SYSTEMS BIOLOGY, BS

Degree: Bachelor of Science (BS)
Major: Systems Biology

Program Overview

Systems biology is a rapidly emerging area of research activity at the interface of mathematics, computer science, and the biological sciences. Many modern areas of biology research (e.g., biochemical, neural, behavioral, and ecosystem networks) require the mastery of advanced quantitative and computational skills. The Systems Biology BS degree program is intended to provide the quantitative and multidisciplinary understanding that is necessary for work in these areas. This skill set is different from that produced by traditional undergraduate programs in biology. Consequently, the Systems Biology BS program adds two core courses (in modeling and analysis of biological systems) beyond the three core lecture courses in the Biology BA and Biology BS programs, as well as foundation courses from computer science and advanced mathematics. The traditional biology core laboratory courses are not required, but may be taken as electives. Undergraduate research is strongly recommended (as BIOL 388S and BIOL 390) but is not formally required.

The Systems Biology BS provides options for specialization in a variety of areas, including biotechnology and genetic engineering, molecular and cellular biology, genetics, immunology, chemical biology, physiology and biophysics, neurobiology and animal behavior, developmental biology, population biology, ecology, and environmental science. Theoretical, mathematical, and computational approaches to these fields are emphasized in the Systems Biology BS program.

Ordinarily, all students begin their biology programs in their first year.

Learning Outcomes

- Students will be able to demonstrate knowledge of biological concepts.
- Students will be able to use mathematical and computational tools to answer biological questions.
- Students will be able to demonstrate clarity of thought and logical rigor in analyzing problems. They will be able to formulate and refine clear questions and design effective tests of hypotheses.
- Students will be able to communicate effectively orally and in writing.
- Students will be able to translate biological phenomena intomathematical/computational language and vice versa.

Advising

Biology faculty advisors are assigned to students at the time of major or minor declaration. All biology majors are required to meet with their departmental advisors at least once each semester to discuss their academic program, receive clearance for electronic course registration, and obtain approval for any drops, adds, or withdrawals. Please contact the undergraduate services coordinator for the Department of Biology for information about major or minor declaration.

Undergraduate Policies

For undergraduate policies and procedures, please review the Undergraduate Academics section of the General Bulletin.

Accelerated Master's Programs

Undergraduate students may participate in accelerated programs toward graduate or professional degrees. For more information and details of the policies and procedures related to accelerated studies, please visit the Undergraduate Academics section of the General Bulletin.

Program Requirements

Students seeking to complete this major and degree program must meet the general requirements for bachelor's degrees and the Unified General Education Requirements. Students completing this program as a secondary major while completing another undergraduate degree program do not need to satisfy the school-specific requirements associated with this major.

Code	Title	Credit Hours
Core Courses		
BIOL 214	Genes, Evolution and Ecology	3
BIOL 215	Cells and Proteins	3
BIOL 216	Development and Physiology	3
BIOL 300	Dynamics of Biological Systems: A Quantitative Introduction to Biology	3
BIOL 306	Mathematical Analysis of Biological Models	3
Choose two courses from one subspecialty:		**6-8**
Neuroscience subspecialty courses:		
BIOL 322	Sensory Biology	
BIOL 373	Introduction to Neurobiology	
BIOL 374	Neurobiology of Behavior	
BIOL/MATH 378	Computational Neuroscience	
NEUR 402	Principles of Neural Science	
Bioinformatics and Genetics subspecialty courses:		
BIOL 301	Biotechnology Laboratory: Genes and Genetic Engineering	
BIOL 311A & BIOL 311B & BIOL 311C or SYBB 311 & SYBB 311E & SYBB 311C	and and and and	
BIOL 326	Genetics	
BIOL 327	Functional Genomics	
BIOL 328	Plant Genomics and Proteomics	
CSDS 458	Introduction to Bioinformatics	
CSDS 459	Bioinformatics for Systems Biology	
Ecology and Evolutionary Biology subspecialty courses:		
BIOL 305	Herpetology	
BIOL 318	Introductory Entomology	
BIOL 336	Aquatic Biology	
BIOL 338	Ichthyology	
BIOL 345	Mammal Diversity and Evolution	
BIOL 351	Principles of Ecology	

BIOL 353	Ecophysiology of Global Change	
BIOL 358	Animal Behavior	
BIOL 364	Research Methods in Evolutionary Biology	
BIOL 365		
BIOL 368	Topics in Evolutionary Biology	
BIOL 471	Foundations of Advanced Ecology	
BIOL 472	Foundations of Advanced Evolution	
Cellular and Molecular Biology subspecialty courses:		
BIOL 316	Fundamental Immunology	
BIOL 324	Introduction to Stem Cell Biology	
BIOL 325	Cell Biology	
BIOL 333	The Human Microbiome	
BIOL 342	Parasitology	
BIOL 343	Microbiology	
BIOL 344	Laboratory for Microbiology	
BIOL 362	Principles of Developmental Biology	
BIOL 365		
BIOL Electives [a]		12
BIOL 388S & BIOL 390	Undergraduate Research - SAGES Capstone and Advanced Undergraduate Research [b]	
Mathematics and Statistics Core Courses:		
MATH 121	Calculus for Science and Engineering I	4
MATH 122	Calculus for Science and Engineering II	4
or MATH 124	Calculus II	
MATH 223	Calculus for Science and Engineering III	3
or MATH 227	Calculus III	
MATH 224	Elementary Differential Equations	3
or MATH 228	Differential Equations	
STAT 312	Basic Statistics for Engineering and Science	3
or STAT 312R	Basic Statistics for Engineering and Science Using R Programming	
Chemistry Core Courses:		
CHEM 105	Principles of Chemistry I	3
CHEM 106	Principles of Chemistry II	3
CHEM 113	Principles of Chemistry Laboratory	2
Physics Core Courses:		
PHYS 121	General Physics I - Mechanics	4
or PHYS 123	Physics and Frontiers I - Mechanics	
PHYS 122	General Physics II - Electricity and Magnetism	4
or PHYS 124	Physics and Frontiers II - Electricity and Magnetism	
Computer Science Core Courses:		
ECSE/CSDS 132	Programming in Java	3
ECSE/CSDS 233	Introduction to Data Structures	4
Systems Electives		**6-7**
Choose two of the following:		
BIOL 304	Fitting Models to Data: Maximum Likelihood Methods and Model Selection	
BIOL 319	Applied Probability and Stochastic Processes for Biology	
or MATH 319	Applied Probability and Stochastic Processes for Biology	
BIOL 321	Design and Analysis of Biological Experiments	
BIOL 378	Computational Neuroscience	
or MATH 378	Computational Neuroscience	
CSDS 310N	Algorithms	
CSDS 341N	Introduction to Database Systems	
CSDS 391	Introduction to Artificial Intelligence	
EBME 308	Biomedical Signals and Systems	
EBME 309	Modeling of Biomedical Systems	
ECSE 246	Signals and Systems	
ECSE 313	Signal Processing	
ECSE 324	Modeling and Simulation of Continuous Dynamical Systems	
ECSE 346	Engineering Optimization	
MATH 201	Introduction to Linear Algebra for Applications	
MATH 330	Introduction to Scientific Computing	
MATH 333	Mathematics and Brain	
MATH 338	Introduction to Dynamical Systems	
MATH 380	Introduction to Probability	
MATH 394	Introduction to Information Theory	
STAT 325	Data Analysis and Linear Regression Models	
STAT 326	Multivariate Analysis and Data Mining	
STAT 332	Statistics for Signal Processing	
STAT 437	Stochastic Models: Time Series and Markov Chains	
STAT 538	Stochastic Models: Diffusive Phenomena and Stochastic Differential Equations	
Total Credit Hours		**79-82**

a Excluding 100-level courses and BIOL 240.
b Undergraduate research strongly recommended.

Concentrations in Areas of the Biological Sciences

Students are encouraged to utilize their elective courses in the biology major to take advantage of concentrations in various specialized areas. These concentrations have been developed between the biology department, the basic science departments of the School of Medicine, and other departments. Currently, concentrations have been developed in the following areas: biotechnology and genetic engineering; computational biology; developmental biology; genetics; cell and molecular biology; neurobiology and animal behavior; population biology, ecology and environmental science. Note: these concentrations are informal; they are not declared, and will not appear on the student's diploma or transcript.

Departmental Honors

To receive a bachelor's degree "with Honors in Biology" (formally noted on the transcript), the student must meet the following criteria:

1. Maintain a 3.4 overall grade point average, with a 3.6 in BIOL courses
2. Carry out two semesters of independent research (taken as BIOL courses) at Case Western Reserve University
3. Write a senior honors thesis with the approval of the faculty supervisor
4. Submit the thesis for review by an ad hoc honors committee
5. Successfully defend the thesis at an oral examination

Additional information and application forms are available from the biology department office.

Sample Plan of Study

First Year

Fall		**Credit Hours**
BIOL 214	Genes, Evolution and Ecology	3
CHEM 105	Principles of Chemistry I	3
CHEM 113	Principles of Chemistry Laboratory	2
MATH 121	Calculus for Science and Engineering I	4
Academic Inquiry Seminar, Breadth, or Elective course [a]		3
	Credit Hours	**15**
Spring		
BIOL 215	Cells and Proteins	3
CHEM 106	Principles of Chemistry II	3
MATH 122 or MATH 124	Calculus for Science and Engineering II or Calculus II	4
Academic Inquiry Seminar, Breadth, or Elective course [a]		3
Open Elective		3
	Credit Hours	**16**
Second Year		
Fall		
BIOL 216	Development and Physiology	3
MATH 223 or MATH 227	Calculus for Science and Engineering III or Calculus III	3
PHYS 121 or ECSE 132	General Physics I - Mechanics [b] or Programming in Java	3-4
Breadth, or Elective course [a]		3
Elective		3
	Credit Hours	**16**
Spring		
BIOL 300	Dynamics of Biological Systems: A Quantitative Introduction to Biology	3
MATH 224 or MATH 228	Elementary Differential Equations or Differential Equations	3
PHYS 122 or PHYS 121	General Physics II - Electricity and Magnetism [b] or General Physics I - Mechanics	4
Breadth, or Elective course [a]		3
Open Elective		3
	Credit Hours	**16**
Third Year		
Fall		
BIOL 306	Mathematical Analysis of Biological Models	3
ECSE 132	Programming in Java	3
MATH 304 or CSDS 302	Discrete Mathematics or Discrete Mathematics	3
Breadth, or Elective course [a]		3
BIOL Elective		3
	Credit Hours	**15**
Spring		
STAT 312 or STAT 312R	Basic Statistics for Engineering and Science or Basic Statistics for Engineering and Science Using R Programming	3
ECSE 233	Introduction to Data Structures	4
Breadth, or Elective course [a]		3
Elective		3
BIOL Elective		3
	Credit Hours	**16**
Fourth Year		
Fall		
BIOL 388S	Undergraduate Research - SAGES Capstone	3
Breadth, or Elective course [a]		3
Elective		3
Subspecialty Elective		3
Systems Elective		3
	Credit Hours	**15**
Spring		
BIOL 390	Advanced Undergraduate Research	3
Breadth, or Elective course [a]		3
Subspecialty Elective		3
Systems Elective		3
BIOL Elective (if needed) or Open Elective		3
	Credit Hours	**15**
	Total Credit Hours	**124**

a Unified General Education Requirement.

b Computer science-oriented students are recommended to take ECSE 132 before the PHYS 121 / PHYS 122 sequence. Other students may take physics first.