them from completing the degree in eight terms. Requests cannot be made until a student's final expected graduation term and will not be reviewed and approved until after the university drop deadline for that semester. Study beyond the eighth term is not automatically granted for the purposes of changing a major. Such requests must be discussed with a college academic advisor and require registrar approval. Requests to add an additional major or minor will not be approved for study beyond the eighth term.

If approved, students in the ninth and tenth term will be on a conditional status and will have restrictions placed on their enrollment to ensure successful completion of their degree. To request a ninth term, students must have their faculty advisor update Part II for any remaining major requirements. They will also need to submit a study plan to their college advisor listing the specific courses that will meet degree requirements for one major.

Student may elect to prorate credits if enrolling in 9 or fewer credits or take a full-time load if they desire. However, enrollment will be limited to 18 credits for the term so students can focus on their remaining required courses. In the rare case where a student may need to enroll in a tenth term to complete their degree, they will be required to prorate tuition and their enrollment will be limited to only the courses/credits needed for successful completion of one major. Additional enrollments will not be allowed.

Graduation Procedures

Application to Graduate

In the first semester of their senior year, students are prompted by Arts & Sciences Student Services to complete an online application to graduate. The application is intended to help seniors identify problems early enough in the final year to make any necessary changes in course selection to satisfy those requirements. Nonetheless, ensuring graduation requirements are fully met is the student's responsibility and any problems that are discovered, even late in the final semester, must be resolved by the student before the degree can be granted. Students are responsible for checking their DUST (https://data.arts.cornell.edu/as-stus/degree_reqts.cfm) reports and transcripts each term and alerting Student Services of any problems with their academic record. To check on their progress in the major, students should consult with their major advisors.

Degree Dates

Cornell has three official degree conferral dates in the year: December, May, and August. Students who plan to graduate in August may attend

commencement ceremonies in the preceding or subsequent May. Students graduating in December are invited to a special recognition ceremony in December and may also attend Commencement the following May. All academic work must be complete by the official conferral date in order to receive a degree on that date. Incomplete academic work will result in a later conferral date.

Honors

Notice: beginning with the December 2026 conferral date, Cornell University will institute a standardized Latin Honors system based solely on final cumulative undergraduate GPA. The Latin Honors categories include: Summa Cum Laude (top 5%), Magna Cum Laude (next 10%), and Cum Laude (next 15%).

The student's cumulative undergraduate GPA percentile at the time of degree conferral will be computed with respect to the student's particular college. Existing college-specific Latin Honors systems not based upon the new standardized criteria will be discontinued at the end of Summer 2026. This will apply to all major honors in Arts & Sciences as they will no longer use Latin Honors and will award "Honors in X" (e.g. Honors in Chemistry, Honors in English, etc.) Please see Graduation and Academic Honors for more information.

Bachelor of Arts with Honors

Almost all departments offer honors programs for students who have demonstrated exceptional accomplishment in the major and succeeded in research. The conferring of honors, and the requirements for conferral (cum laude, magna cum laude, or summa cum laude) are set by the departments for each major, the Independent Major Program, or the College Scholar Program. Minors do not offer honors programs. Students should contact the Director of Undergraduate Studies (https://as.cornell.edu/about/directors-undergraduate-study/) with questions about honors in the respective program.

Bachelor of Arts with Distinction

The degree of Bachelor of Arts with distinction in all subjects will be conferred on students who have completed the requirements for the degree of Bachelor of Arts, if they have met the following requirements by the end of their final semester:

1. completed at least 60 credits while registered in regular sessions at Cornell;
2. achieved a GPA in the upper 30 percent of their class at the end of the seventh semester, or next-to-last semester for transfers and accelerants;
3. received a grade below C– in no more than one course;
4. received no failing grade (excluding PE);
5. have no frozen Incompletes on their records; and
6. maintained good academic standing, including completing a full schedule of at least 12 academic credits, in each of their last four semesters. (Students who have been approved to have prorated tuition for their final semester are considered to be in good academic standing).

Learning Outcomes

After successfully completing the biological sciences major, students will be able to:

- Explain the basic structures and fundamental processes of life over a range of levels of organization within the full scope of biology from molecules to ecosystems, integrated with the basic principles of inheritance and evolution.
- Apply quantitative reasoning and basic principles from the physical sciences to thinking about biology.
- Explain principles by which hypotheses can be evaluated scientifically using examples of observations and experiments that have shaped biological thought.
- Explain, evaluate, and effectively interpret claims, theories, and assumptions in the biological sciences, including those presented in the scientific literature.
- Communicate scientific arguments and ideas clearly and explicitly through writing and speech.
- Demonstrate a deeper working knowledge of one or more biology disciplines (specific outcomes defined by the programs of study).

Animal Physiology Concentration Curriculum Learning Outcomes

After completing the concentration in Animal Physiology, students will be able to:

- Broadly define the structure and function of animals and explain the mechanisms and regulation of animal life at different levels of organization from the cell to the whole organism.
- Assess living systems as biological machines subject to the laws of physics and chemistry, but capable of creating and maintaining steady states.
- Bridge the genotype-phenotype gap by integrating molecular detail in the function of cells, tissues, organs and organisms, and to demonstrate how known gene mutations align with known pathophysiologies exhibited by the whole organism.
- Design and analyze basic laboratory experiments probing physiological mechanisms at all levels of organization from genes to the whole organisms.
- Take a rigorous approach to evaluating new questions in physiology or pathophysiology by navigating the scientific literature including databases.
- Explain physiological studies, experiments, and findings in written and oral formats to diverse audiences from layperson to the scientist.

Biochemistry Concentration Curriculum Learning Outcomes

After completing the concentration in Biochemistry, students will be able to:

- Summarize the fundamentals of biochemistry, including the structure and function of macromolecules, the expression of genes, the organization of metabolic pathways, and the mechanisms enzyme action.
- Use quantitative reasoning to solve biochemical problems by employing the basic principles of physical and chemical sciences.
- Design of experiments that underpin biochemical generalizations, possess basic biochemical laboratory skills, use modern instrumentation and techniques, as well as interpret and analyze data from biochemical experiments.
- Communicate the fundamental concepts of biochemistry, both in written and oral forms.
- Read and critically evaluate the primary scientific literature in biochemistry.

Computational Biology Concentration Curriculum Learning Outcomes

After completing the concentration in Computational Biology, students will be able to:

- Have sufficient background knowledge in mathematics, probability, and statistics to be able to conceptualize key quantitative aspects of biological processes at the cellular, organismal or population level.
- Have the ability to apply computational and mathematical methods to model and/or analyze biological processes.
- Have acquired working skills in at least one computer programming language to be able to implement modeling approaches.
- Be able to organize, manipulate, and maintain the integrity of large, complex data sets.
- Have developed advanced knowledge in at least one area of computational, statistical, mathematical, and/or quantitative modeling or analysis of data from biology. This includes background knowledge of the current literature in the field, and ability to assess the merits of current literature.

General Biology Concentration Curriculum Learning Outcomes

After completing the concentration in General Biology, students will be able to:

- Demonstrate breadth of understanding in three subdisciplines
- Develop advanced technical competence in a laboratory, field, or computational subdiscipline
- Explain and analyze advanced concepts in at least one subdiscipline

Human Nutrition Concentration Curriculum Learning Outcomes

After completing the concentration in Human Nutrition, students will be able to:

- Demonstrate core knowledge of metabolism and the function of the essential nutrients.
- Apply knowledge of the biological aspects of nutrition to the regulation of human health.

Marine Biology Concentration Curriculum Learning Outcomes

After completing the concentration in Marine Biology, students will be able to:

- Articulate understanding of the diversity of marine organisms, their evolutionary history and adaptations to their environments.
- Form hypotheses about marine-related scientific topics.
- Design and execute experiments to test marine-related scientific questions.
- Synthesize knowledge of physical and chemical processes of the ocean and the biology of organisms to ask questions about natural history and ecology.
- Articulate the impact of habitat perturbation on marine organisms, and subsequent ecosystem-level consequences and feedbacks.

We will assess learning outcomes through student surveys, in-class discussions, and examinations in consultation with the Directors of Undergraduate Studies for other concentrations.

Microbiology Concentration Curriculum Learning Outcomes

After completing the Concentration in Microbiology, students will be able to:

- Demonstrate an understanding of core concepts of microbiology, including the evolution and diversity of microbes; cell structure and function; metabolism; information flow and the role of microbes in human and non-human ecosystems.
- Apply the basic principles of chemistry and quantitative reasoning to solve problems in microbiology.
- Demonstrate an understanding of hypotheses testing and experimental design.
- Display proficiency in basic microbiological skills.
- Communicate the fundamental concepts of microbiology, both in written and in oral format.
- Analyze, interpret and evaluate a range of scientific literature in microbiology.

Neurobiology and Behavior Concentration Curriculum Learning Outcomes

After completing the concentration in Neurobiology and Behavior, students will be able to:

- Demonstrate, through writing, speaking, and problem solving, a mastery of core principles and concepts in Neurobiology and Behavior using multiple levels of analysis by asking both "How" and "Why" questions about causation of behavior at the levels of molecules, cells, neural circuits, and whole organisms.
- Utilize the scientific method to make observations, analyze data, and form strong (i.e., falsifiable) predictions in the field of Neurobiology and Behavior which can be rigorously tested through further observation and experimentation.
- Compare human behavior to the behavior of non-human animals leading to an appreciation of how the study of behavior is relevant social systems, to other courses, to their own lives, and to interpreting the world around them.
- Demonstrate mastery of the following core concepts through writing, speaking or problem solving:
  - The relationships among classical Darwinian selection; kin selection, and sexual selection, and the differences in their evolutionary outcomes.
  - Principles of game theory and its usefulness in studies of inclusive fitness theory applied to deciphering animal cooperation and conflict.
  - Principles of animal communication, plant/animal co-evolution and chemical communication.
  - How information is encoded by neurons and neural circuits: how perceptions are represented, stored, and recalled for later use in decision making
  - How the laws of chemistry and physics apply to basic principles of neuronal and synaptic function, and how to solve problems related to the generation of electrical impulses, the function of synapses, and the formation of short and long-term memories.
  - The major components of the central nervous system of humans, and their functional roles to the extent that they are known.

- How the nervous system is built during development, how it changes during experience in life, and how it is disrupted by injury and disease.

Plant Biology Concentration Curriculum Learning Outcomes

After completing the concentration in Plant Biology, students will be able to:

- Demonstrate an understanding of core concepts and factual information from diverse areas of plant biology by placing these in an integrated conceptual framework that encompasses all of plant biology and biology in general.
- Apply factual and conceptual information to problems in basic and applied plant biology.
- Formulate hypotheses, design and carry out experiments, and analyze and interpret data.
- Show proficiency in reading, interpreting and evaluating scientific literature in plant biology.
- Effectively communicate their understanding of plant biology in both oral and written formats.