

BIOCHEMISTRY (AGLS)

The Roy J. Carver Department of Biochemistry, Biophysics and Molecular Biology (<https://www.bbmb.iastate.edu>) offers majors in biochemistry in the College of Liberal Arts and Sciences and in the College of Agriculture and Life Sciences. Biochemists seek to understand life processes in terms of chemical and physical principles. Students in the biochemistry majors develop foundational analytical skills while exploring frontiers in biotechnology and medicine. Graduates in biochemistry will have a rigorous background in chemistry, biology, and physics. Biochemistry coursework focuses on the development of problem-solving skills, critical thinking, communication, and research design. The Biochemistry degree includes focused specializations towards professional goals, including three prescribed options: **Research & Biotechnology**, **Pre-Medicine**, and **Biophysics**.

Graduates with a Biochemistry B.S. degree will be prepared for postgraduate studies in the chemical or biological sciences, medical and health professional training, or immediate laboratory research in biochemistry, biotechnology, or pharmacy. Graduates are also equipped to pursue careers in teaching, technical writing, science communication and policy, intellectual property law, and biotechnology entrepreneurship. The biochemistry major is accredited by the American Society for Biochemistry and Molecular Biology (ASBMB). As such our learning objectives align with ASBMB core concepts.

Student Learning Outcomes

Upon graduation, students should be able to:

- Explain and provide examples to illustrate the biochemical principles underlying the following:
 - a. How energy is required and transformed in biological systems.
 - b. How macromolecular structure determines function and regulation.
 - c. How information storage and flow are dynamic and interactive.
 - d. How biochemistry and biology are driven by evolution and homeostasis
- Apply and justify appropriate techniques to characterize and quantify biomolecules in biological systems.
- Execute effective multimodal communication of the research process and results.
- Implement and justify best practices for laboratory safety and research ethics.

College of Agriculture and Life Sciences Learning Outcomes

Graduates with a Biochemistry B.S. degree from the College of Agriculture and Life Sciences should be able to:

- Explain the role of biochemistry in biotechnology entrepreneurship, pharmaceuticals, agriculture, and allied fields.
- Demonstrate collaboration and leadership in research teams.
- Explain biochemical cycles that impact global ecosystems.

Biochemistry Major in the College of Agriculture and Life Sciences

The Bachelor of Science (B.S.) degree in Biochemistry requires the Biochemistry Core and one of the following three prescribed options. The options represent focused specializations for professional goals, including **Research & Biotechnology**, **Pre-Medicine**, and **Biophysics**. As majors in the College of Agriculture and Life Sciences, Biochemistry students must meet College of Agriculture and Life Sciences (<http://catalog.iastate.edu/collegeofagricultureandlifesciences/#corecurriculumtext>) and University-wide requirements (<http://catalog.iastate.edu/collegescurricula/>) for graduation in addition to those stated below. Focus option-approved science electives can be found on the Biochemistry website (<https://www.bbmb.iastate.edu/approved-course-lists/>).

Total Degree Requirement: 120 cr.

CALS majors require a minimum of 120 credits, including a minimum of 45 credits at the 3000/4000 level. Only 65 cr. from a two-year institution may apply which may include up to 16 technical cr.; 9 P-NP cr. of free electives; 2.00 minimum GPA.

International Perspectives: 3 cr.

3 cr. from approved International Perspectives list: <http://www.registrar.iastate.edu/students/div-ip-guide/IntlPerspectives-current> (<http://www.registrar.iastate.edu/students/div-ip-guide/IntlPerspectives-current/>)

U.S. Cultures and Communities : 3 cr.

3 cr. from approved U.S. Cultures and Communities list: <https://www.registrar.iastate.edu/students/div-ip-guide/uscultures-courses> (<https://www.registrar.iastate.edu/students/div-ip-guide/uscultures-courses/>)

College of Agriculture and Life Sciences General Education Electives: 9 cr.

Humanities

3 cr. from approved humanities list: <http://www.cals.iastate.edu/student-services/humanities> (<http://www.cals.iastate.edu/student-services/humanities/>)

Social Sciences

3 cr. from approved social sciences list: <http://www.cals.iastate.edu/student-services/social-sciences> (<http://www.cals.iastate.edu/student-services/social-sciences/>)

Ethics

3 cr. from approved ethics list: <http://www.cals.iastate.edu/student-services/ethics> (<http://www.cals.iastate.edu/student-services/ethics/>)

Communications Proficiency: 11 cr.

6 cr. of English composition with a C or better and 3 cr. of speech fundamentals with a C or better.

ENGL 1500	Critical Thinking and Communication	3
ENGL 2500	Written, Oral, Visual, and Electronic Composition	3
or ENGL 2500H	Written, Oral, Visual, and Electronic Composition: Honors	
SPCM 2120	Fundamentals of Public Speaking	3
LIB 1600	Introduction to College Level Research	1
BBMB 3110	Writing Scientific Reports in Biochemistry *	1
*BBMB 3110 fulfills the upper-level Communications Proficiency Requirement		
Total Credits		11

Biochemistry Core

The major in biochemistry requires completion of the Biochemistry Core and one of three focus options. Each defined option includes specific supporting coursework in Biology; Chemistry; Mathematics and/or Statistics.

BBMB 1010	Introduction to Biochemistry	2
BBMB 1020	Introduction to Biochemistry Laboratory	1
BBMB 2010	Chemical Principles in Biological Systems	2
BBMB 3110	Writing Scientific Reports in Biochemistry ¹	1
BBMB 3120	Experimental Research Skills in Biochemistry	2
BBMB 4040	Biochemistry I	3-4
or BBMB 5040	Amino Acids and Proteins	
& BBMB 5050	and Bioenergetics and Metabolism	
BBMB 4050	Biochemistry II	3-4
or BBMB 5060	Membrane Biochemistry	
& BBMB 5070	and Biochemistry of Nucleic Acids	
BBMB 4100	Analysis of Scientific Literature	2
BBMB 4110	Techniques in Biochemical Research	4
BBMB 4610	Molecular Biophysics	2
BBMB 5610L	Laboratory in Molecular Biophysics	2-3
or CHEM 3220L	Laboratory in Physical Chemistry	
PHYS 2310	Introduction to Classical Physics I	5
& 2310L	and Introduction to Classical Physics I Laboratory	
PHYS 2320	Introduction to Classical Physics II	5
& 2320L	and Introduction to Classical Physics II Laboratory	

BBMB 4990	Undergraduate Research (highly encouraged elective)	arr †
Total Credits		34-37 †

† Arranged with instructor.

¹ BBMB 3110 fulfills the ISU upper-level Communication Proficiency requirement.

* Prior to graduation all students take the spring semester ASBMB Annual Exam as a measure of program outcomes assessment.

Biochemistry Program of Study: Research & Biotechnology

Students interested in careers in biotechnology research and/or graduate studies in biochemistry, chemistry, or bioscience fields may opt for the Research & Biotechnology Option. The College of Agriculture and Life Sciences (CALS) electives allow specialization in agricultural biochemistry or plant biochemistry.

In addition to the Biochemistry Core (above):

CHEM 2010	Advanced General Chemistry	5-7
or CHEM 1770	General Chemistry I	
& CHEM 1780	and General Chemistry II	
CHEM 2010L	Laboratory in Advanced General Chemistry	1
or CHEM 1770L	Laboratory in General Chemistry I	
or CHEM 1770LL	Laboratory in General Chemistry II	
CHEM 3250	Chemical Thermodynamics	3
CHEM 3310	Organic Chemistry I	3
CHEM 3320	Organic Chemistry II	3
CHEM 3330L	Laboratory in Organic Chemistry I (for Chemistry and Biochemistry Majors)	1-2
or CHEM 3310LL	Laboratory in Organic Chemistry I	
CHEM 3340L	Laboratory in Organic Chemistry II (for Chemistry and Biochemistry Majors)	1-2
or CHEM 3320LL	Laboratory in Organic Chemistry II	
MATH 1650	Calculus I	8
& MATH 1660	and Calculus II	
STAT 2010	Introduction to Statistical Concepts and Methods	4
or STAT 3050	Engineering Statistics	
BIOL 2110	Principles of Biology I	3
BIOL 2120	Principles of Biology II	3
BIOL 3130	Principles of Genetics	4
& 3130L	and Genetics Laboratory	
BIOL 3140	Principles of Molecular Cell Biology	3

Agricultural & Molecular Sciences from approved list	9
Total Credits	51-55

Biochemistry Program of Study: Pre-Medicine

Students interested in qualifying for medical school training for careers as a Doctor of Medicine (MD) or Doctor of Osteopathic Medicine (DO) may opt for the Pre-Medicine Option. Allied health professions (e.g., Physician Assistant, Dentistry, and Ophthalmology) may also consider the Pre-Medicine Option. The CALS option is especially suited to careers in Veterinary Medicine.

In addition to the Biochemistry Core (above):

CHEM 1770 & 1770L & CHEM 1780 & CHEM 1780L	General Chemistry I and Laboratory in General Chemistry I and General Chemistry II and Laboratory in College Chemistry II	6-9
or CHEM 2010 & 2010L	Advanced General Chemistry and Laboratory in Advanced General Chemistry	
CHEM 3250	Chemical Thermodynamics	3
CHEM 3310 & 3310L	Organic Chemistry I and Laboratory in Organic Chemistry I	4
CHEM 3320 & 3320L	Organic Chemistry II and Laboratory in Organic Chemistry II	4
MATH 1650 & MATH 1660	Calculus I and Calculus II	8
STAT 2010 or STAT 3050	Introduction to Statistical Concepts and Methods Engineering Statistics	3-4
PSYCH 1010 or PSYCH 2300	Introduction to Psychology Developmental Psychology	3
SOC 1340	Introduction to Sociology	3
BIOL 2110	Principles of Biology I	3
BIOL 2110L	Principles of Biology Laboratory I	1
BIOL 2120	Principles of Biology II	3
BIOL 2120L	Principles of Biology Laboratory II	1
BIOL 3130	Principles of Genetics	3
BIOL 3140	Principles of Molecular Cell Biology	3
Physiology & Bioscience Electives from approved list		6
Total Credits		54-58

Biochemistry Program of Study: Biophysics

Students interested in research careers focused on the biophysical basis of life processes may opt for the Biophysics Option. The CALS electives offer specialization in agricultural biophysics or plant biophysics.

In addition to the Biochemistry Core (above):

CHEM 2010 or CHEM 1770 & CHEM 1780	Advanced General Chemistry General Chemistry I and General Chemistry II	5-7
CHEM 2010L or CHEM 1770L or CHEM 1770LL	Laboratory in Advanced General Chemistry Laboratory in General Chemistry I Laboratory in General Chemistry I	1
CHEM 3240	Introductory Quantum Mechanics	3
CHEM 3250	Chemical Thermodynamics	3
CHEM 3310	Organic Chemistry I	3
CHEM 3320	Organic Chemistry II	3
MATH 1650 & MATH 1660	Calculus I and Calculus II	8
MATH 2650	Calculus III	4
MATH 2660	Elementary Differential Equations	3
MATH 3170	Theory of Linear Algebra	4
STAT 2010 or STAT 3050 or STAT 2310	Introduction to Statistical Concepts and Methods Engineering Statistics Probability and Statistical Inference for Engineers	4
COMS 2070	Fundamentals of Computer Programming	3
BIOL 2110	Principles of Biology I	3
BIOL 2120	Principles of Biology II	3
Agricultural & Physical Sciences from approved list		6
Total Credits		56-58

Four Year Plans

Biochemistry B.S. Program of Study, College of Agriculture and Life Sciences Research & Biotechnology Option Sample Four-Year Plan

First Year

Fall	Credits Spring	Credits
BBMB 1010	2 BBMB 1020	1
BBMB 1100	1 BBMB 1110	1
MATH 1650	4 MATH 1660	4
CHEM 1770	4 CHEM 1780	3
CHEM 1770N	1 BIOL 2110	3
LIB 1600	1 SPCM 2120	3
ENGL 1500	3	

16

15

Second Year		
Fall	Credits Spring	Credits
MATH 2650, 2660, 2670, STAT 2010, or STAT 3050	3-4 BBMB 2010	2
CHEM 3310	3 CHEM 3320	3
CHEM 3310L	1 CHEM 3320L	1
PHYS 2310	4 PHYS 2320	4
PHYS 2310L	1 PHYS 2320L	1
BIOL 2120	3 ENGL 2500	3
	BBMB 4990	1
15-16		15

Third Year		
Fall	Credits Spring	Credits
BBMB 4040	3 BBMB 4050	3
BBMB 3110*	1 BIOL 3140	3
BBMB 3120	2 BBMB 4100	2
BIOL 3130	3 BBMB 4990	2
BIOL 3130L	1 International Perspectives Elective	3
BBMB 4990	2 General Education Elective	3
General Education Elective	3	
15		16

Fourth Year		
Fall	Credits Spring	Credits
BBMB 4110	4 CHEM 3250	3
Upper-level Agriculture or Mol. Sci. Elective	3 CHEM 3220L or BBMB 4610 <i>and</i> BBMB 5610L	3-4
Upper-level Agriculture or Mol. Sci. Elective	3 BBMB 4990	2
BBMB 4990	2 Upper-level Agriculture or Mol. Sci. Elective	3
General Education Elective	3 U.S. Cultures and Communities Elective	3
15		14-15

"General Education Electives" include 3 credits each in Humanities, Ethics, and Social Sciences.

* BBMB 3110 fulfills the upper-level communication proficiency requirement.

Biochemistry B.S. Program of Study, College of Agriculture and Life Sciences *Pre-Medicine Option* Sample Four-Year Plan

First Year		
Fall	Credits Spring	Credits
BBMB 1010	2 BBMB 1020	1
BBMB 1100	1 BBMB 1110	1
MATH 1650	4 MATH 1660	4
CHEM 1770	4 CHEM 1780	3
CHEM 1770N	1 CHEM 1780L	1
LIB 1600	1 BIOL 2110	3
ENGL 1500	3 BIOL 2110L	1
16		14

Second Year		
Fall	Credits Spring	Credits
BIOL 2120	3 BBMB 2010	2
BIOL 2120L	1 CHEM 3320	3
CHEM 3310	3 CHEM 3320L	1
CHEM 3310L	1 PHYS 2320	4
PHYS 2310	4 PHYS 2320L	1
PHYS 2310L	1 ENGL 2500	3
PSYCH 1010	3	
16		14

Third Year		
Fall	Credits Spring	Credits
BBMB 4040	3 BBMB 4050	3
BBMB 3110*	1 BIOL 3140	3
BBMB 3120	2 BBMB 4100	2
BIOL 3130	3 BBMB 4990	2
STAT 2010	4 SOC 1340	3
General Education Elective	3 International Perspectives Elective	3
16		16

Fourth Year		
Fall	Credits Spring	Credits
BBMB 4110	4 CHEM 3250	3
Upper-level Upper-level Physiology & Biosci. Elective	3 CHEM 3220L or BBMB 4610 <i>and</i> BBMB 5610L	3-4
BBMB 4990	2 BBMB 4990	2
SPCM 2120	3 Upper-level Physiology & Biosci. Elective	3

General Education Elective	3 U.S. Cultures and Communities Elective	3
15		14-15

"General Education Electives" include 3 credits each in Humanities and Ethics. MCAT recommended Soc 1340 satisfies the Social Sciences requirement.

* BBMB 3110 fulfills the upper-level communication proficiency requirement.

Biochemistry B.S. Program of Study, College of Agriculture and Life Sciences *Biophysics Option* Sample Four-Year Plan

First Year

Fall	Credits Spring	Credits
BBMB 1010	2 BBMB 1020	1
BBMB 1100	1 BBMB 1110	1
MATH 1650	4 MATH 1660	4
CHEM 1770	4 CHEM 1780	3
CHEM 1770N	1 BIOL 2110	3
LIB 1600	1 SPCM 2120	3
ENGL 1500	3	
16		15

Second Year

Fall	Credits Spring	Credits
MATH 2650	4 BBMB 2010	2
CHEM 3310	3 CHEM 3320	3
PHYS 2310	4 PHYS 2320	4
PHYS 2310L	1 PHYS 2320L	1
BIOL 2120	3 ENGL 2500	3
	BBMB 4990	1
	International Perspective Elective	3
15		17

Third Year

Fall	Credits Spring	Credits
BBMB 4040	3 BBMB 4050	3
BBMB 3110*	1 CHEM 3250	3
BBMB 3120	2 BBMB 4100	2
MATH 2660	3 MATH 3170	4
COMS 2070	3 BBMB 4990	2

BBMB 4990	1 U.S. Cultures and Communities Elective	3
General Education Elective	3	
16		17

Fourth Year

Fall	Credits Spring	Credits
BBMB 4110	4 CHEM 3240	3
BBMB 4990	2 CHEM 3220L or BBMB 4610 and BBMB 5610L	3-4
STAT 2310	4 BBMB 4990	3
Upper-level Agricultural or Phys. Elective	3 Upper-level Agricultural or Phys. Elective	3
General Education Elective	3 General Education Elective	3
16		15-16

"General Education Electives" include 3 credits each in Humanities, Ethics, and Social Sciences.

* BBMB 3110 fulfills the upper-level communication proficiency requirement.

The Roy J. Carver Department of Biochemistry, Biophysics, and Molecular Biology offers a single minor in Biochemistry, administered by the College of Liberal Arts and Sciences.

See Biochemistry Undergraduate Minor (http://catalog.iastate.edu/collegeofliberalartsandsciences/biochemistry_biophysics_andmolecularbiology/#minortext).

Concurrent Bachelor of Science (B.S.)/ Master of Science (M.S.) Degrees

The department offers a concurrent enrollment degree program in either Biochemistry or Biophysics that allows ISU undergraduate students to obtain both the B.S. and M.S. degrees in about five years. The program is open to undergraduate students in the College of Liberal Arts and Sciences and in the College of Agriculture and Life Sciences. The concurrent degrees can be useful to students entering various career tracks. For those considering careers as research specialists, entry positions with higher-level responsibilities, and a higher-level salary, are made possible with the M.S. degree. For those considering careers as research directors, which require advanced study, the M.S. degree provides an advantage for admission into Ph.D. programs at the most competitive and prestigious graduate schools. Similarly, the M.S. degree can be a competitive advantage for admission in to medical, dental, law, veterinary medicine, or other professional schools.

Application to the program is made near the end of the junior undergraduate (third) year. Concurrent B.S./M.S. degree students begin research for the M.S. thesis during the summer semester after their junior

year and are eligible for research assistantships, which are renewable based on academic standing and satisfactory research performance. The M.S. thesis requires intensive experience in original, independent laboratory research under the close supervision of a faculty mentor. To apply, see the concurrent B.S./M.S. application instructions found on the department's Graduate Study web page (<https://www.bbmb.iastate.edu/graduate-study/>).

Concurrent Bachelor of Science/Graduate Certificate

The Bachelor of Science /Graduate Certificate program is intended for exceptional undergraduate students majoring in Biochemistry. In this program, the student completes all of the requirements for the B.S. degree and the graduate certificate in a four-year period by combining the requirements of the two programs. The student enters the Graduate College after he/she achieves junior status and develops a plan of coursework (graduate and undergraduate) subject to the approval of the Director of Certificate (DOC). Required graduate courses are BBMB 5040, BBMB 5050, BBMB 5060, BBMB 5070, BBMB 5610 and BBMB 5610L. The student must satisfy the requirements of the B.S. in Biochemistry (121 credits) and the Graduate Certificate in Biochemistry (12 credits). Six credits of graduate coursework can satisfy some requirements of the B.S. degree. To apply for the B.S./Graduate Certificate, submit the application form found on the Graduate College Forms web page.

Biochemistry and Biophysics are the science and technology used to understand the mechanisms underlying biological processes at the molecular level, with an emphasis on the fundamental relationships among the chemical, physical, and biological sciences. The Roy J. Carver Department of Biochemistry, Biophysics, and Molecular Biology (BBMB) administers Doctor of Philosophy (Ph.D.), Master's (M.S.), and Graduate Certificate programs (<https://www.bbmb.iastate.edu/graduate-study/>) that lead to an advanced degree or certificate in these disciplines. The prerequisite to graduate study is a sound undergraduate background in biology, chemistry, mathematics, and physics.

BBMB offers Doctor of Philosophy and master's degrees in Biochemistry and in Biophysics that are designed to train students to independently conceive and carry out original research. BBMB also offers two graduate certificate programs in Biochemistry that provide a mechanism for formal recognition of focused graduate study in a specialized area that is less comprehensive than that required for a master's degree. BBMB participates in the Interdepartmental majors of Bioinformatics and Computational Biology; Genetics and Genomics; Immunobiology; Molecular, Cellular, and Developmental Biology; Neuroscience; Plant Biology; and Toxicology. All graduate degree students in BBMB are required to teach as part of their training.

Master's (M.S.) Degree

The M.S. degree programs in Biochemistry and in Biophysics are useful for students who prefer to undertake research training without the longer-

term commitment required for the Ph.D. degree. It is also useful for students interested more in the technical aspects of research rather than in careers as research directors. The program requires about 3 years on average to complete and the successful defense of an independent research dissertation is required. About half the time required to earn the degree is spent on advanced coursework and professional seminars, and the other half is devoted to research undertaken in the laboratory under the close supervision of a faculty mentor. Financial support is available. To apply, applicants first submit the free BBMB online application found on the department website, which is used as a screening tool.

NOTE: Students interested in a research career are encouraged to consider the Ph.D. track. Students may enter the Biochemistry or Biophysics M.S. degree program as a direct admit to a faculty research group at any time during the year.

Doctor of Philosophy (Ph.D.) Degree

The Ph.D. programs in Biochemistry and in Biophysics are designed to train students in the ability to independently conceive and carry out original research in the general area of the chemistry or physics of the processes of life. The programs require about 5-6 years on average to complete and the successful defense of an independent research dissertation. The majority of the time required to earn the degree is spent doing research on the dissertation project in the laboratory under the close supervision of a faculty mentor. Considerable time also is devoted to advanced coursework and professional seminars. Financial support is available. To apply, applicants first submit the free BBMB online application found on the department website, which is used as a screening tool. Students may enter the Biochemistry or Biophysics Ph.D. degree programs either as a rotation student in the fall semester or as a direct admit to a faculty research group at any time during the year.

Minor in Biochemistry

Graduate students in other M.S. and/or Ph.D. programs at ISU can earn a graduate minor in Biochemistry by completing 12 credits of the following courses with a grade point average of 3.0 or above: at least 6 credits from BBMB 5040, BBMB 5050, BBMB 5060 and BBMB 5070 and at least 6 credits of other BBMB 5000- and 6000-level courses. A student wishing to declare a minor in Biochemistry should arrange for a member of the graduate faculty in Biochemistry to serve on the POS Committee and submit the required form found on the Graduate College Forms page.

Graduate Certificate in Biochemistry

The graduate certificate in Biochemistry is designed for students who have a B.S. degree in Biochemistry or a related field and wish to advance their knowledge by taking additional coursework at the graduate level. The graduate certificate courses may be taken either on-line or on campus. Candidates for a graduate certificate in Biochemistry are admitted in the Graduate College. A total of 12 credits is required that includes BBMB 5040, BBMB 5050, BBMB 5060 and BBMB 5070, plus

four additional credits of BBMB coursework at the 5000-level. The 12 credits earned in the graduate certificate program may be applied to meet the course requirements of a M.S. or Ph.D. program in Biochemistry at Iowa State University (ISU) if the student is accepted into one of these programs. To apply for the graduate certificate in Biochemistry, submit the ISU online application.