

Biological Sciences, B.S.

Overview

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 tracks (p. 2) in *biochemistry*, *biomedical sciences*, *cell and developmental biology*, *genetics and molecular biology*, and *neuroscience* that provide the relevant training in each area. The tracks are especially recommended for students who are considering graduate school in one of these areas.

The Bachelor of Science (B.S.) in Biological Sciences is built around a core program and elective units as detailed in the following section. For schedule planning feedback, advising support, and/or sample four year schedules please contact the Biological Sciences Undergraduate Programs Office (bio-grad@andrew.cmu.edu).

Program Learning Outcomes

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

- Recall and understand foundational knowledge in genetics, biochemistry, cell biology, computational biology, and experimental methodology (i.e. core courses required of all majors).
- Apply foundational knowledge to develop an understanding of specialized fields in Biological Sciences (i.e. topics covered in advanced electives 300-level+).
- Apply the scientific method to generate knowledge and solve problems.
- Apply acquired knowledge to analyze and interpret data.
- Identify and critically evaluate scientific information relevant to Biological Sciences from multiple sources.
- Clearly, logically, and accurately communicate Biological Sciences content in written and oral formats.
- Practice working collaboratively in teams and demonstrate effective teamwork.
- Recall and understand the principles of the responsible conduct of research and apply selected aspects of the responsible conduct of research (i.e. data management and citation of sources).

Degree Requirements

Biological Sciences	Units
03-151 Honors Modern Biology	10
or 03-121 Modern Biology	
03-201 Undergraduate Colloquium for Sophomores	2
03-231 Honors Biochemistry	9
03-320 Cell Biology	9
*New course number (03-240) starting Fall 2027	
02-250 Introduction to Computational Biology	12
03-220 Genetics	9
*New course number (03-330) starting Fall 2027	
or 03-221 Genomes, Evolution, and Disease: Introduction to Quantitative Genetic Analysis	
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
02-120 Programming for Scientists	12
or 15-110 Principles of Computing	
or 15-112 Fundamentals of Programming and Computer Science	
21-120 Differential and Integral Calculus (prerequisite: 21-090)	10
21-122 Integration and Approximation	10
33-121 Physics I for Science Students	12
or 33-141 Physics I for Engineering Students	
33-122 Physics II for Biological Sciences and Chemistry Students	9
or 33-142 Physics II for Engineering and Physics Students	

Total Mathematics, Physics and Computer Science units 53

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	45
MCS Nontechnical Breadth Requirements ³	75
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/#generaleducationrequirements>) 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:

- 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.
- Physical Sciences: 09-105, 09-106, 33-121 and 33-122
- Math/CS/Stats: 21-120 and 21-122
- 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, Dr. Amanda Willard (awillard@cmu.edu).

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		6
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	Human Anatomy and Physiology	*Offered only in Doha	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
03-444	Precision Medicine	*Offered only in Doha	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
03-728	Genome Editing Biotechnology		6
03-729	Entrepreneurship and protein-based drug development		6
03-730	Advanced Genetics		12
03-737	Biosensors		6
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

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
09-530	Chemistry of Gene Expression	9
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
85-170	Foundations of Brain and Behavior	9

Core Areas of Study

Students who are pursuing a B.S. in Biological Sciences and wish to specialize in a particular area of biology can do so through a set of departmentally defined tracks. Tracks are **not required** and need not be declared. The elective courses required for each of the tracks are listed below. Students can elect to complete a maximum of two tracks. Please discuss interest in these tracks with your Carnegie Mellon Department of Biological Sciences advisor to plan out any prerequisite coursework and identify appropriate course alternatives in the event that a graduate-level course is not being offered during a particular academic year. Completed tracks are listed on the transcript, not on the diploma. All tracks are available for B.S. Biological Sciences students at the Carnegie Mellon University Pittsburgh and Qatar campuses, with the exception of the Biochemistry Track, which is currently only offered for students at the Pittsburgh campus. Electives for the following degree tracks are detailed below:

- Biochemistry (<http://coursecatalog.web.cmu.edu/schools-colleges/melloncollegeofscience/departments/biologicalsciences/biological-sciences-bs/#Biochemistry> Track)
- Biomedical Sciences (<http://coursecatalog.web.cmu.edu/schools-colleges/melloncollegeofscience/departments/biologicalsciences/biological-sciences-bs/#Biomedical> Sciences Track)
- Cell and Developmental Biology (<http://coursecatalog.web.cmu.edu/schools-colleges/melloncollegeofscience/departments/biologicalsciences/biological-sciences-bs/#Cell> and Developmental Biology Track)
- Genetics and Molecular Biology (<http://coursecatalog.web.cmu.edu/schools-colleges/melloncollegeofscience/departments/biologicalsciences/biological-sciences-bs/#Genetics> and Molecular Biology Track)
- Neuroscience (<http://coursecatalog.web.cmu.edu/schools-colleges/melloncollegeofscience/departments/biologicalsciences/biological-sciences-bs/#Neuroscience> Track)

Biochemistry TRACK*

FIVE (5) courses total:

TWO (2) required biology electives:

03-442/742	Molecular Biology	9
03-740	Advanced Biochemistry	12
And any THREE (3) of the following:		
02-542	Biological Circuit Design	12
03-445	Undergraduate Research (with advisor approval - 1 semester of 9+ units)	Var.
03-728	Genome Editing Biotechnology	6
03-737	Biosensors	6
06-685	Bioseparations and Bioprocess Analytical Technologies	12
06-722	Bioprocess Design	12
09-403	Hooked: The Chemical Basis of Drug Addiction	9
09-518/719	Bioorganic Chemistry: Nucleic Acids and Carbohydrates	9
09-519/719	Bioorganic Chemistry: Peptides, Proteins and Combinatorial Chemistry	9
09-530	Chemistry of Gene Expression	9

09-563	Molecular Modeling and Computational Chemistry	9
09-737	Medicinal Chemistry and Drug Development	12

* The biochemistry track is only available for students at the CMU-Pittsburgh campus.

BioMEDICAL SCIENCES TRACK

FIVE (5) courses total:

At least TWO (2) of the following courses:

03-350	Developmental Biology	9
03-390	Molecular and Cellular Immunology	9
03-391/791	Microbiology ¹	9

And any TWO (2) or THREE (3) of the following for a total of FIVE (5) courses (no more than 9 units at the 100-level):

02-518	Computational Medicine	12
03-132	Basic Science to Modern Medicine ^{*Only offered in Summer}	9

03-133	Neurobiology of Disease	9
03-135	Structure and Function of the Human Body ²	9
or 42-202	Physiology	

03-435	Cancer Biology	9
03-444	Precision Medicine ^{*Only offered at Doha}	9

03-445	Undergraduate Research (with advisor approval - 1 semester of 9+ units)	Var.
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03-451/751	Advanced Developmental Biology and Human Health	9
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03-728	Genome Editing Biotechnology	6
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03-730	Advanced Genetics	12
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09-403	Hooked: The Chemical Basis of Drug Addiction	9
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09-737	Medicinal Chemistry and Drug Development	12
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A maximum of one elective can be (with advisor approval):

42-612	Tissue Engineering	12
or 42-624	Biological Transport and Drug Delivery	
or 42-650	Introduction to Biomedical Imaging	
or 42-695	Special Topics: Engineering Protein Therapeutics	
or 80-245	Medical Ethics	

¹ Students completing this track at the CMU-Qatar campus can take 03-380 Virology

² Students completing this track at the CMU-Qatar campus can take 03-230 Human Anatomy and Physiology

Cell AND DEVELOPMENTAL Biology TRACK

FIVE (5) courses total:

THREE (3) required biology electives:

03-350	Developmental Biology	9
03-442/742	Molecular Biology	9
03-741	Advanced Cell Biology ¹	12

And any TWO (2) of the following:

03-362/762	Cellular Neuroscience	9
03-390	Molecular and Cellular Immunology	9

03-435	Cancer Biology	9
03-445	Undergraduate Research (with advisor approval - 1 semester of 9+ units)	Var.

03-451/751	Advanced Developmental Biology and Human Health	9
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03-737	Biosensors	6
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¹ Students completing this track at the CMU-Qatar campus can take 03-362 Cellular Neuroscience

Genetics and Molecular Biology TRACK

FIVE (5) courses total:

TWO (2) required biology electives:

03-442/742	Molecular Biology	9
03-730	Advanced Genetics ¹	12

And any THREE (3) of the following (no more than 9 units at the 100-level):

03-125	Evolution	9
03-161	Molecules to Mind	9

03-351	Computation and Biology Integrated Research Lab	9
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03-360/02-319	Genomics and Epigenetics of the Brain	9
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03-390	Molecular and Cellular Immunology	9
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03-391/791	Microbiology	9
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03-435	Cancer Biology	9
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03-445	Undergraduate Research (with advisor approval - 1 semester of 9+ units)	Var.
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03-511	Computational Molecular Biology and Genomics	9
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03-728	Genome Editing Biotechnology	6
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A maximum of one elective can be:

02-331	Modeling Evolution	12
or 02-510	Computational Genomics	
or 02-544	Introduction to Statistical Genetics	

¹ Students completing this track at the CMU-Qatar campus can take 03-444 Precision Medicine

Neuroscience Track

FIVE (5) courses total:

At least TWO (2) of the following:

03-362/762	Cellular Neuroscience	9
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03-363/763	Systems Neuroscience	9
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03-365	Neural Correlates of Learning and Memory	9
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And TWO (2) or THREE (3) of the following for a total of FIVE (5) courses (no more than 9 units at the 100-level):

03-133	Neurobiology of Disease	9
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03-161	Molecules to Mind	9
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03-135	Structure and Function of the Human Body ¹	9
or 42-202	Physiology	

03-350	Developmental Biology	9
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03-351	Computation and Biology Integrated Research Lab	9
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03-445	Undergraduate Research (with advisor approval - 1 semester of 9+ units)	Var.
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03-360/02-319	Genomics and Epigenetics of the Brain	9
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03-366/766	Neuropharmacology: Drugs, Brain and Behavior	9
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85-170	Foundations of Brain and Behavior	9
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85-110	Cognitive Psychology	9
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or 85-213	Human Information Processing and Artificial Intelligence	
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¹ Students completing this track at the CMU-Qatar campus can take 03-230 Human Anatomy and Physiology