

# Department of Biological Sciences

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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/servicesandoptions/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. The B.S. degrees in Biological Sciences/Neuroscience Track and Neuroscience are available to those students who wish to pursue an in-depth study of neuroscience.

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. degrees in Computational Biology and Neuroscience as well as the unified B.S. degree in Biological Sciences and Psychology. Students also explore interdisciplinary studies through the Science and Humanities Scholars program, or 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 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 80 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 B.S. degrees in Biological Sciences as well as Computational Biology at Carnegie Mellon University in Doha, Qatar. Students enrolled in either of these degree programs will also complete the requirements outlined below.

However, a limited number of required courses for the CMU-Qatar program are 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 (<https://www.qatar.cmu.edu/curriculum-bs>).

## Program Outcomes

Upon graduation recipients of the BS or BA 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
03-121	Modern Biology	9
or 03-151	Honors Modern Biology	
03-201	Undergraduate Colloquium for Sophomores	2
03-220	Genetics	9
03-231/232	Biochemistry I	9
03-250	Introduction to Computational Biology	12
or 03-251 AND 03-252		
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 <sup>1</sup>	54
Total Biology units		130

<sup>1</sup> Details on electives can be found in the "Biological Sciences Electives" section (see below).

Mathematics, Physics and Computer Science		Units
02-201	Programming for Scientists <sup>2</sup>	10
21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	
33-121	Physics I for Science Students <sup>3</sup>	12
33-122	Physics II for Biological Sciences & Chemistry Students <sup>4</sup>	9

99-10x	Computing at Carnegie Mellon	3
Total Science units		54

<sup>2</sup> 15-112 Fundamentals of Programming and Computer Science or 15-110 Principles of Computing can substitute for 02-201 towards the completion of the Programming course requirement.

<sup>3</sup> 33-111 Physics I for Science Students may substitute for 33-121 towards completion of the Physics I requirement.

<sup>4</sup> 33-112 Physics II for Science Students may substitute for 33-122 towards completion of the Physics II requirement.

Chemistry		Units
09-105	Introduction to Modern Chemistry I <sup>5</sup>	10
or 09-107	Honors Chemistry: Fundamentals, Concepts and Applications	
09-106	Modern Chemistry II	10
09-217	Organic Chemistry I	9
or 09-219	Modern Organic Chemistry	
09-218	Organic Chemistry II	9
or 09-220	Modern Organic Chemistry II	
09-207	Techniques in Quantitative Analysis	9
or 09-221	Laboratory I: Introduction to Chemical Analysis	
09-208	Techniques for Organic Synthesis and Analysis	9
or 09-222	Laboratory II: Organic Synthesis and Analysis	
Total Chemistry units		56

<sup>5</sup> 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	72
Total Elective units	120

**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 (these can be counted as general bio electives towards your degree)
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 03-370.
- Up to three interdisciplinary electives may count as biology electives.
- Up to 18 units of 03-445 Undergraduate Research may count as general biology electives; a maximum of 36 units 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 Carnegie Mellon Department of Biological Sciences advisor.

#### Departmental Electives Group

03-115/116	Phage Genomics Research	6
03-116	Phage Genomics Research	6
03-124	Modern Biology Laboratory	9
03-125	Evolution	9
03-126	Cellular Response to the Environment	4
03-127	How Biological Experiments Work - A Project Course	9
03-133	Neurobiology of Disease	9
03-161	Molecules to Mind	9
03-326	Evolution of Regulatory Genomics	4.5

03-327	Phylogenetics	9
03-350	Developmental Biology	9
03-362	Cellular Neuroscience	9
03-363	Systems Neuroscience	9
03-364	Developmental Neuroscience	9
03-365	Neural Correlates of Learning and Memory	9
03-366	Biochemistry of the Brain	9
03-370	Principles of Biotechnology	9
03-390	Molecular and Cellular Immunology	9
03-391	Microbiology	9
03-392	Microbiology Laboratory	6
03-428	Genome Editing Biotechnology	4.5
03-435	Cancer Biology	9
03-439	Introduction to Biophysics	9
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
03-512	Computational Methods for Biological Modeling and Simulation	9
03-534	Biological Imaging and Fluorescence Spectroscopy	9
03-545	Honors Research	9
03-620	Techniques in Electron Microscopy	9
03-709	Applied Cell and Molecular Biology	12
03-711	Computational Molecular Biology and Genomics	12
03-712	Computational Methods for Biological Modeling and Simulation	12
03-713	Bioinformatics Data Integration Practicum	6
03-726	Evolution of Regulatory Genomics	6
03-727	Phylogenetics	12
03-728	Genome Editing Biotechnology	6
03-730	Advanced Genetics	12
03-740	Advanced Biochemistry	12
03-741	Advanced Cell Biology	12
03-742	Molecular Biology	12
03-744	Membrane Trafficking	9
03-751	Advanced Developmental Biology and Human Health	12
03-762	Advanced Cellular Neuroscience	12
03-763	Advanced Systems Neuroscience	12
03-765	Advanced Neural Correlates of Learning and Memory	12
03-770	Principles of Biotechnology	12
03-791	Advanced Microbiology	12
03-871	Structural Biophysics	12

#### Interdisciplinary Electives Group

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

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
09-535	Applied topics in Macromolecular and Biophysical Techniques	9
21-127	Concepts of Mathematics	10
21-259	Calculus in Three Dimensions	9
21-260	Differential Equations	9
36-201	Statistical Reasoning and Practice	9
36-247	Statistics for Lab Sciences	9
42-202	Physiology	9
85-219	Biological Foundations of 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. A student who completes the required biology electives for any option can have up to two noted on his or her transcript. Options need not be declared. The elective courses required for each of the options are listed below.

### Biochemistry Option

Required Biology Electives:

03-740	Advanced Biochemistry	12
21-259	Calculus in Three Dimensions	9
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
03-534	Biological Imaging and Fluorescence Spectroscopy	9
03-439	Introduction to Biophysics	9
03-871	Structural Biophysics	12

### Biophysics Option

Required Biology Electives:

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

Recommended Biology Electives:

03-534	Biological Imaging and Fluorescence Spectroscopy	9
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:

36-247	Statistics for Lab Sciences	9
21-260	Differential Equations	9
21-241	Matrices and Linear Transformations	10

Recommended Biology Electives:

03-512	Computational Methods for Biological Modeling and Simulation	9
15-451	Algorithm Design and Analysis	12
09-560	Computational Chemistry	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:

03-326	Evolution of Regulatory Genomics	4.5
03-741	Advanced Cell Biology	12

### Genetics Option

Required Biology Electives:

03-326	Evolution of Regulatory Genomics	4.5
03-327	Phylogenetics	9
03-442	Molecular Biology	9
03-730	Advanced Genetics <sup>6</sup>	12

<sup>6</sup> Minimum grade of B in 03-330 or 03-220 required.

Recommended Biology Electives:

03-391	Microbiology	9
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### Molecular Biology Option

Required Biology Electives:

03-442	Molecular Biology	9
09-518	Bioorganic Chemistry: Nucleic Acids and Carbohydrates	9
03-726	Evolution of Regulatory Genomics	6
03-727	Phylogenetics	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 <sup>7</sup>	9
03-363	Systems Neuroscience <sup>7</sup>	9

Any ONE of the following courses:

03-133	Neurobiology of Disease	9
03-350	Developmental Biology	9
03-364	Developmental Neuroscience	9
03-365	Neural Correlates of Learning and Memory	9
03-366	Biochemistry of the Brain	9
03-534	Biological Imaging and Fluorescence Spectroscopy	9
42-202	Physiology	9
85-219	Biological Foundations of Behavior	9

<sup>7</sup> 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
03-765	Advanced Neural Correlates of Learning and Memory	12

Plus three of the following electives:

03-133	Neurobiology of Disease	9
03-350	Developmental Biology	9

03-364	Developmental Neuroscience	9
03-366	Biochemistry of the Brain	9
03-534	Biological Imaging and Fluorescence Spectroscopy	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	Biological Foundations of Behavior	9

## B.S. Neuroscience

The Bachelor of Science in Neuroscience is listed in the Intercollege (<http://coursecatalog.web.cmu.edu/servicesandoptions/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 Dr. Becki Campanaro (DH 1320). More information can also be found on the CMU Neuroscience website (<http://www.cmu.edu/neuro>).

## B.S. Biological Sciences and 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. Students in the joint Science and Humanities Scholars (SHS) program can complete the SHS educational core and choose either departmental order for their diploma.

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/dietrichcollegeofhumanitiesandsocialsciences/#hampssgeneraleducationprogram160>) and MCS (<http://coursecatalog.web.cmu.edu/melloncollegeofscience>) are found on their respective Catalog pages.

### Degree Requirements:

Biological Sciences		Units
03-121	Modern Biology	9
or 03-151	Honors Modern Biology	
03-220	Genetics	9
03-231/232	Biochemistry I	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 <sup>1</sup>	9
03-3xx	Advanced Biology Elective <sup>1</sup>	18
Total Biology units		77

<sup>1</sup> 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
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	
36-247	Statistics for Lab Sciences	9
or 36-201	Statistical Reasoning and Practice	
36-309	Experimental Design for Behavioral and Social Sciences	9
33-121	Physics I for Science Students <sup>2</sup>	12
15-110	Principles of Computing	10-12
or 15-112	Fundamentals of Programming and Computer Science	
or 02-201	Programming for Scientists	

99-10x	Computing at Carnegie Mellon	3
Total Science units		63-65

<sup>2</sup> 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
or 09-219	Modern Organic Chemistry	
09-218	Organic Chemistry II	9
or 09-220	Modern Organic Chemistry II	
09-207	Techniques in Quantitative Analysis	9-12
or 09-221	Laboratory I: Introduction to Chemical Analysis	
09-208	Techniques for Organic Synthesis and Analysis	9-12
or 09-222	Laboratory II: Organic Synthesis and Analysis	
Total Chemistry units		56-62

Psychology Courses		Units
85-102	Introduction to Psychology	9
85-219	Biological Foundations of Behavior	9
85-2xx	Survey Psychology Courses *	18
85-310	Research Methods in Cognitive Psychology	9
or 85-340	Research Methods in Social Psychology	
or 85-320	Research Methods in Developmental Psychology	
or 85-314	Cognitive Neuroscience Research Methods	
or 85-330	Analytic Research Methods	
85-3xx	Advanced Psychology Electives	18
Total Psychology units		63

\* Excluding 85-261 Abnormal Psychology

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
85-310	Research Methods in Cognitive Psychology	9
85-314	Cognitive Neuroscience Research Methods	9
85-320	Research Methods in Developmental Psychology	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
03-121	Modern Biology	9
or 03-151	Honors Modern Biology	
03-201	Undergraduate Colloquium for Sophomores	2

03-220	Genetics	9
03-231/232	Biochemistry I	9
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 <sup>8</sup>	18
03-3xx	Advanced Biology Electives <sup>8</sup>	18
Total Biology units		85-88

<sup>8</sup> 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 <sup>9</sup>	10
or 09-107	Honors Chemistry: Fundamentals, Concepts and Applications	
09-106	Modern Chemistry II	10
09-217	Organic Chemistry I	9
or 09-219	Modern Organic Chemistry	
09-218	Organic Chemistry II	9
or 09-220	Modern Organic Chemistry II	
09-207	Techniques in Quantitative Analysis	9-12
or 09-221	Laboratory I: Introduction to Chemical Analysis	
Total Chemistry units		47-50

<sup>9</sup> 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
02-201	Programming for Scientists <sup>10</sup>	10
21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
or 21-124	Calculus II for Biologists and Chemists	
33-121	Physics I for Science Students <sup>11</sup>	12
33-122	Physics II for Biological Sciences & Chemistry Students <sup>12</sup>	9
99-10x	Computing at Carnegie Mellon	3
Total Science units		54

<sup>10</sup> 15-112 Fundamentals of Programming and Computer Science or 15-110 Principles of Computing can substitute for 02-201 towards completion of the Programming course requirement.

<sup>11</sup> 33-111 Physics I for Science Students can substitute for 33-121 Physics I for Science Students towards completion of the Physics I requirement.

<sup>12</sup> 33-112 Physics II for Science Students can substitute for 33-122 Physics II for Biological Sciences & Chemistry Students towards completion of the Physics II requirement.

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

### 360 Minimum number of units required for degree:

## 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.

### 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
03-231/232	Biochemistry I	9
03-320	Cell Biology	9
03-xxx	General Biology Elective	9
03-3xx	Advanced Biology Elective	9

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

## 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.

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	Biological Foundations of Behavior	9
or 03-161	Molecules to Mind	

Distribution Requirements:

Three courses, including at least 1 from each of the following categories:

Approaches to Neuroscience Category		Units
15-386	Neural Computation	9
15-883	Computational Models of Neural Systems	12
85-412	Cognitive Modeling	9
85-414	Cognitive Neuropsychology	9
85-419	Introduction to Parallel Distributed Processing	9
85-429	Cognitive Brain Imaging	9

Cognitive Neuroscience Category		Units
03-133	Neurobiology of Disease	9
03-364	Developmental Neuroscience	9
85-211	Cognitive Psychology *	9
85-356	Music and Mind: The Cognitive Neuroscience of Sound	9
85-370	Perception	9
85-390	Human Memory	9
85-406	Autism: Psychological and Neuroscience Perspectives	9

\*NOTE: 85-213 may be used instead of 85-211 when offered

## B.S. in Computational Biology

Students who entered CMU in Fall 2016 and earlier may pursue the Intercollege Bachelor of Science in Computational Biology joint program between the Mellon College of Sciences and the School of Computer Science. Degree requirements for this program can be found in the 2016-2017 catalog (<http://coursecatalog.web.cmu.edu/> previous). Interested students should contact Dr. Becki Campanaro ([bcampana@andrew.cmu.edu](mailto:bcampana@andrew.cmu.edu)) for more information.

## Masters Degree in Computational Biology

Students who are interested in more advanced training in this emerging field may want to consider the Master of Science Program in Computational Biology. For more information about this program, contact the Biological Sciences Graduate Programs Office ([bio-gradoffice@andrew.cmu.edu](mailto:bio-gradoffice@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.

## Transfer credit for Modern Biology

Students wishing to transfer credit for 03-121 Modern Biology from another institution must meet the following requirements:

1. 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.*
2. The textbook used in the transfer course should be at a comparable level to S. Freeman (2010) "Biological Science, Vol. 1 (The Cell, Genetics, and Development)," Fourth Edition, Pearson Benjamin Cummings, ISBN 0-321-61347-3.
3. 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.
4. Students should contact their departmental academic advisor for the transfer credit approval process in their college.

## Faculty

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