

BIOLOGICAL SCIENCES (BS)

College of Agriculture and Life Sciences

Program Website (<https://cals.cornell.edu/biological-sciences/>)

CIP: 26.0101 | HEGIS: 0401.00 | NYSED: 13088

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).

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:		
<i>Cell Biology</i>		
BIOMG 1350	Introductory Biology: Cell and Developmental Biology	
<i>Physiology</i>		
BIOG 1440	Introductory Biology: Comparative Physiology	
or BIOG 1445	Introduction to Comparative Anatomy and Physiology, Individualized Instruction	
<i>Ecology</i>		
BIOSM 1610	Ecology and the Marine Environment	
or BIOSM 1615	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	
BIOEE 1780	An Introduction to Evolutionary Biology and Diversity (Shoals Marine Lab)	

General Chemistry: (4-8 Credits)

Code	Title	Hours
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Select one of the following options:

Option 1

CHEM 2070 & CHEM 2071	General Chemistry I and General Chemistry I Laboratory	
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CHEM 2080 & CHEM 2081	General Chemistry II and General Chemistry II Laboratory	
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Option 2

CHEM 2150	Honors General and Inorganic Chemistry	
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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
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Select one of the following: 3-6

CHEM 1570	Introduction to Organic and Biological Chemistry	
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CHEM 3570 & CHEM 3580	Organic Chemistry for the Life Sciences and Organic Chemistry for the Life Sciences	
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CHEM 3570 & CHEM 2510	Organic Chemistry for the Life Sciences and Introduction to Experimental Organic Chemistry	
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CHEM 3590 & CHEM 3600	Honors Organic Chemistry I and Honors Organic Chemistry II	
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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
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Select one of the following: 8

PHYS 1101 & PHYS 1102	General Physics I and General Physics II	
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PHYS 2207 & PHYS 2208	Fundamentals of Physics I and Fundamentals of Physics II	
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PHYS 1112 & PHYS 1110 & PHYS 2213	Physics I: Mechanics and Heat and Introduction to Experimental Physics and Physics II: Electromagnetism ¹
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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-ebbbabacd94>). 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
<i>Lecture ²</i>		
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	
<i>Laboratory (minimum 4 credits) ²</i>		
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-ebbbabacd94>). 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	
BIOMG 3300 & BIOMG 3340	Principles of Biochemistry: Molecular Biology and Principles of Biochemistry: Individualized Instruction	
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-ebbbabdc94>). 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-ebbbabdc94>) 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		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:

- computational and statistical genomics,
- population, comparative, and functional genomics,
- bioinformatics,
- proteomics,
- ecology and evolutionary biology, and
- 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-ebbbabacd94>).

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-ebbbabacd94>). 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-ebbbabacd94>). 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-ebbbabacd94>). Exceptions may 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, BIONB 4300, NS 3420, PLSCI 2410. 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-ebbbabacd94>) 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 at 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-ebbbabacd94>). 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 (Python), CS 1112 (Matlab), CS 1132 (Matlab). 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-ebbbabacd94>) 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-ebbbabacd94>).
- 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-ebbbabacdac94>). 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-ebbbabacd94>). 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
VLEN 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:		
BIOMG 3310 & BIOMG 3320	Principles of Biochemistry: Proteins and Metabolism and Principles of Biochemistry: Molecular Biology	5
BIOMG 3300 & BIOMG 3340	Principles of Biochemistry, Individualized Instruction and Computer Graphics and Molecular Biology	

Cell Biology

BIOMG 4320	Survey of Cell Biology
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A Laboratory Course in Molecular Biology

BIOMG 4400	Laboratory in Biochemistry and Molecular Biology or BIONB 431Experimental Molecular Neurobiology
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Additional Credits¹

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
BIOISM 3450	Marine Mammal Biology	3
BIOISM 3210	Anatomy and Function of Marine Vertebrates	3
BIOISM 3740	Field Ornithology	3
BIOISM 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 continues 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 largest 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-ebbbabcbdac94>). 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
Students are required to take:		
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
Students choose, in consultation with their faculty advisor, a minimum of 7 additional credits from the following list:		7

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 2250	Plant Genetics
PLSCI 3421	Plant Physiology, Laboratory
PLSCI 4030	Genetic Improvement of Crop Plants
PLSCI 4070	Nutritional Quality Improvement of Food Crops
PLSCI 4080	Methods of Plant Breeding Laboratory
PLSCI 4220	Comparative Plant Development: Evo-Devo
PLSCI 4540	Plant Cell Biology
PLSCI 4620	Plant Biochemistry
PLSCI 6841	Plant Form and Function: Anatomy, Cell Biology, and Development

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.

CALS Graduation Requirements for the Bachelor of Science

Students are responsible for understanding and fulfilling all the requirements necessary for graduation. Additionally, students must promptly notify the college of any discrepancies or issues with their academic records.

CALS undergraduate students follow college distribution requirements corresponding to their matriculation/entry term and class standing. Students matriculating/entering before Fall 2025 will complete the existing CALS distribution requirements. First-year students matriculating/entering Fall 2025 or later will be subject to the new CALS 2025+ distribution requirements. However, sophomore and junior transfer students matriculating/entering in Fall 2025 will follow the existing CALS distribution requirement to align with students in their corresponding cohort year. All students must adhere to the requirements designated for their matriculation/entry term and class standing. *There are no exceptions to this policy.*

Although specific requirements vary between the curriculums, all students must complete the following Graduation Requirements to earn the Bachelor of Science degree:

1. University Graduation Requirements
2. Credit Requirements
3. Distribution Requirements
4. Residency Requirement
5. GPA Requirement
6. Major Requirements
7. Application to Graduate

Credit Requirement Policies

1. Minimum total credits: 120 academic credits are required for graduation.
 - Important Exceptions:
 - Repeated Cornell courses that do not allow repeat for credit will not count towards the number of credits required for graduation. These credits do count toward the minimum twelve (12) credits required for full-time status and good academic standing.
 - Forbidden Overlaps will not count towards credits required for graduation. These credits do count toward the minimum twelve (12) credits required for full-time status and good academic standing. More information can be found under the Course Enrollment and Credits page.
 - Review or supplemental courses (e.g., 1000- to 1099-level) do not count towards the number of credits required for graduation. These credits do not count toward the minimum twelve (12) credits required for full-time status or good academic standing.
 - Physical Education courses do not count toward the required 120 credits for graduation. They also do not count toward the minimum twelve (12) credits required for full-time status or good academic standing.
2. Minimum Credits at Cornell: Sixty (60) academic credits must be completed at Cornell (includes Cornell in Rome, Capital Semester, and Brooks School Cornell in Washington DC Connect Program, and Shoals Marine Laboratory).
3. Maximum Non-Cornell Credits: Sixty (60) non-Cornell credits (AP, CASE, IB, GCE, French Baccalauréat, Cambridge Pre-University, and external transfer coursework) can be applied toward degree requirements. A student can transfer in a maximum of fifteen (15) academic credits earned before matriculation as a first-year student at any accredited college/university (AP, CASE, IB, GCE, French Baccalauréat, and external transfer credits). Refer to Non-Cornell (Transfer) Credit under Policies and Procedures for additional information.
4. All CALS students are required to fulfill a minimum number of CALS Credits, structured credits, and letter-graded credits. Specific policies are in the curriculum sections below.

Residency Requirements

- Eight (8) semesters of full-time study are expected. External transfer students are credited with one (1) semester in residence for each full-time semester (or equivalent) completed at another accredited institution prior to matriculation at Cornell.
- Internal transfer students must complete two (2) semesters in residence in CALS.

- The final semester before graduation must be completed in a Cornell program as a full-time student. Summer or winter semesters cannot be counted as a final semester. (The School of Continuing Education does not count towards a final semester in residency.)
- Students in the ninth (9th) (or equivalent) and final semester may be eligible to apply for prorated tuition. The eligibility criteria are listed online (<https://cals.cornell.edu/undergraduate-students/cals-student-services/degree-advising/cals-graduation-requirements-for-bachelor-of-science/>).
- The following programs are in residency: Cornell in Washington DC Connect Program (Fall or Spring only), Capital Semester, Shoals Summer Semester.

Grade Point Average (GPA) Requirements

Minimum cumulative GPA: 2.00 or above must be maintained. Students must earn a minimum cumulative GPA of 2.00 or better to graduate. The cumulative GPA includes all letter grades earned at Cornell.

CALS Degree Requirements Prior to 2025 (applies to Transfers entering Fall 2025)

These requirements apply to: First-year students who matriculated before Fall 2025, sophomore transfers who matriculate prior to Fall 2026, and junior transfers who matriculate before Fall 2027. All students must follow the requirements based on their matriculation and expected graduation dates. *There are no exceptions to this policy.*

Students are required to fulfill:

1. University Graduation Requirements:
 - a. Physical Education.
 - b. Swim Requirement.
2. Credit Requirements: 120 academic credits, of which a minimum of fifty-five (55) must be taken from the College of Agriculture and Life Sciences at Cornell. A minimum of one hundred (100) credits must be in courses for which a letter grade was received. PE and supplemental courses do not count as academic credit.
 - a. Fifty-five (55) CALS Credits are required for graduation. CALS Credits consist of courses offered within CALS and in Applied Economics and Management, Biological Sciences, Biology & Society, Earth and Atmospheric Sciences, Environment and Sustainability, Information Science, Nutritional Science, and the Department of Statistics and Data Science. CALS Credits include all courses with the following subjects: AGSCI, AIISP, ALS, AEM, ANSC, BEE, BIOG, BIOAP, BIOCB, BIOEE, BIOMG, BIOMI, BIOMS, BIONB, BIOSM, BSOC, BTRY, COMM, DSOC, EAS, EDUC, ENTOM, ENVS, FDSC, GDEV, IARD, INFO, LA, LEAD, NS, NTRES, PLBIO, PLBRG, PLHRT, PLPPM, PLSCI, PLSCS, STSCI, VIEN.
 - b. Minimum Letter-Graded Credits: One hundred (100) credits. Proration of letter-graded credits may be applicable to students that transfer non-Cornell credits (see Proration Chart for non-Cornell credit (<https://experience.cornell.edu/sites/default/files/resource-files/Proration%20Chart%20for%20Students%20with%20Non%20Cornell%20Credit.pdf>)).
 - c. Maximum Credits earned through Special Studies (Independent Study, Research, Teaching Assistantships, and/or Internships): Fifteen (15) credits of "unstructured" coursework can be applied towards graduation requirements. Proration of structured credits may be applicable to students that transfer non-Cornell credits (see Proration Chart for non-Cornell credit (<https://experience.cornell.edu/sites/default/files/resource-files/Proration>

[%20Chart%20for%20Students%20with%20Non%20Cornell%20Credit.pdf](https://experience.cornell.edu/sites/default/files/resource-files/Proration%20Chart%20for%20Students%20with%20Non%20Cornell%20Credit.pdf))).

3. Residency: Eight (8) semesters of full-time study are expected. External transfer students are credited with one (1) semester of residence for each full-time semester (or equivalent) completed at another accredited institution prior to matriculating at Cornell.
4. GPA: Students must earn a minimum cumulative GPA of 2.00 or better to graduate. The cumulative GPA includes all letter grades earned at Cornell.
5. Physical and Life Sciences: Eighteen (18) credits, of which six (6) credits must be Introductory Life Sciences/Biology and three (3) credits must be Chemistry or Physics.
6. Quantitative Literacy: Faculty legislation requires minimum competency in quantitative literacy. This requirement can be satisfied by taking an approved calculus or statistics class.
7. Social Science and Humanities: Students must complete four (4) courses within the seven (7) categories of Humanities and Social Sciences. The courses MUST span at least three (3) different categories. Human Diversity (D) is a required category. Humanities courses must be a minimum of three (3) credits.
8. Written and Oral Expression: Nine (9) credits total, of which at least six (6) must be in Written Expression. Oral Expression is not required by the college but may be required for some majors. If Oral Expression is not required by the major, all nine credits may be in Written Expression.
9. Major: See individual department listings for major requirements.
10. Application to Graduate: See Graduation Resources (<https://cals.cornell.edu/undergraduate-students/cals-student-services/graduation-resources/>).

Distribution Requirements

The purpose of the distribution requirement is to have all students achieve common learning outcomes. It is expected that through college and major course requirements graduates will be able to:

- Explain, evaluate, and effectively interpret factual claims, theories, and assumptions in the student's discipline(s) (especially in one or more of the college's priority areas of Food & Energy Systems, Social Sciences, Life Sciences, and Environmental Sciences) and more broadly in the sciences and humanities.
- Find, access, critically evaluate, and ethically use information.
- Integrate quantitative and qualitative information to reach defensible and creative conclusions.
- Communicate effectively through writing, speech, and visual information.
- Articulate the views of people with diverse perspectives.
- Demonstrate the capability to work both independently and in cooperation with others.

Through the study of Physical and Life Sciences, students develop their understanding and appreciation of the physical sciences, enhance their quantitative reasoning skills, and gain an appreciation of the variability of living organisms. Social Sciences and Humanities gives students perspective on the structure and values of the society in which we live and prepares them to make decisions on ethical issues that will affect their work and role in society. Written and Oral Expression is designed to help students become competent and confident in the use of oral and written communication to express themselves and their ideas.

Important Notes:

- Credits received for independent study, fieldwork, teaching, research, work experience, and internships cannot be used to fulfill the distribution requirements
- Review or supplemental courses, such as 1000- to 1099-level courses, will not be counted in the distribution areas.
- First-Year Writing Seminars (FWS) cannot be used to satisfy the Physical and Life Sciences distribution area.
- Courses that fulfill distributions are approved by the CALS Curriculum Committee. Distributions cannot be applied to a course retroactively, and individual student petitions for Cornell courses to fulfill distributions will not be accepted. Students may request a review of external transfer courses for fulfilling distribution requirements.

Physical and Life Sciences:

Eighteen (18) credits, of which six (6) credits must be Introductory Life Sciences/Biology and three (3) credits in Chemistry or Physics. Courses that count for Introductory Life Sciences/ Biology, Chemistry/Physics, Quantitative Literacy, and Other Physical and Life Sciences count towards the eighteen (18) credits for this requirement

Introductory Life Sciences/Biology Requirement (BIO-AG):

Students must complete at least six (6) academic credits of Introductory Life Sciences/Biology. Courses that count towards this requirement have the BIO-AG distribution attribute. Note: CALS does NOT accept BIO-AS for BIO-AG.

Offerings in the area provide a foundation in the field of biology. Courses must include: an evolutionary component, instruction on applying the process of science and a significant student-centered teaching component.

Chemistry/Physics (CHPH-AG):

Students must complete a minimum of three (3) credits of Chemistry or Physics. Includes all Cornell courses with the CHEM or PHYS prefix (excluding courses that are supplemental, independent study, research, TA, internship, and First-Year Writing Seminar). Courses that count towards this requirement have a CHPH-AG distribution attribute. Additionally, courses with the prefix CHEM or PHYS of at least 11xx numbering and a minimum of three (3) credits are accepted as fulfilling CHPH-AG.

Courses that meet the CALS Chemistry or Physics (CHPH) requirement provide students with a foundational understanding of key scientific principles. These courses delve into the study of chemistry (focusing on the composition, properties, and transformations of substances) or physics (exploring the principles of matter, energy, and their interactions). Fulfilling this requirement equips students with essential scientific knowledge that supports practical and innovative applications in fields like agriculture, environmental science, and food science, thereby fostering their ability to address and solve critical challenges within these domains.

Quantitative Literacy (MQL-AG):

Students must complete one (1) Quantitative Literacy course. Courses that count towards these requirements have an MQL-AG distribution attribute. Additionally, courses of at least 11xx numbering with the MATH prefix may fulfill this category. Calculus courses and Introductory Statistics courses may also fulfill MQL-AG.

Faculty legislation requires minimum competency in quantitative literacy. Courses that fulfill the Mathematics and Quantitative Literacy distribution in CALS enhance students' problem-solving skills by teaching them to understand abstract, logical relationships. These classes focus on the

mathematical analysis of data, modeling natural and man-made systems, and developing algorithms critical for computation. Students will learn various quantitative methods and how to apply quantitative reasoning across different fields.

This requirement can also be satisfied by earning a score of four (4) or five (5) on the AP Calculus exam or a score of five (5) on the AP Statistics exam, or transfer of an approved calculus or statistics course with a minimum letter grade of "C" or better.

Other Physical Life Sciences (OPHLS-AG):

Other Physical Life Sciences courses count towards the eighteen (18) credit total for the Physical and Life Sciences requirement. Courses that count towards this requirement have the OPHLS-AG distribution attribute. The number of OPHLS-AG courses taken will vary by student. Courses with the following distributions are also accepted for the CALS OPHLS-AG distribution: PBS-HE, BIO-AS, PHS-AS, SDS-AS. Additionally, any course with BIO-AG, CHPH-AG or MQL-AG may alternatively fulfill OPHLS-AG.

Offerings in this area explore additional physical and life science subjects as well as quantitative literacy (math) courses. Courses satisfying this requirement help students understand and appreciate the physical sciences, enhance quantitative reasoning skills, or explore the variability of living organisms.

Social Sciences and Humanities:

Students must complete four (4) courses within the seven (7) categories of Humanities and Social Sciences. The courses MUST span at least three (3) different categories. Human Diversity (D) is a required category. Humanities courses must be a minimum of three (3) credits.

No more than two (2) courses in the same department will be counted toward the distribution requirement. Social Sciences & Humanities Categories:

(Also refer to Distribution Requirement Codes (<https://catalog.cornell.edu/general-information/distribution-codes/>))

Cultural Analysis (CA-AG)

These courses study human life in particular cultural contexts through interpretive analysis of individual behavior, discourse, and social practice. Topics include belief systems (science, medicine, religion), expressive arts and symbolic behavior (visual arts, performance, poetry, myth, narrative, ritual), identity (nationality, race, ethnicity, gender, sexuality), social groups and institutions (family, market, community), and power and politics (states, colonialism, inequality).

CALS also accepts courses of at least three (3) credits with the following distributions as fulfilling CA-AG: ALC-AS, ALC-HA, ALC-AAP, CA-HE, CA-AAP, GLC-AS

Foreign Language (FL-AG)

Foreign Language courses available for CALS students at Cornell are offered by several departments, including Africana Studies and Research Center (AS&RC – language courses only), Asian Studies with languages such as Bangla-Bengali, Burmese, Chinese, Hindi, Indonesian, Japanese, Khmer, Korean, Sanskrit, Tagalog, Thai, and Vietnamese, and Classics (CLASS – language courses only). Additional offerings are provided by German Studies, which includes German, Dutch, and Swedish (language courses only), Linguistics (LING – language courses only), Near Eastern Studies (NES - language courses only), Romance Studies with languages like Catalan, French, Italian, Portuguese, Quechua, and Spanish, and Russian Studies, covering Russian, Hungarian, Polish, Serbian/Croatian, and Ukrainian. CALS will recognize these Foreign

Language (FL) classifications by any college at Cornell, provided the class is taken for three (3) or more credits. Transfer students may have non-Cornell courses that meet SUNY World Languages requirements and are a minimum of three (3) credits reviewed as fulfilling FL-AG.

Human Diversity (D-AG)

These courses analyze historical or contemporary marginalized communities and the culturally specific contexts that produce unequal power relations in terms of race, nationality, ethnicity, indigeneity, sexuality, disability, religion, gender, or economic status.

Definition of “marginalize”: Any groups with reduced access to social status, political influence, economic advancement, educational advancement, healthcare, information, or any of the goods, services, and powers of a society can be considered “marginalized.” Causes of marginalization may be related to ethnic status, religion, country of origin, sexual orientation, geography, economics, and government policies. Those who exist on the furthest margins of a society are frequently subject to several of these forces.

CALS also accepts courses of at least three (3) credits with the following distributions as fulfilling D-AG: SCD-AS, SCD-HA, D-HE.

Non-equated external transfer courses will only be considered for junior transfer students who have taken an appropriate course at their prior institution and whose schedule does not allow space to take a Human Diversity (D-AG) course at Cornell. These situations will be reviewed individually after a required appointment with CALS Student Services.

Historical Analysis (HA-AG)

These courses interpret continuities and changes—political, social, economic, diplomatic, religious, intellectual, artistic, scientific—through time. The focus may be on groups of people, dominant or subordinate, a specific country or region, an event, a process, or a time period.

CALS also accepts courses of at least three (3) credits with the following distributions as fulfilling HA-AG: HA-AAP, HST-AAP, HST-AS, HST-HA, HA-HE

Knowledge, Cognition, and Moral Reasoning (KCM-AG)

These courses investigate the bases of human knowledge in its broadest sense, ranging from cognitive faculties shared by humans and animals such as perception, to abstract reasoning, to the ability to form and justify moral judgments. Courses investigating the sources, structure, and limits of cognition may use the methodologies of science, cognitive psychology, linguistics, or philosophy. Courses focusing on moral reasoning explore ways of reflecting on ethical questions that concern the nature of justice, the good life, or human values in general.

CALS also accepts courses of at least three (3) credits with the following distributions as fulfilling KCM-AG: ETM-AAP, ETM-AS, ETM-HA, KCM-AAP, KCM-HE

Literature and the Arts (LA-AG)

These courses explore literature and the arts in two different but related ways. Some courses focus on the critical study of artworks and on their history, aesthetics, and theory. These courses develop skills of reading, observing, and hearing and encourage reflection on such experiences; many investigate the interplay among individual achievement, artistic tradition, and historical context. Other courses are devoted to the production and performance of artworks (in creative writing, performing arts, and media such as film and video). These courses emphasize the interaction among technical mastery, cognitive knowledge, and creative imagination.

CALS also accepts courses of at least three (3) credits with the following distributions as fulfilling LA-AG, ALC-AS, ALC-HA, ALC-AAP, LA-AAP

Social and Behavioral Analysis (SBA-AG)

These courses examine human life in its social context through the use of social scientific methods, often including hypothesis testing, scientific sampling techniques, and statistical analysis. Topics studied range from the thoughts, feelings, beliefs, and attitudes of individuals to interpersonal relations between individuals (e.g., in friendship, love, conflict) to larger social organizations (e.g., the family, society, religious or educational or civic institutions, the economy, government) to the relationships and conflicts among groups or individuals (e.g., discrimination, inequality, prejudice, stigmas, conflict resolution).

CALS also accepts courses of at least three (3) credits with the following distributions as fulfilling SBA-AG: SSC-AS, SBA-HE, SBA-AAP, SSC-AAP

Written and Oral Expression:

Nine (9) credits total, of which at least six (6) must be in Written Expression. Oral Expression is not required by the college but may be required for some majors. If Oral Expression is not required by the major, all nine (9) credits may be in Written Expression. Writing in the Majors (WIM) courses do not count towards Written Expression.

Written Expression (WRT-AG)

All students are required to take at least six (6) credits of Written Expression and may take nine (9) credits to fulfill the Written and Oral Expression requirement. Courses that fulfill the Written Expression requirement in CALS focus on enhancing students' writing skills. Courses meeting this requirement devote at least 50% of class time to writing proficiency, involve at least five (5) writing assignments with detailed feedback, and emphasize revision and development. These courses ensure personalized attention and help students articulate ideas clearly, argue effectively, and engage with evidence critically. This structure supports students in improving both their writing mechanics and their ability to communicate persuasively across contexts.

CALS also accepts FWS courses as fulfilling WRT-AG. Transfer students may have courses that meet the SUNY Writing Requirement considered to fulfill this requirement.

Oral Expression (ORL-AG)

Students may take one (1) Oral Expression course towards the nine (9) required credits for Written and Oral Expression. Courses that fulfill the CALS Oral Expression requirement enhance students' public speaking and communication skills. Courses meeting this requirement center on improving oral proficiency, dedicating over 50% of class time to the principles of effective communication. Each course involves at least five (5) formal oral presentations, with four (4) undergoing detailed revisions based on structured feedback that focuses on speech organization, clarity, evidence use, and delivery. These courses offer personalized guidance and encourage students to apply feedback to subsequent presentations. The aim is to refine students' abilities to articulate ideas persuasively and adapt messages for different contexts, ensuring they can communicate effectively on any topic.

CALS 2025+ Degree Requirements (applies to first-year students who start Fall 2025 or after)

The 2025+ CALS Curriculum applies to first-year students who enter CALS starting Fall 2025 and all semesters after. Transfer students entering Fall 2025 and all continuing students will follow the Prior to Fall 2025 Requirements. There are no exceptions to this policy.

All students are required to complete:

1. University Graduation Requirements
2. Credit Requirements
3. 120 Credits are required to graduate, of the 120:
 - A minimum seventy-five (75) must be CALS Credits (fifty-five (55) for transfer students).
 - A minimum of 105 must be structured academic credits (transfer courses can count towards this requirement).
 - A minimum of one hundred (100) letter-graded academic credits (transfer courses can count towards this requirement).
 - The following courses do not count towards the 120: PE course, courses numbered 1000-1099, forbidden overlap courses, and repeated courses (that do not allow repeats).
4. Residency Requirement
5. GPA Requirement
6. Distribution Requirements
7. E3 Learning Milestone
8. Major Requirements: See individual department listings for major requirements.
9. Application to Graduate: Information can be found on graduation webpage.

75 CALS Credits

Students are required to take seventy-five (75) CALS Credits. The following counts as CALS Credit:

- Any course with the following prefixes: AGSCI, AIIS, ALS, ANSC, BEE, BIOG, BIOAP, BIOCB, BIOEE, BIOMG, BIOMI, BIOMS, BIONB, BIOSM, BSOC, BTRY, COMM, EAS, EDUC, ENTOM, ENVS, FDSC, GDEV, INFO, LA, LEAD, NS, NTRES, PLSCI, STSCI, VIEN
- Courses with the FWS attribute (two (2) courses maximum)
- For BSBU students only: prefix AEM
 - AEM courses will not count towards the required seventy-five (75) CALS Credits, except for students who have officially been accepted to the AEM major. CALS students who choose to complete an AEM minor cannot count AEM courses towards their seventy-five (75) required CALS courses.

Students with matriculation status of Transfer will have a requirement of fifty-five (55) CALS Credits.

Distribution Requirements

The College of Agriculture and Life Sciences (CALS) college distribution requirements are the cornerstone of a diverse and comprehensive education.

These requirements encourage our students to venture beyond familiar subjects, develop a deeper understanding of others, uncover insights that can spark new interests, and pave the way toward meaningful careers that can shape a just and sustainable future.

The CALS distribution requirements consist of:

- A minimum of thirty-nine (39) credit hours of coursework.
- A single course may not fulfill more than one college distribution requirement. However, a single course can simultaneously fulfill college and major requirements.
- Students in CALS have the option to take some of these courses either for a grade or using S/U grading. However, letter grades may be required for some majors.

- Non-academic credit courses (numbered 1000-1099 and PE) do not fulfill distribution requirements. Special Topics Courses (numbered 4940) do not fulfill distribution requirements.
- Courses that fulfill distributions are approved by the CALS Curriculum Committee. Distributions cannot be applied to a course retroactively, and individual student petitions for Cornell courses to fulfill distributions will not be accepted. Students may request a review of external transfer courses for fulfilling distribution requirements.

Students must complete all of the following:

Agriculture, Food Systems & Human Nutrition (AFS-AG)

- Take one (1) Agriculture, Food Systems & Human Nutrition (AFS-AG) course.

The Agriculture, Food Systems & Human Nutrition distribution requirement at CALS emphasizes a comprehensive understanding of the food system, including production, processing, distribution, consumption, and waste, with a focus on the integration of these multiple components. Students must learn to describe, analyze, and understand the interdependent nature and the environmental and nutritional impacts of the food system. To fulfill the requirement, a course must cover at least two components of the food system, analyze their interactions, and dedicate at least half of its content to this holistic view, potentially including topics like agricultural history, food sustainability, and nutrition access.

Biological Sciences (BSC-AG)

- Take one (1) Biological Sciences (BSC-AG) course. Note: the following are NOT accepted as fulfilling BSC-AG: BIO-AG, BIO-AS.

Courses that meet the Biological Sciences requirement for CALS dedicate most of their content (at least 75%) to exploring one or more of the following biological concepts: evolution, structure and function, the flow, exchange and storage of information, pathways and transformations of energy and matter, or living systems. These courses include an evolutionary component, teach students how to apply scientific methods, and include at least one of the following competencies: quantitative reasoning, modeling and simulation, interdisciplinary thinking, interdisciplinary collaboration and communication, or science and society relational understanding. Courses also emphasize student-centered learning activities such as labs, problem solving, case studies, research projects, or collaborative projects. Some courses within this distribution are identified as suitable for non-life sciences majors— these courses have no prerequisites and require only high school-level science knowledge.

Physical Sciences (PSC-AG)

- Take one (1) Physical Sciences (PSC-AG) course.

CALS Physical Sciences courses cover at least 75% of their content in fields such as chemistry, physics, earth science, atmospheric science, or astronomy, connecting theoretical knowledge to practical applications. Courses also emphasize student-centered learning activities such as labs, problem solving, case studies, research projects, or collaborative projects. Some courses within this distribution are identified as suitable for non-sciences majors - these courses have no prerequisites and require only high school-level science knowledge.

Sustainability Challenges (SCH-AG)

- Take one (1) Sustainability Challenges (SCH-AG) course.

Courses that satisfy the sustainability distribution requirement in CALS must allocate at least 30% of content or learning outcomes to examining the intricate interplay between economic, socio-political, and environmental aspects of sustainability issues or their solutions or to exploring the connections among three or more UN Sustainable Development Goals in relation to the main class topic. Additionally, the course must incorporate a learning outcome focused on one of three key proficiencies: systems thinking, decision-making amidst uncertainty, or understanding the factors that constrain sustainability, thereby ensuring students gain a comprehensive and interdisciplinary perspective on sustainability challenges.

Data Literacy (DLG-AG and DLS-AG)

Two required courses:

- Take one (1) course with attribute Data Literacy Statistics (DLS-AG).
- Take one (1) course with attribute Data Literacy General (DLG-AG) OR one (1) course with attribute Data Literacy Statistics (DLS-AG).

CALS courses fulfilling the Data Literacy General (DLG-AG) requirement are designed to teach students how to interpret and articulate insights from both quantitative and qualitative data, with an emphasis on various competencies such as data analysis, acquisition methods, curation, and security. Students will be expected to understand the types of data, their applications, and the ethical implications of data misuse upon completion of these courses. The courses must dedicate a significant portion of content to at least three (3) specific data literacy competencies and include at least one of these competencies as a main learning outcome.

Courses that fulfill Data Literacy Statistics (DLS-AG) additionally provide explicit instruction on mathematical approaches to collection, description, analysis, and inference of conclusions from quantitative data. Course content focuses on the Data Manipulating & Analysis competency: Ability to draw conclusions from data with quantitative and/or qualitative methods, which may include statistical or computational methods and may include tools like R, Python, Stata, Tableau, Unix, NVivo, QGIS, Excel, SPSS, etc.

Ethics (ETH-AG)

- Take one (1) course with attribute Ethics (ETH-AG). Note the following are NOT accepted as fulfilling ETH-AG: KCM-AG, ETM-AAP, ETM-AS, ETM-HA, KCM-AAP, KCM-HE.

Courses that fulfill the CALS Ethics requirement are designed to immerse students in the study of ethical principles impacting various facets of life, including personal, social, and global spheres, as well as in research and professional practices. These courses aim for students to critically engage with their values, understand diverse ethical perspectives, and articulate reasoned ethical positions. To satisfy the Ethics requirement, a course must devote over half of its content to ethical issues relevant to its main topic, incorporate historical or modern ethical debates, foster personal ethical reflection, and include specific learning outcomes focused on ethics.

Human Diversity (D-AG)

- Take one (1) course with attribute Human Diversity (D-AG).

CALS Human Diversity courses foster a comprehensive understanding of the complexities surrounding historically or contemporarily marginalized communities, emphasizing the critical analysis of unequal power dynamics shaped by factors such as race, nationality, ethnicity, indigeneity, sexuality, disability, religion, gender, or economic status. To meet this requirement, a course must allocate at least 50% of its

content to examining these issues, be a minimum of three (3) credits, and achieve specific learning outcomes. These outcomes include demonstrating knowledge of diverse cultural practices, understanding systemic oppression, and assessing personal cultural perspectives to identify potential biases.

CALS also accepts courses of at least three (3) credits with the following distributions as fulfilling D-AG: SCD-AS, SCD-HA, D-HE.

Non-equated external transfer courses will only be considered for junior transfer students who have taken an appropriate course at their prior institution and whose schedule does not allow space to take a Human Diversity (D-AG) course at Cornell. These situations will be reviewed individually after a required appointment with CALS Student Services.

Cultural, Social & Historical Understanding

Take two (2) courses of the below distributions, with a maximum of one (1) course in each category: CA-AG, FL-AG, HA-AG, LA-AG, SBA-AG.

Cultural Analysis (CA-AG)

These courses study human life in particular cultural contexts through interpretive analysis of individual behavior, discourse, and social practice. Topics include belief systems (science, medicine, religion), expressive arts and symbolic behavior (visual arts, performance, poetry, myth, narrative, ritual), identity (nationality, race, ethnicity, gender, sexuality), social groups and institutions (family, market, community), and power and politics (states, colonialism, inequality).

CALS also accepts courses of at least three (3) credits with the following distributions as fulfilling CA-AG: ALC-AS, ALC-HA, ALC-AAP, CA-HE, CA-AAP, GLC-AS.

Foreign Language (FL-AG)

Foreign Language - Foreign Language courses available for CALS students at Cornell are offered by several departments, including Africana Studies and Research Center (AS&RC – language courses only), Asian Studies with languages such as Bangla-Bengali, Burmese, Chinese, Hindi, Indonesian, Japanese, Khmer, Korean, Sanskrit, Tagalog, Thai, and Vietnamese, and Classics (CLASS – language courses only). Additional offerings are provided by German Studies, which includes German, Dutch, and Swedish (language courses only), Linguistics (LING – language courses only), Near Eastern Studies (NES - language courses only), Romance Studies with languages like Catalan, French, Italian, Portuguese, Quechua, and Spanish, and Russian Studies, covering Russian, Hungarian, Polish, Serbian/Croatian, and Ukrainian. CALS will recognize these Foreign Language (FL) classifications by any college at Cornell, provided the class is taken for three (3) or more credits. Transfer students may have non-Cornell courses that meet SUNY World Languages and are a minimum of three (3) credits reviewed as fulfilling FL-AG.

Historical Analysis (HA-AG)

These courses interpret continuities and changes - political, social, economic, diplomatic, religious, intellectual, artistic, scientific - through time. The focus may be on groups of people, dominant or subordinate, a specific country or region, an event, a process, or a time period.

CALS also accepts courses of at least three (3) credits with the following distributions as fulfilling HA-AG: HA-AAP, HST-AAP, HST-AS, HST-HA, HA-HE.

Literature and the Arts (LA-AG)

These courses explore literature and the arts in two different but related ways. Some courses focus on the critical study of artworks and on their history, aesthetics, and theory. These courses develop skills of reading,

observing, and hearing and encourage reflection on such experiences; many investigate the interplay among individual achievement, artistic tradition, and historical context. Other courses are devoted to the production and performance of artworks (in creative writing, performing arts, and media such as film and video). These courses emphasize the interaction among technical mastery, cognitive knowledge, and creative imagination.

CALS also accepts courses of at least three (3) credits with the following distributions as fulfilling LA-AG: ALC-AS, ALC-HA, ALC-AAP, LA-AAP.

Social and Behavioral Analysis (SBA-AG)

These courses examine human life in its social context through the use of social scientific methods, often including hypothesis testing, scientific sampling techniques, and statistical analysis. Topics studied range from the thoughts, feelings, beliefs, and attitudes of individuals to interpersonal relations between individuals (e.g., in friendship, love, conflict) to larger social organizations (e.g., the family, society, religious or educational or civic institutions, the economy, government) to the relationships and conflicts among groups or individuals (e.g., discrimination, inequality, prejudice, stigmas, conflict resolution).

CALS also accepts courses of at least three (3) credits with the following distributions as fulfilling SBA-AG: SSC-AS, SBA-HE, SBA-AAP, SSC-AAP.

Written and Oral Expression

Nine (9) credits total, of which at least six (6) must be in Written Expression. Oral Expression is not required by the college but may be required for some majors. If Oral Expression is not required by the major, all nine (9) credits may be in Written Expression. Writing in the Majors (WIM) courses do not count towards Written Expression.

Written Expression (WRT-AG)

All students are required to take at least six (6) credits of Written Expression and may take nine (9) credits to fulfill the Written and Oral Expression requirement. Courses that fulfill the Written Expression requirement in CALS focus on enhancing students' writing skills. Courses meeting this requirement devote at least 50% of class time to writing proficiency, involve at least five (5) writing assignments with detailed feedback, and emphasize revision and development. These courses ensure personalized attention and help students articulate ideas clearly, argue effectively, and engage with evidence critically. This structure supports students in improving both their writing mechanics and their ability to communicate persuasively across contexts.

CALS also accepts FWS courses as fulfilling WRT-AG. Transfer students may have courses that meet the SUNY Writing Requirement considered to fulfill this requirement.

Oral Expression (ORL-AG)

Students may take one (1) Oral Expression course towards the nine (9) required credits for Written and Oral Expression. Courses that fulfill the CALS Oral Expression requirement enhance students' public speaking and communication skills. Courses meeting this requirement center on improving oral proficiency, dedicating over 50% of class time to the principles of effective communication. Each course involves at least five (5) formal oral presentations, with four (4) undergoing detailed revisions based on structured feedback that focuses on speech organization, clarity, evidence use, and delivery. These courses offer personalized guidance and encourage students to apply feedback to subsequent presentations. The aim is to refine students' abilities to articulate ideas persuasively and adapt messages for different contexts, ensuring they can communicate effectively on any topic.

Engaged, Experiential, Entrepreneurial (E3) Learning Milestone

The E3 Learning Milestone allows students to blend experiential learning with academics, apply theory to practice, and deepen their community and professional engagement. This milestone emphasizes learning through experience, engagement, and/or entrepreneurship, encouraging students to apply their academic knowledge in real-world settings in collaboration with diverse groups and community partners. By completing an E3-designated course or experience, students are able to link their classroom learning with practical application, understand how their experiences align with their academic goals at Cornell, and recognize their contributions to a broader community. Eligible E3 experiences include community-engaged courses, undergraduate research, internships, study-abroad programs, and more—each designed to foster these outcomes and enhance the student's role in their field and community.

Learning Outcomes

Upon completion of a course or experience that fulfills the E3 Learning Milestone requirement, students should be able to:

- Make connections between their disciplinary and scholarly learning and the practice or application of that knowledge.
- Explain how their course/experience contributes to and is informed by their learning goals at Cornell (i.e. in their major or course of study, as they define it).
- Explain how they engaged with and contributed to, or served, a community or cause greater than themselves.

The E3 Learning Milestone can be fulfilled by courses or non-course-based experiences. Courses cannot apply to another distribution requirement if used for E3.

The following courses are accepted as fulfilling E3:

- Any course with CU-CEL attribute.
- Any course with EEE-AG distribution.
- CALS E3 Research and Teaching courses with EEE-AG. With advisor approval some Independent Study (4970) and Internship academic components (4960) may fulfill this requirement.

Courses and experiences that fulfill the E3 Learning Milestone must meet the following requirements:

1. Involve practice and application of knowledge in a real context.
2. Provide learning outcomes at the outset of the course or experience, including but not limited to the learning outcomes articulated above.
3. Include an assignment or activity that promotes student reflection on their experience.

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 pathophysiologicals 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.