

Biochemistry, Biophysics, and Molecular Biology

Undergraduate Study

The department offers majors in biochemistry or biophysics in the College of Liberal Arts and Sciences and a major in agricultural biochemistry in the College of Agriculture and Life Sciences.

Biochemists and biophysicists seek to understand life processes in terms of chemical and physical principles. They conduct research in the frontiers of biology such as metabolic networking; structure and function of enzymes, membranes, and hormones; computational approaches; genomic and proteomic technology; protein engineering; plant biotechnology; muscle structure and function; and the design and evaluation of drugs for the treatment of disease. Biochemistry, biophysics and molecular biology provide the basis for much of modern biotechnology. Graduates have opportunities in industry, especially the biotechnology sector, in universities, veterinary and medical schools, and government laboratories. Students who meet the necessary high scholastic standards have the opportunity to continue their education to pursue advanced degrees in graduate school, medicine, pharmacy or veterinary medicine.

Graduates of biochemistry, agricultural biochemistry and biophysics understand the chemical principles of biological systems including molecular biology. They have developed laboratory expertise in modern biochemical techniques, including the ability to analyze data and prepare scientific reports. Most have participated in undergraduate research and have developed the skills necessary for both written and oral presentations at a level that will serve the student both within the university and in postgraduate professional life. Graduates have the experience of interacting with persons of different disciplines and cultures. Students have the training in biological and physical science and mathematics to solve problems of broad scope in biological, biomedical and environmental sciences and to provide leadership in diverse scientific and technological arenas.

Graduate Study

The department offers work for the degrees master of science and doctor of philosophy with majors in biochemistry and biophysics and with interdepartmental majors in genetics, immunobiology, MCDB (molecular, cellular, and developmental biology), plant physiology, and toxicology. Minor work is offered to students taking major work in other departments.

Prerequisite to graduate work is a sound undergraduate background in biology, chemistry, mathematics, and physics.

All graduate students are required by the department to teach as part of their training for an advanced degree.

The department offers a B.S./M.S. program in biochemistry that allows students to obtain both the B.S. and M.S. degrees in five years. The program is open to students in the College of Liberal Arts and Sciences and in the College of Agriculture. Students interested in this program should contact the department office for details. Application for admission to the Graduate College should be made near the end of the junior undergraduate (third) year. Students would begin research for the M.S. thesis during the summer semester after their junior year and are eligible for research assistantships.

Agricultural Biochemistry Major in the College of Agriculture and Life Sciences

For the undergraduate curriculum leading to the degree bachelor of science, see College of Agriculture, Curricula. Agricultural biochemistry is recommended to students interested in the areas of agriculture requiring strong preparation in biochemistry, chemistry, physics, and mathematics, or in preparation for the study of veterinary medicine. Employment opportunities exist in agrochemical industries, and animal and plant biotechnology.

Agricultural Biochemistry program of study

BBMB 101	Introduction to Biochemistry	1
BBMB 102	Introduction to Biochemistry Laboratory	1
BBMB 201	Chemical Principles in Biological Systems	2
BBMB 404	Biochemistry I	3-4
or BBMB 501	Comprehensive Biochemistry I	

BBMB 405	Biochemistry II	3-4
or BBMB 502	Comprehensive Biochemistry II	
BBMB 411	Techniques in Biochemical Research	4
BBMB 490	Independent Study (Not required)	arr †
BBMB 499	Undergraduate Research (Not required but strongly encouraged)	1-5
Take one of the following:		
CHEM 201	Advanced General Chemistry	
CHEM 177 & CHEM 178	General Chemistry I and General Chemistry II	
CHEM 201L	Laboratory in Advanced General Chemistry	1
or CHEM 177N	Laboratory in General Chemistry I	
or CHEM 177L	Laboratory in General Chemistry I	
CHEM 211	Quantitative and Environmental Analysis	2
CHEM 211L	Quantitative and Environmental Analysis Laboratory	2
One of the following:		
CHEM 322L	Laboratory in Physical Chemistry	
BBMB 461 & BBMB 561L	Molecular Biophysics and Laboratory in Molecular Biophysics	
CHEM 324	Introductory Quantum Mechanics	3
CHEM 325	Chemical Thermodynamics	3
CHEM 331	Organic Chemistry I	3
CHEM 332	Organic Chemistry II	3
CHEM 333L	Laboratory in Organic Chemistry I (for Chemistry and Biochemistry Majors)	1-2
or CHEM 331L	Laboratory in Organic Chemistry I	
CHEM 334L	Laboratory in Organic Chemistry II (for Chemistry and Biochemistry Majors)	2
or CHEM 332L	Laboratory in Organic Chemistry II	
MATH 165	Calculus I	4
MATH 166	Calculus II	4
MATH 265	Calculus III	3-4
or MATH 266	Elementary Differential Equations	
or MATH 267	Elementary Differential Equations and Laplace Transforms	
PHYS 221	Introduction to Classical Physics I	5
PHYS 222	Introduction to Classical Physics II	5
BIOL 211	Principles of Biology I	3
BIOL 211L	Principles of Biology Laboratory I	1
or BIOL 212L	Principles of Biology Laboratory II	
or BIOL 313L	Genetics Laboratory	
BIOL 212	Principles of Biology II	3
BIOL 313	Principles of Genetics	3
BIOL 314	Principles of Molecular Cell Biology	3
Biological Science electives from Biology, Genetics or Microbiology		4
Total Credits		73-81
		†

† Arranged with instructor.

The College of Agriculture and Life Sciences requires the following:

Communications Proficiency (with a C or better)

ENGL 150	Critical Thinking and Communication	3
ENGL 250	Written, Oral, Visual, and Electronic Composition	3
SP CM 212	Fundamentals of Public Speaking	3
LIB 160	Information Literacy	1
Total Credits		10

Ethics

Courses from an approved list. 3

Humanities and Social Sciences

Humanities course		3
Social Science course		3
Total Credits		6

Agricultural Sciences

Courses from an approved list

Curriculum in Agricultural Biochemistry

Administered by the Department of Biochemistry, Biophysics and Molecular Biology.

Total Degree Requirement: 128 cr.

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 Perspective: 3 cr.

U.S. Diversity: 3 cr.

Communications Proficiency:

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

ENGL 150	Critical Thinking and Communication	3
ENGL 250	Written, Oral, Visual, and Electronic Composition	3
SP CM 212	Fundamentals of Public Speaking	3
LIB 160	Information Literacy	0.5
Total Credits		9.5

Ethics: 3 cr.

3 cr. from approved list.

Humanities and Social Sciences: 6 cr.

3 cr. from approved humanities list; 3 cr. from approved social science list.

Mathematical Sciences: 12 cr.

MATH 165	Calculus I	4
MATH 166	Calculus II	4
MATH 265 or MATH 266	Calculus III Elementary Differential Equations	4
Total Credits		12

Physical Sciences: 38 cr.

CHEM 177 or CHEM 201	General Chemistry I Advanced General Chemistry	4
CHEM 177L or CHEM 201L	Laboratory in General Chemistry I Laboratory in Advanced General Chemistry	1
CHEM 178	General Chemistry II	3
CHEM 211	Quantitative and Environmental Analysis	2
CHEM 211L	Quantitative and Environmental Analysis Laboratory	2
CHEM 324	Introductory Quantum Mechanics	3
CHEM 325	Chemical Thermodynamics	3
CHEM 322L	Laboratory in Physical Chemistry	3
CHEM 331	Organic Chemistry I	3
CHEM 331L	Laboratory in Organic Chemistry I	1
CHEM 332	Organic Chemistry II	3
PHYS 221	Introduction to Classical Physics I	5
PHYS 222	Introduction to Classical Physics II	5
Total Credits		38

Life Sciences: 13 cr.

BIOL 211	Principles of Biology I	3
BIOL 212	Principles of Biology II	3
BIOL 211L or BIOL 212L	Principles of Biology Laboratory I Principles of Biology Laboratory II	1
BIOL 313	Principles of Genetics	3
BIOL 314	Principles of Molecular Cell Biology	3
Total Credits		13

Agricultural Biochemistry: 13 cr.

BBMB 101	Introduction to Biochemistry	1
BBMB 102	Introduction to Biochemistry Laboratory	1

BBMB 201	Chemical Principles in Biological Systems	2
BBMB 404 or BBMB 501	Biochemistry I Comprehensive Biochemistry I	3
BBMB 405 or BBMB 502	Biochemistry II Comprehensive Biochemistry II	3
BBMB 411	Techniques in Biochemical Research	3
Total Credits		13

Agricultural Sciences: 9 cr.

Complete 9 cr. from approved list.

See also the B.S./M.S. program under Graduate Study.

Courses primarily for undergraduates:**BBMB 101. Introduction to Biochemistry.**

(1-0) Cr. 1. F.

Research activities, career opportunities in biochemistry and biophysics, and an introduction to the structure of biologically important compounds. For students majoring in biochemistry, agricultural biochemistry or biophysics or considering one of these majors.

BBMB 102. Introduction to Biochemistry Laboratory.

(0-2) Cr. 1. S. Prereq: Credit or enrollment in CHEM 177 and CHEM 177L or CHEM 201 and CHEM 201L

Topics in the scientific background of biochemistry, such as macromolecules, metabolism, and catalysis. Laboratory experimentation covers biochemical concepts and the study of bio-molecules including proteins, lipids and nucleic acids. A significant component is practice in scientific communication. For students majoring in biochemistry, agricultural biochemistry or biophysics or considering one of these majors.

BBMB 201. Chemical Principles in Biological Systems.

(2-0) Cr. 2. S. Prereq: Credit or enrollment in CHEM 332

Survey of chemical principles as they apply in biological systems including: water, organic chemistry of functional groups in biomolecules and biochemical cofactors, weak bonds and their contribution to biomolecular structure, oxidation-reduction reactions and redox potential, thermodynamic laws and bioenergetics, chemical equilibria and kinetics, inorganic chemistry in biological systems, data presentation. The subjects will be taught using molecules from biological systems as examples. Intended for majors in biochemistry, biophysics, or agricultural biochemistry.

BBMB 221. Structure and Reactions in Biochemical Processes.

(3-0) Cr. 3. F. Prereq: CHEM 163, CHEM 167, or CHEM 177

Fundamentals necessary for an understanding of biochemical processes. Primarily for students in agriculture. Not acceptable for credit toward a major in biochemistry, biophysics, or agricultural biochemistry. Credit for both BBMB 221 and Chem 231 may not be applied toward graduation.

BBMB 301. Survey of Biochemistry.

(3-0) Cr. 3. F.S.SS. Prereq: CHEM 231 or CHEM 331

A survey of biochemistry: structure and function of amino acids, proteins, carbohydrates, lipids, and nucleic acids; enzymology; metabolism; biosynthesis; and selected topics. Not acceptable for credit toward a major in biochemistry, biophysics, or agricultural biochemistry.

BBMB 316. Principles of Biochemistry.

(3-0) Cr. 3. F. Prereq: CHEM 231 or CHEM 331; BIOL 212.

Understanding biological systems at the molecular level; chemistry of biological macromolecules, enzyme function and regulation, metabolic pathways; integration of metabolism in diverse living systems. For students in biology and related majors who do not require the more rigorous treatment of biochemistry found in BBMB 404/405. Not acceptable for credit toward a major in biochemistry, biophysics, or agricultural biochemistry.

BBMB 404. Biochemistry I.

(3-0) Cr. 3. F. Prereq: CHEM 332

A general overview for graduate and advanced undergraduate students in agricultural, biological, chemical and nutritional sciences. Chemistry of amino acids, proteins, carbohydrates, and lipids, vitamins; protein structure; enzymology; carbohydrate metabolism. Nonmajor graduate credit. Credit for both BBMB 420 and the BBMB 404 - 405 sequence may not be applied toward graduation.

BBMB 405. Biochemistry II.(3-0) Cr. 3. S. *Prereq: BBMB 404*

A general overview for graduate and advanced undergraduate students in agricultural, biological, chemical, and nutritional sciences. Metabolism of carbohydrates, amino acids, nucleotides and lipids; formation, turnover, and molecular relationships among DNA, RNA, and proteins; genetic code; regulation of gene expression; selected topics in the molecular physiology of plants and animals. Nonmajor graduate credit. Credit for both BBMB 420 and the BBMB 404 - BBMB 405 sequence may not be applied toward graduation.

BBMB 411. Techniques in Biochemical Research.(2-8) Cr. 4. F. *Prereq: Credit or enrollment in BBMB 404 or BBMB 501; CHEM 211*

Introduction to laboratory techniques for studying biochemistry, including: chromatographic methods; electrophoresis; spectrophotometry; enzyme purification; enzyme kinetics; and characterization of carbohydrates, proteins, lipids, and nucleic acids. Nonmajor graduate credit.

BBMB 420. Physiological Chemistry.(3-0) Cr. 3. F. *Prereq: CHEM 332, BBMB 301 or BIOL 314*

Structure and function of proteins; enzymology; biological oxidation; chemistry and metabolism of carbohydrates, lipids, amino acids and nucleic acids; protein synthesis and the genetic code; relationship of biochemistry to selected animal diseases. Biochemistry of higher animals emphasized. Nonmajor graduate credit. Not acceptable for credit toward a major in agricultural biochemistry, biochemistry or biophysics. Credit for both BBMB 420 and the BBMB 404 - 405 sequence may not be applied toward graduation.

BBMB 430. Prokaryotic Diversity and Ecology.(Dual-listed with BBMB 530). (Cross-listed with MICRO). (3-0) Cr. 3. Alt. S., offered 2013. *Prereq: MICRO 302, MICRO 302L*

Survey of the diverse groups of prokaryotes emphasizing important and distinguishing metabolic, phylogenetic, morphological, and ecological features of members of those groups.

BBMB 440. Laboratory in Microbial Physiology, Diversity, and Genetics.(Cross-listed with MICRO). (2-6) Cr. 4. F. *Prereq: MICRO 302, MICRO 302L, CHEM 332, BIOL 313L*

Study of the fundamental techniques and theory of studying the cellular mechanisms and diversity of microbial life. Experimental techniques will include isolation and physiological characterization of bacteria that inhabit different environments. Also included are techniques for the phylogenetic characterization, and genetic manipulation of diverse species of bacteria.

BBMB 461. Molecular Biophysics.(Dual-listed with BBMB 561). (2-0) Cr. 2. S. *Prereq: Credit or enrollment in CHEM 324 and CHEM 325*

Physical methods for the study of molecular structure and organization of biological materials. X-ray diffraction, nuclear magnetic resonance, hydrodynamics and fluorescence spectroscopy. Registration for the graduate credit commits the student to graduate-level examinations, which differ from undergraduate-level examinations in the number and/or difficulty of questions.

BBMB 490. Independent Study.Cr. arr. Repeatable. F.S.SS. *Prereq: College of Agriculture: junior or senior classification and permission of instructor; College of Liberal Arts and Sciences: permission of instructor*

College of Agriculture: a maximum of 6 credits of 490 may be applied toward graduation., College of Liberal Arts and Sciences: a maximum of 9 credits may be applied toward graduation.

BBMB 490H. Independent Study, Honors.Cr. arr. Repeatable. F.S.SS. *Prereq: College of Agriculture: junior or senior classification and permission of instructor; College of Liberal Arts and Sciences: permission of instructor*

Independent study with a faculty mentor. College of Agriculture: a maximum of 6 credits of 490 may be applied toward graduation., College of Liberal Arts and Sciences: a maximum of 9 credits of 490 may be applied toward graduation.

BBMB 499. Undergraduate Research.Cr. 1-5. Repeatable. F.S.SS. *Prereq: Permission of faculty member with whom student proposes to work.*

Independent research under faculty guidance.

Courses primarily for graduate students, open to qualified undergraduates:

BBMB 501. Comprehensive Biochemistry I.(4-0) Cr. 4. F. *Prereq: CHEM 211, CHEM 332; a previous course in biochemistry is strongly recommended*

Chemical composition of living matter and the chemistry of life processes. Chemical characterization of amino acids, proteins, carbohydrates and lipids; enzymology and co-enzymes; metabolism of carbohydrates; biological oxidations.

BBMB 502. Comprehensive Biochemistry II.(4-0) Cr. 4. S. *Prereq: BBMB 501*

Chemical composition of living matter and the chemistry of life processes. Metabolism of lipids, amino acids, and nucleotides; membrane biochemistry; biosynthesis of DNA, RNA, and proteins; gene regulation; selected topics.

BBMB 503. Bioinorganic Chemistry.(Cross-listed with CHEM). (2-0) Cr. 2. Alt. S., offered 2012. *Prereq: CHEM 402 or BBMB 405*

Essential elements: transport and storage of ions and of oxygen; metalloenzymes and metallocoenzymes; electron-transfer processes in respiration and photosynthesis; metabolism of nonmetals and redox processes involved in it; medicinal aspects of inorganic chemistry.

BBMB 520. Genetic Engineering.(Cross-listed with GDCB, MCDB). (3-0) Cr. 3. Alt. S., offered 2012. *Prereq: GEN 411 or BBMB 405*

Strategies and rationale of recombinant DNA technologies. The methodology of genetic engineering in basic research and implications for applied research will be considered. Topics include: basic tools of molecular cloning, targeted mutagenesis, fluorescent proteins, protein expression systems, and transgenic model systems.

BBMB 530. Prokaryotic Diversity and Ecology.(Dual-listed with BBMB 430). (Cross-listed with MICRO). (3-0) Cr. 3. Alt. S., offered 2013. *Prereq: MICRO 302, MICRO 302L*

Survey of the diverse groups of prokaryotes emphasizing important and distinguishing metabolic, phylogenetic, morphological, and ecological features of members of those groups.

BBMB 542. Introduction to Molecular Biology Techniques.Cr. 1. Repeatable. F.S.SS. *Prereq: Graduate classification*
Sessions in basic molecular biology techniques and related procedures. Offered on a satisfactory-fail basis only.**BBMB 542A. DNA Techniques..**(Cross-listed with B M S, EEOB, FS HN, GDCB, HORT, NREM, NUTRS, V MPM, VDPAM). Cr. 1. Repeatable. F.S.SS. *Prereq: Graduate classification*
Includes genetic engineering procedures, sequencing, PCR, and genotyping. Offered on a satisfactory-fail basis only.**BBMB 542B. Introduction to Molecular Biology Techniques: Protein.**(Cross-listed with B M S, EEOB, FS HN, GDCB, HORT, NREM, NUTRS, V MPM, VDPAM). Cr. 1. Repeatable. S.SS. *Prereq: Graduate classification*
Includes fermentation, protein isolation, protein purification, SDS-PAGE, Western blotting, NMR, introduction to high-performance computing, immunophenotyping, and monoclonal antibody production. Offered on a satisfactory-fail basis only.**BBMB 542C. Cell Techniques. Includes immunophenotyping, ELISA, flow cytometry, microscopic techniques, and image analysis. (F.S.).**Cr. 1. Repeatable. F.S.SS. *Prereq: Graduate classification*
Sessions in basic molecular biology techniques and related procedures. Offered on a satisfactory-fail basis only.**BBMB 542D. Plant Transformation. Includes Agrobacterium and particle gun-mediated transformation of tobacco, Arabidopsis, and maize, and analysis of transformants. (S.).**Cr. 1. Repeatable. F.S.SS. *Prereq: Graduate classification*
Sessions in basic molecular biology techniques and related procedures. Offered on a satisfactory-fail basis only.**BBMB 542E. Introduction to Molecular Biology Techniques: Proteomics.**(Cross-listed with B M S, EEOB, FS HN, GDCB, HORT, NREM, NUTRS, V MPM, VDPAM). Cr. 1. Repeatable. F. *Prereq: Graduate classification*
Includes two-dimensional electrophoresis, laser scanning, mass spectrometry, and database searching. Offered on a satisfactory-fail basis only.**BBMB 542F. Introduction to Molecular Biology Techniques: Metabolomics.**(Cross-listed with B M S, EEOB, FS HN, GDCB, HORT, NREM, NUTRS, V MPM, VDPAM). Cr. 1. Repeatable. F. *Prereq: Graduate classification*
Includes metabolomics and the techniques involved in metabolite profiling. For non-chemistry majoring students who are seeking analytical aspects into their biological research projects. Offered on a satisfactory-fail basis only.**BBMB 542G. Genomic Techniques.**Cr. 1. Repeatable. F.S.SS. *Prereq: Graduate classification*
Sessions in basic molecular biology techniques and related procedures. Offered on a satisfactory-fail basis only.

BBMB 552. Biomolecular NMR Spectroscopy.

(2-0) Cr. 2. Alt. S., offered 2013. *Prereq: CHEM 325 or permission of instructor*
Advanced solution state Nuclear Magnetic Resonance spectroscopy as applied to biological systems. Topics include theoretical principles of NMR, practical aspects of experimental NMR, methodologies for protein structure determination, NMR relaxation, recent advances in NMR spectroscopy.

BBMB 561. Molecular Biophysics.

(Dual-listed with BBMB 461). (2-0) Cr. 2. S. *Prereq: Credit or enrollment in CHEM 324 and CHEM 325*

Physical methods for the study of molecular structure and organization of biological materials. X-ray diffraction, nuclear magnetic resonance, hydrodynamics and fluorescence spectroscopy. Registration for graduate credit commits the student to graduate-level examinations, which differ from undergraduate-level examinations in the number and/or difficulty of questions.

BBMB 561L. Laboratory in Molecular Biophysics.

(1-3) Cr. 2. S. *Prereq: Credit or enrollment in BBMB 461/BBMB 561*

Practice in methods of X-ray diffraction, nuclear magnetic resonance, hydrodynamics and fluorescence spectroscopy as applied to macromolecules.

BBMB 569. Bioinformatics III (Structural Genome Informatics).

(Cross-listed with BCB, COM S, CPR E). (3-0) Cr. 3. F. *Prereq: BCB 567, GEN 411, STAT 430*

Algorithmic and statistical approaches in structural genomics including protein, DNA and RNA structure. Structure determination, refinement, representation, comparison, visualization, and modeling. Analysis and prediction of protein secondary and tertiary structure, disorder, protein cores and surfaces, protein-protein and protein-nucleic acid interactions, protein localization and function.

BBMB 590. Special Topics.

Cr. arr.

By arrangement.

BBMB 593. Workshop in Biochemistry and Biophysics.

Cr. 1. Repeatable. F.S. *Prereq: Permission and signature of course administrator required.*

Workshops in selected topics in biochemistry and biophysics. Credit in this course does not meet the requirement for advanced graduate electives in Biochemistry. Spring only: BBMB Undergraduate Research Symposium participation. Scheduled class meetings are required in addition to attending the symposium.

Courses for graduate students:**BBMB 607. Plant Biochemistry.**

(2-0) Cr. 2. Alt. F., offered 2012. *Prereq: BBMB 405 or BBMB 502*

Description of unique aspects of plant biochemistry including lipid metabolism, cell wall structure, secondary metabolism, phytoalexin biosynthesis, and plant defenses.

BBMB 615. Molecular Immunology.

(Cross-listed with MICRO, V MPM). (3-0) Cr. 3. Alt. F., offered 2013. *Prereq: BBMB 405 or BBMB 502*

Current topics in molecular aspects of immunology: T and B cell receptors; major histocompatibility complex; antibody structure; immunosuppressive drugs and viruses; and intracellular signaling pathways leading to expression of genes that control and activate immune function.

BBMB 622. Carbohydrate Chemistry.

(2-0) Cr. 2. Alt. S., offered 2012. *Prereq: BBMB 404 or BBMB 501*

Structure, occurrence, properties, function, and chemical and enzymatic modifications of monosaccharides, oligosaccharides, polysaccharides, and glycoproteins.

BBMB 632. Kinetics of Enzyme Action.

(2-0) Cr. 2. Alt. F., offered 2014. *Prereq: BBMB 501*

Fundamental and advanced enzyme kinetics. Topics include integrated rate equations, methods for deriving initial-rate equations, inhibition, product effects, methods for verifying kinetic mechanisms, allostery, hysteresis, isotope effects, and complex kinetic mechanisms.

BBMB 642. Mechanisms of Enzymatic Catalysis.

(2-0) Cr. 2. Alt. S., offered 2013. *Prereq: BBMB 404, BBMB 420, or BBMB 501*

The chemical basis of enzymatic catalysis with emphasis on mechanisms of substrate recognition, general acid-base catalysis and stereo-electronic factors.

BBMB 645. Molecular Signaling.

(2-0) Cr. 2. Alt. S., offered 2013. *Prereq: BBMB 405, BBMB 420, or BBMB 502*

Molecular mechanisms of cellular signaling including receptor activation, desensitization and cross talk, signal transduction pathways, and nuclear receptors. Discussion includes a variety of cell surface receptors and their hormone; growth factor and extracellular matrix activators; protein kinases; caspase and transcription factor downstream signals; lipids, gases and cyclic nucleotides as regulators of cell signaling. Course content includes current literature, student and instructor presentations and research proposal writing.

BBMB 652. Protein Chemistry - Chemical Methods.

(2-0) Cr. 1. Alt. F., offered 2013. *Prereq: BBMB 404 or BBMB 501*

First 8 weeks. Chemical reactions as a means of determining protein structure and biological function.

BBMB 653. Protein Chemistry - Physical Methods.

(2-0) Cr. 1. Alt. F., offered 2013. *Prereq: BBMB 404 or BBMB 501*

Second 8 weeks. Protein structure determination as a means of understanding biological function.

BBMB 660. Membrane Biochemistry.

(2-0) Cr. 2. Alt. F., offered 2012. *Prereq: BBMB 405 or BBMB 502*

Protein and lipid constituents of biological membranes. Structure and topography of membrane proteins. Selected topics concerning the membrane proteins involved in diverse biochemical processes, such as energy transduction transport across membranes, neurotransmission and signal transduction.

BBMB 661. Current Topics in Neuroscience.

(Cross-listed with NEURO, GDCB). (2-0) Cr. 2-3. Repeatable. Alt. S., offered 2014. *Prereq: NEURO 556 (or comparable course) or permission of instructor*

Topics may include molecular and cellular neuroscience, neurodevelopment, neuroplasticity, neurodegenerative diseases, cognitive neuroscience, sensory biology, neural integration, membrane biophysics, neuroethology, techniques in neurobiology and behavior.

BBMB 675. Nucleic Acid Structure and Function.

(2-0) Cr. 2. Alt. F., offered 2012. *Prereq: BBMB 405 or BBMB 502*

In-depth discussion of nucleic acid properties, structures and structure/function relationships. Interactions between nucleic acids and proteins will be emphasized.

BBMB 676. Biochemistry of Gene Expression in Eucaryotes.

(Cross-listed with MCDB). (2-0) Cr. 2. Alt. S., offered 2012. *Prereq: BBMB 404 or BBMB 501, BBMB 405 or BBMB 502 or GDCB 511*

Analysis of the biochemical processes involved in expression of eucaryotic genes and the regulation thereof, including RNA polymerase, transcriptional regulatory proteins, enhancers and silencers, chromosome structure, termination, RNA processing, RNA transport, RNA turnover, small RNAs translational regulation, protein turnover.

BBMB 681. Advanced Seminar.

Cr. 1. Repeatable. F.S. *Prereq: Permission of instructor*
Student presentations.

BBMB 682. Departmental Seminar.

Cr. R. F.S. *Prereq: Permission of instructor*
Faculty, staff and invited guest research seminar.

BBMB 696. Research Seminar.

(Cross-listed with AGRON, PLBIO, GDCB, HORT, FOR). Cr. 1. Repeatable. F.S.
Research seminars by faculty and graduate students. Offered on a satisfactory-fail basis only.

BBMB 698. Seminar in Molecular, Cellular, and Developmental Biology.

(Cross-listed with MCDB, GDCB, MICRO, V MPM). (2-0) Cr. 1-2. Repeatable. F.S.
Student and faculty presentations.

BBMB 699. Research.

Cr. arr. Repeatable. F.S. *Prereq: Permission of instructor*