Department of Biological Sciences

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Location: Doherty Hall 1321
www.cmu.edu/bio (http://www.cmu.edu/bio/)

A major revolution is occurring in the field of biological sciences. Biology is undergoing unprecedented technological advances in biochemistry, biophysics, cell biology, genetics, molecular biology, developmental biology, neuroscience and computational biology. Carnegie Mellon's Department of Biological Sciences is nationally recognized as one of the outstanding departments in these areas. Advances in basic research are already being used to solve problems, not only in medicine and public health, but also in areas such as agriculture, forestry, mining, energy, and in industrial and pharmaceutical manufacturing processes. The department provides its students with an education that has both intellectual breadth and depth of exposure to modern research biology. This education can be used to gain employment immediately after graduation in government, industry or academic research laboratories, or to pursue graduate studies in a variety of areas such as science, medicine, public health, law, or business. A degree in biological sciences provides excellent preparation for medical school or other graduate programs in the health professions. These students are aided by the Carnegie Mellon Health Professions Program (HPP), an advisory and resource service for all Carnegie Mellon students who are considering careers in the health care field. (See the HPP (http://coursecatalog.web.cmu.edu/aboutcmu/undergraduateoptions/#healthprofessionsprogram) section in this catalog or www.cmu.edu/hpp (http://www.cmu.edu/hpp/) for more information.)

The department offers a Bachelor of Science (B.S.) degree in Biological Sciences. This program has a distinctive core curriculum that provides a foundation in biology, chemistry, computer science, mathematics, and physics. In addition to the core courses, the program includes six biology electives, free electives as well as humanities, social science and fine arts electives. With these electives, students can shape a degree program according to their own interests and career goals. For students who have an interest in a particular field of biology and wish to have a specialized focus, the department offers options in biochemistry, biophysics, cell biology, computational biology, developmental biology, genetics, molecular biology and neuroscience that provide the relevant training in each area. The options are especially recommended for students who are considering graduate school in one of these areas.

In this exciting era that includes the influence of biology and the life sciences on many fields from medicine to law, the in-depth exposure to multiple disciplines provides opportunities for students to prepare for involvement at the forefront of emerging new fields, markets, and policy changes. The Department of Biological Sciences at Carnegie Mellon is working at these new interfaces through interdisciplinary research and educational programs. Innovative interdisciplinary degrees which are offered by the department include the inter-college B.S. degree in Neuroscience as well as the unified B.S. degree in Biological Sciences and Psychology. Students also pursue interests at the interface between the arts and sciences through the Bachelor of Science and Arts (B.S.A.) degree program combining biological sciences or neurobiology with a discipline in the College of Fine Arts. A stand-alone Bachelor of Arts (B.A.) degree is available for students who wish to expand their educational training into other fields. Many students choose to broaden their education by pursuing minors and additional majors in disciplines throughout the university, not just within the Mellon College of Science.

One of the most important features of the Department of Biological Sciences is the opportunity for undergraduate students to interact with faculty. Providing a solid foundation to scientific practice is critical; therefore, the department offers first-year students a variety of inquiry-based, hands-on courses that incorporate a wide range of topics and interests within Biological Sciences. These courses kick-start the transformation of science students to scientists. We encourage our students to get to know their faculty through one of these courses, or through mentored, independent research projects in the faculty laboratories. Our faculty members are prominent research scientists who also teach beginning and advanced courses. The upper level teaching laboratories are located in the same building as the faculty research laboratories and share scientific equipment. We encourage students to make themselves aware of the research areas of the faculty and to develop research projects with faculty. While such research is usually most important in the senior year, it may begin earlier in a student's undergraduate training. The department has an Honors Program in Research Biology to facilitate a more intensive involvement in research for eligible students. During the past four years, more than 85 percent of the undergraduate biology majors have worked with faculty on their research and, in some cases, have been co-authors of research papers and have given presentations at national meetings.

Since the fall of 2011, the Department of Biological Sciences has offered a B.S. degree in Biological Sciences at Carnegie Mellon University in Doha, Qatar. Students enrolled in this degree program will also complete the requirements outlined below. One of the required courses for the CMU-Qatar program is offered through a collaboration with the Weill Cornell Medical College in Qatar. For a listing of how the degree requirements are fulfilled for students enrolled in Doha, please consult the CMU-Qatar website (www.qatar.cmu.edu/curriculum-bs (https://www.qatar.cmu.edu/curriculum-bs/)).

Program Outcomes

Upon graduation recipients of the B.S. or B.A. degree in Biological Sciences will:

- Use the basic concepts and experimental, computational, and theoretical methods of the core fields of science, mathematics and technology.
- Use foundational knowledge from the natural sciences and mathematics for advanced work in the discipline.
- Understand and apply the scientific method.
- Apply disciplinary knowledge toward solving problems.
- Use modern methods for finding and sharing current scientific information and primary literature.
- Convey information including scientific content in written and oral formats within Biological Sciences.
- Work in multidisciplinary and culturally diverse teams.
- Demonstrate proper values and ethics within Biological Sciences, the University, and the larger scientific community.

B.S. Biological Sciences

The Bachelor of Science (B.S.) in Biological Sciences is built around a core program and elective units as detailed in the following section.

Degree Requirements:

Biological Sciences		Units
03-151	Honors Modern Biology	10
or 03-121	Modern Biology	
03-201	Undergraduate Colloquium for Sophomores	2
03-220	Genetics	9
or 03-221	Genomes, Evolution, and Disease: Introduction to Quantitative Genetic Analysis	
03-231	Honors Biochemistry	9
or 03-232	Biochemistry I	
02-250	Introduction to Computational Biology	12
03-320	Cell Biology	9
03-343	Experimental Techniques in Molecular Biology	12
03-344	Experimental Biochemistry	12
or 03-345	Experimental Cell and Developmental Biology	
or 03-346	Experimental Neuroscience	
03-411	Topics in Research	1
03-412	Topics in Research	1
03-xxx	Biological Sciences Electives [1]	54
Total Biology units		**131**

[1] Details on electives can be found in the "Biological Sciences Electives" section (see below).

Mathematics, Physics and Computer Science		Units
15-110	Principles of Computing	10
or 15-112	Fundamentals of Programming and Computer Science	
21-120	Differential and Integral Calculus	10
21-124	Calculus II for Biologists and Chemists	10
or 21-122	Integration and Approximation	
33-121	Physics I for Science Students	12
or 33-141	Physics I for Engineering Students	

33-122	Physics II for Biological Sciences & Chemistry Students	9
or 33-142	Physics II for Engineering and Physics Students	
99-101	Core@CMU	3
Total Science units		**54**

Chemistry		Units
09-105	Introduction to Modern Chemistry I [2]	10
or 09-107	Honors Chemistry: Fundamentals, Concepts and Applications	
09-106	Modern Chemistry II	10
09-217	Organic Chemistry I	9
09-218	Organic Chemistry II	9
09-207	Techniques in Quantitative Analysis	9
09-208	Techniques for Organic Synthesis and Analysis	9
Total Chemistry units		**56**

[2] Students who complete 09-107 with an A grade will be exempted from the requirement to take 09-106 Modern Chemistry II.

Elective Units	Units
Free Electives	48
MCS Nontechnical Breadth Requirements [3]	72
Total Elective units	**120**

[3] For more information on the MCS Technical and Nontechnical Breadth Requirements, please refer to the MCS General Education Requirements (http://coursecatalog.web.cmu.edu/schools-colleges/melloncollegeofscience/#generaleducationrequirementstext) section of this catalog. MCS Technical Breadth Requirements are all met through the required curriculum for the Biological Sciences degree (see below).

Minimum number of units required for degree: 360

MCS Technical Breadth Requirements

Majors entering CMU and majoring in Biological Sciences (or affiliated majors) in the Fall of 2015 or beyond will fulfill the MCS Technical Breadth requirements as follows:

1. Life Sciences: any courses in this category except for the 03-xxx courses. For the B.S. in Biological Sciences, this will be fulfilled by 02-250.
2. Physical Sciences: 09-105, 09-106, 33-121 and 33-122
3. Math/CS/Stats: 21-120 and (21-122 or 21-124)
4. STEM Elective: will be filled by courses above or any STEM course from the approved list.

Biological Sciences Electives

The following specifications apply to Biological Sciences electives:

- At least 18 units must be at the 03-3xx level or above, exclusive of 03-445 and 03-545 and interdisciplinary electives.
- Up to three interdisciplinary electives may count as general biology electives.
- Up to 18 units of 03-445 Undergraduate Research and/or 03-545 Honors Research may count as general biology electives; a maximum of 36 units of research can count for the minimum units required for graduation.
- Courses in biology taken through cross-registration or study abroad at another university may count as electives if prior permission is obtained from the Director of Undergraduate Studies.

Departmental Electives Group

03-113	Biologies in Text and Film *Offered only in Doha	9
03-117	Frontiers, Analysis, and Discovery in Biological Sciences	6
03-118	Beer: A Yeast's Perspective	6
03-119	Biology for Life Special Topics Micro	3
03-120	Biology for Life Special Topics Mini	Var.
03-124	Modern Biology Laboratory	9
03-125	Evolution	9
03-128	Biology for Life Special Topics	9
03-129	Human Health and Disease *Offered only in Doha	9
03-132	Basic Science to Modern Medicine	9
03-133	Neurobiology of Disease	9
03-135	Structure and Function of the Human Body	9
03-140	Ecology and Environmental Science	9
03-161	Molecules to Mind	9
03-230	Intro to Mammalian Physiology *Offered only in Doha	9
03-327	Evolutionary Bioinformatics: Trees, Sequences and the Comparative Method	9
03-350	Developmental Biology	9
03-351	Computation and Biology Integrated Research Lab	9
03-360/02-319	Genomics and Epigenetics of the Brain	9
03-362	Cellular Neuroscience	9
03-363	Systems Neuroscience	9
03-365	Neural Correlates of Learning and Memory	9
03-366	Neuropharmacology: Drugs, Brain and Behavior	9
03-380	Virology *Offered only in Doha	9
03-390	Molecular and Cellular Immunology	9
03-391	Microbiology	9
03-410	Special Topics in Biological Sciences	Var.
03-435	Cancer Biology	9
03-439	Introduction to Biophysics	10
03-442	Molecular Biology	9
03-445	Undergraduate Research	Var.
03-451	Advanced Developmental Biology and Human Health	9
03-511	Computational Molecular Biology and Genomics	9
03-545	Honors Research	9
03-711	Computational Molecular Biology and Genomics	12
03-713	Bioinformatics Data Integration Practicum	6
03-727	Evolutionary Bioinformatics: Trees, Sequences and the Comparative Method	12
03-728	Genome Editing Biotechnology	6
03-729	Entrepreneurship and protein-based drug development	6
03-730	Advanced Genetics	12
03-738	Synthetic Biology	6
03-740	Advanced Biochemistry	12
03-741	Advanced Cell Biology	12
03-742	Advanced Molecular Biology	12
03-751	Advanced Developmental Biology and Human Health	12
03-762	Advanced Cellular Neuroscience	12
03-763	Advanced Systems Neuroscience	12
03-766	Advanced Neuropharmacology: Drugs, Brain and Behavior	12
03-791	Advanced Microbiology	12
03-871	Structural Biophysics	12

Interdisciplinary Electives Group

Up to three of the following courses may count as general biology electives:

02-331	Modeling Evolution	12
02-425	Computational Methods for Proteogenomics and Metabolomics	9
02-450	Automation of Scientific Research	9
02-510	Computational Genomics	12
02-512	Computational Methods for Biological Modeling and Simulation	9
02-518	Computational Medicine	12
02-740	Bioimage Informatics	12
09-518	Bioorganic Chemistry: Nucleic Acids and Carbohydrates	9
09-519	Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry	9
09-803	Chemistry of Gene Expression	12
21-127	Concepts of Mathematics	12
21-259	Calculus in Three Dimensions	10
21-260	Differential Equations	9
36-200	Reasoning with Data	9
42-202	Physiology	9
85-219	Foundations of Brain and Behavior	9

Options for the B.S. in Biological Sciences

Students who wish to specialize in a particular area of biology can do so through a set of departmentally defined options. Options are not required and need not be declared. The elective courses required for each of the options are listed below. Students can elect to complete a maximum of two options. Please discuss interest in these options with the Carnegie Mellon Department of Biological Sciences advisor to plan out any pre-requisite coursework and identify appropriate course alternatives in the event that a graduate-level course is not being offered during a particular academic year.

Biochemistry Option

Required Biology Electives:

03-740	Advanced Biochemistry	12
21-259	Calculus in Three Dimensions	9-10
or 21-260	Differential Equations	

Any ONE of the following courses:

09-518	Bioorganic Chemistry: Nucleic Acids and Carbohydrates	9
09-519	Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry	9
09-521	Metals in Biology: Function and Reactivity	6

Recommended Biology Electives:

03-442	Molecular Biology	9
03-439	Introduction to Biophysics	10
03-871	Structural Biophysics	12

Biophysics Option

Required Biology Electives:

03-740	Advanced Biochemistry	12
03-439	Introduction to Biophysics	10
21-259	Calculus in Three Dimensions	9-10
or 21-260	Differential Equations	

Recommended Biology Electives:

03-871	Structural Biophysics	12

Cell Biology Option

Required Biology Electives:

03-350	Developmental Biology	9
03-741	Advanced Cell Biology	12

Any ONE of the following courses:

03-362	Cellular Neuroscience	9
03-390	Molecular and Cellular Immunology	9

Computational Biology Option

Required Biology Electives:

03-711	Computational Molecular Biology and Genomics	12
15-210	Parallel and Sequential Data Structures and Algorithms	12

Any ONE of the following courses:

36-200	Reasoning with Data	9
21-260	Differential Equations	9
21-241	Matrices and Linear Transformations	11

Recommended Biology Electives:

02-512	Computational Methods for Biological Modeling and Simulation	9
15-451	Algorithm Design and Analysis	12

Developmental Biology Option

Required Biology Electives:

03-350	Developmental Biology	9
03-442	Molecular Biology	9
03-751	Advanced Developmental Biology and Human Health	12

Recommended Biology Electives:

03-741	Advanced Cell Biology	12

Genetics Option

Required Biology Electives:

03-327	Evolutionary Bioinformatics: Trees, Sequences and the Comparative Method	9
03-442	Molecular Biology	9
03-730	Advanced Genetics [6]	12

[6] Minimum grade of B in 03-220 required.

Recommended Biology Electives:

03-391	Microbiology	9

Molecular Biology Option

Required Biology Electives:

03-442	Molecular Biology	9
09-518	Bioorganic Chemistry: Nucleic Acids and Carbohydrates	9
03-727	Evolutionary Bioinformatics: Trees, Sequences and the Comparative Method	12

Recommended Biology Electives:

03-390	Molecular and Cellular Immunology	9
03-391	Microbiology	9
03-730	Advanced Genetics	12

Neuroscience Option

Required Biology Electives:

03-362	Cellular Neuroscience [7]	9
03-363	Systems Neuroscience [7]	9

Any ONE of the following courses:

03-133	Neurobiology of Disease	9
03-350	Developmental Biology	9
03-365	Neural Correlates of Learning and Memory	9
03-366	Neuropharmacology: Drugs, Brain and Behavior	9
42-202	Physiology	9
85-219	Foundations of Brain and Behavior	9

[7] One of these courses must be completed at the Graduate Level (Complete either 03-762 or 03-763).

B.S. Biological Sciences/Neuroscience Track

The Bachelor of Science in Biological Sciences/Neuroscience Track provides an option for those Biological Sciences majors who are interested in an intensive curricular focus in neuroscience. The requirements of the Track are the same as those listed for the B.S. in Biological Sciences with the following changes to the biological sciences elective requirements:

Degree Requirements:

03-362	Cellular Neuroscience	9
03-363	Systems Neuroscience	9
03-365	Neural Correlates of Learning and Memory	9

Plus three of the following electives:

03-133	Neurobiology of Disease	9
03-350	Developmental Biology	9
03-360/02-319	Genomics and Epigenetics of the Brain	9
03-366	Neuropharmacology: Drugs, Brain and Behavior	9
15-385	Introduction to Computer Vision	6
15-386	Neural Computation	9
42-202	Physiology	9
85-211	Cognitive Psychology	9

85-213	Human Information Processing and Artificial Intelligence	9
85-219	Foundations of Brain and Behavior	9

B.S. Neuroscience

The Bachelor of Science in Neuroscience is listed in the Intercollege Programs (http://coursecatalog.web.cmu.edu/intercollegeprograms/#bachelorofscienceinneurosciencetext) section of this catalog. It is a joint degree program offered between the Mellon College of Science and the Dietrich College of Humanities and Social Sciences. Current MCS students interested in pursuing this degree should contact Biological Sciences Undergraduate Programs Office (bio-ungrad@andrew.cmu.edu).

B.S. Biological Sciences and Psychology

Veronica Hinman, *Department Head, Biological Sciences*

Susanne Ferber, *Department Head, Psychology*

This major is intended to reflect the interdisciplinary nature of current research in the fields of biology and psychology, as well as the national trend in some professions to seek individuals broadly trained in both the social and natural sciences.

Note: Students entering from the Dietrich College of Humanities and Social Sciences will earn a Bachelor of Science in Psychology and Biological Sciences. Students in the Mellon College of Science will earn a Bachelor of Science in Biological Sciences and Psychology.

Depending on a student's home college (DC or MCS), General Education (GenEd) requirements will be different. GenEd requirements for DC (http://coursecatalog.web.cmu.edu/schools-colleges/dietrichcollegeofhumanitiesandsocialsciences/#hampssgeneraleducationprogram160) and MCS (http://coursecatalog.web.cmu.edu/schools-colleges/melloncollegeofscience/) are found on their respective Catalog pages.

Degree Requirements:

Biological Sciences		Units
03-151	Honors Modern Biology	10
or 03-121	Modern Biology	
03-201	Undergraduate Colloquium for Sophomores *Only required for MCS Students	2
03-220	Genetics	9
or 03-221	Genomes, Evolution, and Disease: Introduction to Quantitative Genetic Analysis	
03-231	Honors Biochemistry	9
03-320	Cell Biology	9
03-343	Experimental Techniques in Molecular Biology	12
03-411	Topics in Research	1
03-412	Topics in Research	1
03-xxx	General Biology Elective [1]	9
03-3xx	Advanced Biology Elective [1]	18
Total Biology units		**80**

[1] Please see description and requirements for electives under the B.S. in Biological Sciences section of this Catalog.

Mathematics, Statistics, Physics and Computer Science		Units
21-120	Differential and Integral Calculus	10
21-124	Calculus II for Biologists and Chemists	10
or 21-122	Integration and Approximation	
36-200	Reasoning with Data	9
36-309	Experimental Design for Behavioral & Social Sciences	9
or 85-309	Statistical Concepts and Methods for Behavioral and Social Science	
33-121	Physics I for Science Students [3]	12
or 33-141	Physics I for Engineering Students	
15-110	Principles of Computing	10-12
or 15-112	Fundamentals of Programming and Computer Science	
99-101	Core@CMU	3
Total Science units		**63-65**

[3] MCS students must also complete 33-122 Physics II for Biological Sciences & Chemistry Students.

Chemistry		Units
09-105	Introduction to Modern Chemistry I	10
09-106	Modern Chemistry II	10
09-217	Organic Chemistry I	9
09-218	Organic Chemistry II	9
09-207	Techniques in Quantitative Analysis	9
09-208	Techniques for Organic Synthesis and Analysis	9
Total Chemistry units		**56**

Psychology Courses		Units
85-102	Introduction to Psychology	9
85-219	Foundations of Brain and Behavior	9
85-xxx	Survey Psychology Courses *	18
85-310	Research Methods in Cognitive Psychology	9
or 85-300	Introduction to Research Methods	
or 85-314	Cognitive Neuroscience Research Methods	
or 85-320	Research Methods in Developmental Psychology	
or 85-330	Analytic Research Methods	
or 85-340	Research Methods in Social Psychology	
85-3xx	Advanced Psychology Electives	18
Total Psychology units		**63**

* Excluding 85-104 Psychopathology

Additional Advanced Elective 9 units

(Choose one of the following courses)		
85-3xx	Advanced Psychology Elective	9
or		
03-3xx	Advanced Biology Elective	9

Additional Laboratory or Research Methods 9-12 units

(Choose one of the following courses)		
03-344	Experimental Biochemistry	12
03-345	Experimental Cell and Developmental Biology	12
03-346	Experimental Neuroscience	12
85-310	Research Methods in Cognitive Psychology	9
85-314	Cognitive Neuroscience Research Methods	9
85-320	Research Methods in Developmental Psychology	9
85-330	Analytic Research Methods	9
85-340	Research Methods in Social Psychology	9

Elective Units	Units
Free Electives	33-36
MCS Nontechnical Breadth or DC General Education requirements	36-48
Total Elective units	**69-84**

Minimum number of units required for degree: 360

B.A. Biological Sciences

The Department of Biological Sciences offers a Bachelor of Arts (B.A.) degree that is intended for students who wish to combine their interest in science with their interest(s) in other discipline(s) across campus. The requirements for the B.A. degree are distributed as follows:

Degree Requirements:

Biological Sciences		Units
03-151	Honors Modern Biology	10
or 03-121	Modern Biology	
03-201	Undergraduate Colloquium for Sophomores	2
03-220	Genetics	9
or 03-221	Genomes, Evolution, and Disease: Introduction to Quantitative Genetic Analysis	
03-231	Honors Biochemistry	9
or 03-232	Biochemistry I	
03-320	Cell Biology	9

03-343	Experimental Techniques in Molecular Biology	9-12
or 03-124	Modern Biology Laboratory	
03-411	Topics in Research	1
03-412	Topics in Research	1
03-xxx	General Biology Electives [1]	18
03-3xx	Advanced Biology Electives [1]	18
Total Biology units		**86-89**

[1] Please see description and requirements for electives under the B.S. in Biological Sciences section of this Catalog.

Chemistry		Units
09-105	Introduction to Modern Chemistry I [2]	10
or 09-107	Honors Chemistry: Fundamentals, Concepts and Applications	
09-106	Modern Chemistry II	10
09-217	Organic Chemistry I	9
09-218	Organic Chemistry II	9
09-207	Techniques in Quantitative Analysis	9
Total Chemistry units		**47**

[2] Students who complete 09-107 with an A grade will be exempted from the requirement to take 09-106 Modern Chemistry II.

Mathematics, Physics, and Computer Science		Units
15-110	Principles of Computing	10
or 15-112	Fundamentals of Programming and Computer Science	
21-120	Differential and Integral Calculus	10
21-124	Calculus II for Biologists and Chemists	10
or 21-122	Integration and Approximation	
33-121	Physics I for Science Students	12
or 33-141	Physics I for Engineering Students	
33-122	Physics II for Biological Sciences & Chemistry Students	9
or 33-142	Physics II for Engineering and Physics Students	
99-101	Core@CMU	3
Total Science units		**54**

Elective courses	Units
MCS Nontechnical Breadth Requirements	72
Free Electives	96-99
Total Elective units	**168-171**

360Minimum number of units required for degree:

Additional Major and Dual Degree in Biological Sciences

Biological Sciences may be taken as an additional major (also known as a "double major") or as a second degree, with another department granting the primary degree. The rules of the Biological Sciences Department for these two options are distinct, as discussed below.

Additional Major

In order to receive an Additional Major in Biological Sciences, with another department granting the primary degree, all requirements listed below must be fulfilled:

Biological Sciences		Units
03-151	Honors Modern Biology	10
or 03-121	Modern Biology	
03-201	Undergraduate Colloquium for Sophomores	2
03-220	Genetics	9
or 03-221	Genomes, Evolution, and Disease: Introduction to Quantitative Genetic Analysis	
03-231	Honors Biochemistry	9
or 03-232	Biochemistry I	
02-250	Introduction to Computational Biology [1]	12
03-320	Cell Biology	9
03-343	Experimental Techniques in Molecular Biology	12
03-344	Experimental Biochemistry	12
or 03-345	Experimental Cell and Developmental Biology	
or 03-346	Experimental Neuroscience	
03-411	Topics in Research	1
03-412	Topics in Research	1
03-xxx	Biological Sciences Electives [2]	54
Total Biology units		**131**

[1] This course requires 15-110 or 15-112 as a prerequisite.

[2] Please see description and requirements for electives under the B.S. in Biological Sciences section of this Catalog.

Chemistry		Units
09-105	Introduction to Modern Chemistry I [3]	10
or 09-107	Honors Chemistry: Fundamentals, Concepts and Applications	
09-106	Modern Chemistry II	10
09-217	Organic Chemistry I	9
09-218	Organic Chemistry II	9
09-207	Techniques in Quantitative Analysis	9
09-208	Techniques for Organic Synthesis and Analysis	9
Total Chemistry units		**56**

[3] Students who complete 09-107 with an A grade will be exempted from the requirement to take 09-106 Modern Chemistry II.

Minimum number of units required for additional major: 187

Dual Degree

In order to receive a Dual Degree in another subject and Biological Sciences, all requirements of the Biological Sciences degree must be fulfilled. Students may choose to complete the B.A. or the B.S. in Biological Sciences, with or without Options. Students must complete all technical and non-technical requirements, and should consult with the Carnegie Mellon Biological Sciences advisor for questions about double counting. The number of units required for a Dual Degree is 90 more than the total units required by the department requiring the fewer total units. Since Biological Sciences requires 360 units, the lowest possible minimum for a Dual Degree with Biological Sciences is 450 units.

Minor in Biological Sciences

All university students are eligible to pursue a minor in biological sciences in conjunction with a major in any other department in the university. A minimum of six biological sciences courses (and two chemistry prerequisites) must be completed to fulfill the minor in biological sciences. The curriculum includes four required courses and two elective courses as specified below. Units awarded for undergraduate research are not applicable to elective courses. Courses taken in other departments or colleges will be considered on an individual basis by the Director of Undergraduate Studies.

Courses for the Minor in Biological Sciences

Prerequisites:		Units
09-105	Introduction to Modern Chemistry I	10
09-217	Organic Chemistry I	9

Required courses:		Units
03-121	Modern Biology	9
or 03-151	Honors Modern Biology	
03-220	Genetics	9
or 03-221	Genomes, Evolution, and Disease: Introduction to Quantitative Genetic Analysis	
03-231	Honors Biochemistry	9
or 03-232	Biochemistry I	
03-320	Cell Biology	9
03-xxx	General Biology Elective [1]	9
03-3xx	Advanced Biology Elective [1]	9

[1] Please see description and requirements for electives under the B.S. in Biological Sciences section of this Catalog.

Minimum number of units required for the Minor in Biological Sciences: 73

Minor in Neuroscience

The curriculum within the Neuroscience minor will allow students from various disciplines to gain fundamental knowledge of neuroscience concepts. The interdisciplinary nature of the coursework echoes the nature of the field itself; students will select courses from the natural, social, and computer sciences. Neuroscientists not only require foundational knowledge of molecular, cellular, and systems neuroscience, but they should also understand the behavioral significance and appreciate how computational work and imaging techniques can aid in clarifying normal and abnormal functioning of these fundamental processes.

Students pursuing the minor in Neuroscience will:

- Acquire foundational knowledge of the basic biological foundations of the nervous system, from the cellular through systems levels.
- Understand the effects of basic neurological function on behavior, including cognition.
- Gain an appreciation of the interdisciplinary nature of the field of neuroscience.

All university students are eligible to pursue a minor in neuroscience in conjunction with a major in any other department in the university. A minimum of seven courses must be completed to fulfill the minor in neuroscience. The curriculum includes four required courses and three elective courses as specified below. Units awarded for undergraduate research are not applicable to elective courses. Courses taken in other departments or colleges will be considered on an individual basis by the Director of Undergraduate Studies.

NOTE: Because the curriculum within this minor may overlap with some degree requirements, no more than 2 courses fulfilling Neuroscience Minor requirements may count towards the requirements of a student's major or other minor.

Course Requirements

Minimum units required for Neuroscience minor 63

Required courses (4):

		Units
03-121	Modern Biology	9
or 03-151	Honors Modern Biology	
03-362	Cellular Neuroscience	9
03-363	Systems Neuroscience	9
85-219	Foundations of Brain and Behavior	9
or 03-161	Molecules to Mind	

Neurobiology Elective Requirements:

27 units of electives required, including at least 1 course 300-level or higher

Neurobiology Electives		Units
03-133	Neurobiology of Disease	9
03-351	Computation and Biology Integrated Research Lab	9
03-360/02-319	Genomics and Epigenetics of the Brain	9
03-365	Neural Correlates of Learning and Memory	9
03-366	Neuropharmacology: Drugs, Brain and Behavior	9
85-104	Psychopathology	9
85-211	Cognitive Psychology [1]	9
85-310	Research Methods in Cognitive Psychology	9
85-370	Perception	9
85-406	Autism: Psychological and Neuroscience Perspectives	9
85-414	Cognitive Neuropsychology	9
85-435	Biologically Intelligent Exploration	9
03-119	Biology for Life Special Topics Micro *Offered only in Doha, requires approval from minor advisor	3

[1]NOTE: 85-213 may be used instead of 85-211 when offered

Masters Degrees

Students who are interested in more advanced training in the intersection of biology and computation or biology and engineering may want to consider the Department of Biological Science's Masters programs: the Master of Science in Quantitative Biology and Bioinformatics (https://www.cmu.edu/bio/graduate/ms_quant_bioinformatics/), the Master of Science in Computational Biology (https://www.cmu.edu/ms-compbio/) (joint with the Department of Computational Biology), or the Master of Science in Biotechnology and Pharmaceutical Engineering (https://www.cmu.edu/ms-biotech-pharma/) (joint with the Department of Chemical Engineering). For more information about these programs, contact the Biological Sciences Graduate Programs Office (bio-graduate-office@andrew.cmu.edu).

Honors Program in Research Biology

The departmental Honors Program offers an opportunity to become extensively involved in research. The program requires students to conduct an independent project and to prepare a formal thesis that is written and defended in the senior year. This program does not preclude a student from completing any of the options within the department nor is it the only way in which students can participate in undergraduate research, although it is excellent preparation for graduate studies. Please contact the Director of Undergraduate Studies for more information.

Transfer Credit for Biological Sciences Courses

1. Requests for transfer credit for biology classes taken at other institutions should be made to the Director of Undergraduate Studies. Students making such requests should follow the policies and procedures in place within their home colleges in assembling materials for such requests. Consult with your advisor on the appropriate steps.
2. Requests should be placed **before** paying tuition for a class in case transfer credit is denied. Allow 1-2 weeks for approval.
3. At minimum requests must be accompanied by a complete syllabus including the textbook that will be used, a detailed list of topic areas and an indication of whether or not the course is part of the curriculum for science majors at the other institution. Check to ensure that the institution is on a semester system. Most schools on a quarter system (many in the UC system of schools) teach general biology over three quarters; therefore one of these classes would not be equivalent to one CMU class.
4. In assessing the suitability of courses for transfer credit, the following factors are considered:
   - The rigor of the course must be comparable to that offered at Carnegie Mellon. This is usually assessed via the quality of the institution and its biology program, the textbook used, the amount of time spent on topic areas, and the course assessment structure.
   - The topic areas should match to a degree of at least 80% those covered in the comparable course at Carnegie Mellon University.
5. No transfer credit will be awarded for the laboratory classes required for the biological sciences majors at Carnegie Mellon University, 03-124, 03-343, 03-344, 03-345 and 03-346. Core biological sciences courses required for the BS degrees and the additional major that are numbered 03-2xx or higher must be taken at Carnegie Mellon University. Exceptions must be requested of and approved by the Director of Undergraduate Studies. In general such requests will be approved only under unusual or extenuating circumstances. Transfer credit for biological elective coursework will be assessed on a case by case basis by the Director of Undergraduate Studies.
6. Students wishing to transfer credit for 03-121 Modern Biology from another institution must meet the following requirements:
   - The course in question should have at least an 80% match in topics with 03-121. Topics in 03-121 cover the genetic, molecular, cellular, developmental, and evolutionary mechanisms that underlie biological processes and include: Cell theory; Cell chemistry; Cell structure; Function and structure of proteins, DNA, RNA, lipids and carbohydrates; Cell respiration and fermentation; The cell cycle; Cell-cell interactions and communication; Transcription; Translation; RNA processing in Eukaryotes; DNA replication; DNA mutation and repair; Meiosis; Mitosis; and Regulation of Gene Expression. *This information is sometimes available in the course description, but more detail is often found in a course syllabus.*
   - The textbook used in the transfer course should be at a comparable level to S. Freeman et al (2016) "Biological Science" Sixth Edition, Pearson, ISBN 9780134255033 (eText).
   - Introductory level courses that focus on other biology areas (i.e. anatomy, physiology, ecology, evolution, and/or development) will not be accepted for 03-121 credit. These courses may receive credit for a general biology elective.

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