Department of Biological Sciences

Veronica Hinman, Department Head
Amanda Willard, Director of Undergraduate Studies
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 interest 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 either of these degree programs 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:

<table>
<thead>
<tr>
<th>Biological Sciences</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>03-151 or 03-121</td>
<td>Honors Modern Biology 10</td>
</tr>
<tr>
<td>03-201</td>
<td>Undergraduate Colloquium for Sophomores 2</td>
</tr>
<tr>
<td>03-220</td>
<td>Genetics 9</td>
</tr>
<tr>
<td>03-221</td>
<td>Genomes, Evolution, and Disease: Introduction to Quantitative Genetic Analysis 10</td>
</tr>
<tr>
<td>03-231 or 03-232</td>
<td>Honors Biochemistry 9</td>
</tr>
<tr>
<td>02-250</td>
<td>Introduction to Computational Biology 12</td>
</tr>
<tr>
<td>03-320</td>
<td>Cell Biology 9</td>
</tr>
<tr>
<td>03-343</td>
<td>Experimental Techniques in Molecular Biology 12</td>
</tr>
<tr>
<td>03-344</td>
<td>Experimental Biochemistry 12</td>
</tr>
<tr>
<td>03-345 or 03-346</td>
<td>Experimental Cell and Developmental Biology 12</td>
</tr>
<tr>
<td>03-411</td>
<td>Topics in Research 1</td>
</tr>
<tr>
<td>03-412</td>
<td>Topics in Research 1</td>
</tr>
<tr>
<td>03-xxx</td>
<td>Biological Sciences Electives 54</td>
</tr>
</tbody>
</table>

**Total Biology units** 131

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

Mathematics, Physics and Computer Science

<table>
<thead>
<tr>
<th>Mathematics, Physics and Computer Science</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-110</td>
<td>Principles of Computing 10</td>
</tr>
<tr>
<td>21-120</td>
<td>Fundamentals of Programming and Computer Science 10</td>
</tr>
<tr>
<td>21-124</td>
<td>Differential and Integral Calculus 10</td>
</tr>
<tr>
<td>21-122</td>
<td>Calculus II for Biologists and Chemists 10</td>
</tr>
<tr>
<td>33-121 or 33-141</td>
<td>Physics I for Science Students 12</td>
</tr>
<tr>
<td>or 33-141</td>
<td>Physics I for Engineering Students</td>
</tr>
</tbody>
</table>
33-122 Physics II for Biological Sciences & Chemistry Students 9
or 33-142 Physics II for Engineering and Physics Students 9
99-101 Computing @ Carnegie Mellon 3

Total Science units 54

Chemistry
09-105 Introduction to Modern Chemistry I 2 10
or 09-107 Honors Chemistry: Fundamentals, Concepts and Applications 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

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 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/#generaleducationrequirementssection) of this catalog.

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.
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 specificities 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.
• Up to three interdisciplinary electives may count as 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 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

03-117 Frontiers, Analysis, and Discovery in Biological Sciences 6
03-118 Beer: A Yeast's Perspective 6
03-120 Biology for Life Special Topics Mini Var.
03-124 Modern Biology Laboratory 9
03-125 Evolution 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
03-327 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
03-390 Molecular and Cellular Immunology 9
03-391 Microbiology 9
03-410 Special Topics in Biological Sciences Var.
03-428 Genome Editing 6
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
03-742 Advanced Cell Biology 12
03-747 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
03-765 Advanced Neural Correlates of Learning and Memory 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:
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
09-521 Metals in Biology: Function and Reactivity 6
09-535 Applied topics in Macromolecular and Biophysical Techniques 9
09-803 Chemistry of Gene Expression 12
21-127 Concepts of Mathematics 12
21-259 Calculus in Three Dimensions 9
21-260 Differential Equations 9
36-205 Reasoning with Data 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. Options are not required and 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 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
  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 Evolutionary Bioinformatics: Trees, Sequences and the Comparative Method 9
- 03-442 Molecular Biology 9
- 03-730 Advanced Genetics 9

Minimum grade of B in 03-330 or 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
- 03-726 Evolution of Regulatory Genomics 6
- 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 9
- 03-363 Systems Neuroscience 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
- 03-534 Biological Imaging and Fluorescence Spectroscopy 9
- 42-202 Physiology 9
- 85-219 Biological Foundations of Behavior 9

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
- 03-360/02-319 Genomics and Epigenetics of the Brain 9
- 03-366 Neuropharmacology: Drugs, Brain and Behavior 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
- 85-219 Biological Foundations of Behavior 9

**Department of Biological Sciences**

3
Degree Requirements:

B.S. Neuroscience

The Bachelor of Science in Neuroscience is listed in the Intercollege Programs (http://coursecatalog.web.cmu.edu/intercollegeprograms/bachelorscienceneurosciencetext) 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

Michael Tarr, 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 Biological Sciences. Students in the Mellon College of Science will earn a Bachelor of Science in Psychology and Biological Sciences. 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**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-121</td>
<td>Honors Modern Biology</td>
<td>10</td>
</tr>
<tr>
<td>9-124</td>
<td>Modern Biology</td>
<td>9</td>
</tr>
<tr>
<td>9-125</td>
<td>Genomics, Evolution, and Disease: Introduction to Quantitative Genetic Analysis</td>
<td>9</td>
</tr>
<tr>
<td>9-126</td>
<td>Honors Biochemistry</td>
<td>9</td>
</tr>
<tr>
<td>9-127</td>
<td>Cell Biology</td>
<td>9</td>
</tr>
<tr>
<td>9-128</td>
<td>Experimental Techniques in Molecular Biology</td>
<td>12</td>
</tr>
<tr>
<td>9-129</td>
<td>Topics in Research</td>
<td>1</td>
</tr>
<tr>
<td>9-130</td>
<td>Topics in Research</td>
<td>1</td>
</tr>
<tr>
<td>03-xxx</td>
<td>General Biology Elective 1</td>
<td>9</td>
</tr>
<tr>
<td>03-xxx</td>
<td>Advanced Biology Elective 1</td>
<td>18</td>
</tr>
</tbody>
</table>

**Total Biology units** 78

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

**Chemistry**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-121</td>
<td>Introduction to Modern Chemistry I</td>
<td>10</td>
</tr>
<tr>
<td>9-122</td>
<td>Modern Chemistry II</td>
<td>10</td>
</tr>
<tr>
<td>9-123</td>
<td>Organic Chemistry I</td>
<td>9</td>
</tr>
<tr>
<td>9-124</td>
<td>Organic Chemistry II</td>
<td>9</td>
</tr>
<tr>
<td>9-125</td>
<td>Techniques in Quantitative Analysis</td>
<td>9</td>
</tr>
<tr>
<td>9-126</td>
<td>Techniques for Organic Synthesis and Analysis</td>
<td>9</td>
</tr>
</tbody>
</table>

**Total Chemistry units** 56

1 Excluding 85-261 Psychopathology

**Additional Advanced Elective** 9 units

(Choose one of the following courses)

- 85-3xx Advanced Psychology Elective 9
- 03-3xx Advanced Biology Elective 9

**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**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-121</td>
<td>Honors Modern Biology</td>
<td>10</td>
</tr>
<tr>
<td>9-122</td>
<td>Modern Biology</td>
<td>10</td>
</tr>
<tr>
<td>9-123</td>
<td>Genetics</td>
<td>9</td>
</tr>
<tr>
<td>9-124</td>
<td>Genomes, Evolution, and Disease: Introduction to Quantitative Genetic Analysis</td>
<td>9</td>
</tr>
<tr>
<td>9-125</td>
<td>Honors Biochemistry</td>
<td>9</td>
</tr>
<tr>
<td>9-126</td>
<td>Cell Biology</td>
<td>9</td>
</tr>
<tr>
<td>9-127</td>
<td>Experimental Techniques in Molecular Biology</td>
<td>12</td>
</tr>
<tr>
<td>9-128</td>
<td>Topics in Research</td>
<td>1</td>
</tr>
<tr>
<td>9-129</td>
<td>Principles of Computing</td>
<td>10-12</td>
</tr>
<tr>
<td>9-130</td>
<td>Fundamentals of Programming and Computer Science</td>
<td>3</td>
</tr>
</tbody>
</table>

**Total Science units** 63-65

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

**Psychology Courses**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>85-102</td>
<td>Introduction to Psychology</td>
<td>9</td>
</tr>
<tr>
<td>85-219</td>
<td>Biological Foundations of Behavior</td>
<td>9</td>
</tr>
<tr>
<td>85-220</td>
<td>Survey Psychology Courses 1</td>
<td>18</td>
</tr>
<tr>
<td>85-310</td>
<td>Research Methods in Cognitive Psychology</td>
<td>9</td>
</tr>
<tr>
<td>85-314</td>
<td>Cognitive Neuroscience Research Methods</td>
<td>9</td>
</tr>
<tr>
<td>85-320</td>
<td>Research Methods in Developmental Psychology</td>
<td>9</td>
</tr>
<tr>
<td>85-330</td>
<td>Analytic Research Methods</td>
<td>9</td>
</tr>
<tr>
<td>85-340</td>
<td>Research Methods in Social Psychology</td>
<td>9</td>
</tr>
<tr>
<td>85-3xx</td>
<td>Advanced Psychology Electives</td>
<td>18</td>
</tr>
</tbody>
</table>

**Total Psychology units** 63

**Additional Laboratory or Research Methods** 9-12 units

(Choose one of the following courses)

- 03-3xx Advanced Biology Elective 9
- 85-3xx Advanced Psychology Elective 9

**Total Elective units** 69-84

Minimum number of units required for degree: 360
Minor in Biological Sciences

Courses for the Minor in Biological Sciences

Prerequisites:

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

Required courses:

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

Total Biology units: 86-89

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

Chemistry

- 09-105 Introduction to Modern Chemistry I 9
- or 09-107 Honors Chemistry: Fundamentals, Concepts and Applications 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

Total Chemistry units: 47

9 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

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

Total Science units: 54

Elective courses: Units

MCS Nontechnical Breadth Requirements: 72

Free Electives: 96-99

Total Elective units: 168-171

Minimum number of units required for degree: 360

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):

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

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
  - 85-429 Cognitive Brain Imaging 9
  - 85-435 Biologically Intelligent Exploration 9
- Cognitive Neuroscience Category: Units
  - 03-133 Neurobiology of Disease 9
  - 03-365 Neural Correlates of Learning and Memory 9
  - 03-366 Neuropharmacology: Drugs, Brain and Behavior 9
  - 85-211 Cognitive Psychology* 9
  - 85-370 Perception 9
  - 85-406 Autism: Psychological and Neuroscience Perspectives 9

*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/), the Master of Science in Biotechnology and Pharmaceutical Engineering (https://www.cmu.edu/ms-biotech-pharma/), and the Master of Science in Chemistry (https://www.cmu.edu/ms-chemistry/). 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.

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.


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.

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