***521. Medical Biochemistry***
*Fall. 5(5-0)*
*R: Graduate-professional students in colleges of Human and Osteopathic Medicine.*
Basic biochemical principles and terminology: metabolism and function of biomolecules of importance in medical biology and processes pertinent to human pathophysiology.

***523. Genetics for Medical Practice***
*Summer. 1(1-0) Interdepartmental with Pediatrics and Human Development. Administered by Pediatrics and Human Development.*
*R: Graduate-professional students in colleges of Human and Osteopathic Medicine.*
Basic principles of genetics for medical students.

***801. Molecular Biology***
*Fall. 3(3-0)*
*P: BCH 462, CEM 383.*
Organization of genes. Regulation of gene expression, replication, and recombination.

***802. Metabolic Regulation and Signal Transduction***
*Spring. 3(3-0)*
*P: BCH 801.*
Molecular basis for metabolic regulation. Molecular signalling mechanisms and mechanisms for allosteric and covalent protein modifications.

***803. Protein Structure and Function***
*Fall. 2(2-0)*
*P: BCH 462, CEM 383.*
Protein structure and relationship of function to structure. Applications of kinetic methods to elucidation of enzyme mechanisms and regulation.

***821. Biochemical Mechanisms and Structure***
*Spring. 3(3-0)*
*P: BCH 462, CEM 383 or concurrently.*
Structures, methods of structural analysis, synthesis, and reaction mechanisms of biological substances including proteins, carbohydrates, lipids, porphyrins, phosphate esters, enzymes, and coenzymes.

***825. Cell Structure and Function***
*Spring. 3(3-0) Interdepartmental with Physiology and Microbiology.*
*P: BCH 401 or BCH 461.*
Molecular basis of structure and function. Cell properties: reproduction, dynamic organization, integration, programmed and integrative information transfer. Original investigations in all five kingdoms.

***829. Methods of Macromolecular Analysis and Synthesis***
*Fall. 2(2-0)*
*P: BCH 462.*
Techniques of isolation and characterization of macromolecules. Computer use in structure-function analysis of macromolecules.

***831. Physiological Biochemistry***
*Spring. 4(4-0)*
*P: BCH 401 or BCH 462.*
Mammalian physiological biochemistry. Metabolic interpretation of normal and altered physiological states of humans and other mammals.

***855. Special Problems***
*Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 8 credits in all enrollments for this course.*
*R: Approval of department.*
Laboratory or library research on special problems in biochemistry.

***856. Plant Molecular Biology***
*Spring. 3(3-0) Interdepartmental with Botany and Plant Pathology. Administered by Botany and Plant Pathology.*
*P: ZOL 341.*
Recent advances in genetics and molecular biology of higher plants.

***864. Plant Biochemistry***
*Spring. 3(3-0) Interdepartmental with Botany and Plant Pathology.*
*P: BCH 401 or BCH 462.*
Biochemistry unique to photosynthetic organisms. Photosynthetic and respiratory electron transport, nitrogen fixation, carbon dioxide fixation, lipid metabolism, carbon partitioning, cell walls, biosynthesis of plant hormones.

***888. Laboratory Rotation***
*Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 12 credits in all enrollments for this course.*
*R: Open only to graduate students in Biochemistry.*
Participation in research laboratories to learn experimental techniques and approaches, broaden research experience, and assess research interests prior to selecting a thesis or dissertation adviser.

***899. Master's Thesis Research***
*Fall, Spring, Summer. 1 to 12 credits. A student may earn a maximum of 24 credits in all enrollments for this course.*
*R: Open only to master's students in Biochemistry.*

***960. Selected Topics in Biochemistry I***
*Fall, Spring. 1 to 2 credits. A student may earn a maximum of 7 credits in all enrollments for this course.*
*R: Open only to graduate students in Biochemistry or approval of department.*
Contemporary biochemical research topics in such areas as biochemical genetics, biochemistry of development, biochemical evolution, complex proteins, or lipid metabolism.

***961. Selected Topics in Biochemistry II***
*Fall, Spring. 1 to 3 credits. A student may earn a maximum of 7 credits in all enrollments for this course.*
*R: Open only to graduate students in the Department of Biochemistry.*
Contemporary biochemical research topics in such areas as bioenergetics, bioinstrumentation, complex carbohydrates, mass spectrometry, biomolecular spectroscopy or computer-based modeling and analysis of DNA and protein sequences and structures.

***978. Seminar in Biochemistry***
*Fall, Spring. 1(1-0) A student may earn a maximum of 8 credits in all enrollments for this course.*
*R: Open only to graduate students in Biochemistry.*
Seminars on biochemistry research mainly with visiting scientists.

***999. Doctoral Dissertation Research***
*Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 99 credits in all enrollments for this course.*
*R: Open only to doctoral students in Biochemistry.*

## BIOLOGICAL SCIENCE BS

### College of Natural Science

***110. Organisms and Populations***
*Fall, Spring. 4(3-3)*
*R: Not open to students with credit in LBS 144.*
Biological diversity and organismal biology. Principles of evolution, population biology, and community structure.

***111. Cells and Molecules***
*Fall, Spring, Summer. 3(3-0)*
*P: CEM 141 or CEM 151. R: Not open to students with credit in LBS 145.*
Cell structure and function; macromolecular synthesis; energy metabolism; molecular aspects of development; principles of genetics.

***111L. Cell and Molecular Biology Laboratory***
*Fall, Spring, Summer. 2(1-3) Interdepartmental with Microbiology, Botany and Plant Pathology, and Zoology.*
*P: BS 111 or concurrently*
Principles and applications of common techniques used in cell and molecular biology.

***148H. Honors Organismal Biology***
*Fall. 3 credits. Interdepartmental with Lyman Briggs School. Administered by Lyman Briggs School.*
*R: Honors College student or approval of department. Not open to students with credit in BS 110 or LBS 144.*
Diversity and basic properties of organisms, with emphasis on genetic principles, ecological interactions, and the evolutionary process. Historical approach to knowledge discovery.

***149H. Honors Cell and Molecular Biology***
*Spring. 3 credits. Interdepartmental with Lyman Briggs School. Administered by Lyman Briggs School.*
*P: CEM 141 or CEM 151 or CEM 181H or LBS 165 R: Honors College student or approval of department. Not open to students with credit in BS 111 or LBS 145.*
The physicochemical and molecular organization of cells as the unifying framework for genetics, evolution, and the social relevance of biology.

***158H. Honors Organismal Biology Laboratory***
*Fall. 2 credits. Interdepartmental with Lyman Briggs School. Administered by Lyman Briggs School.*
*C: LBS 148H concurrently. R: Honors College student or approval of department. Not open to students with credit in BS 110 or LBS 144.*
Basic procedures used by organismal biologists, including experimental design and statistical methods. Development and implementation of research projects to test hypotheses in genetics, ecology, and evolution.

***159H. Honors Cell and Molecular Biology Laboratory***
*Spring. 2 credits. Interdepartmental with Lyman Briggs School. Administered by Lyman Briggs School.*
*P: CEM 141 or CEM 151 or CEM 181H or LBS 165 C: LBS 149H concurrently. R: Honors College student or approval of department. Not open to students with credit in BS 111 or LBS 145.*
Basic techniques of cellular and molecular biology, including experimental design and hypothesis formulation. Developoment and implementation of research projects to test hypotheses in biochemistry, molecular biology, or genetics.

## BIOMEDICAL ENGINEERING BME

### College of Engineering

***424. Biomaterials and Biocompatibility***
*Spring of even-numbered years. 3(3-0) Interdepartmental with Materials Science and Mechanics.*
*P: MSM 250, PSL 250.*
Materials science of human implants. Design requirements imposed by the body's milieu and the need to protect the body.

***441. Tissue Mechanics***
*Spring of odd-numbered years. 3(3-0) Interdepartmental with Materials Science and Mechanics.*
*P: MSM 211.*
Application of solid mechanics to understanding mechanical responses of biological tissues. Microstructure and biological function for soft and hard connective tissues and muscle.

***491. Special Topics (MTC)***
*Fall, Spring. 3 to 12 credits. A student may earn a maximum of 12 credits in all enrollments for this course.*
*P: BME 311.*
Special topics in biomedical engineering or bioengineering such as biochemical design, occupational biomechanics, biological surface science, or low temperature biotechnology.

# BIOSYSTEMS ENGINEERING BE

## Department of Agricultural Engineering
## College of Agriculture and Natural Resources
## College of Engineering

***180. Current Issues in Biosystems***
*Fall, Spring. 2(2-0)*
*P: MTH 110 or MTH 116. R: Open only to freshmen or sophomores.*
The relationship of biosystems engineering to current problems in food production and processing. Environment, natural resources, harvesting, handling, safety, and water quality.

***230. Principles of Biosystems Engineering***
*Fall. 3(3-0)*
*P: MTH 132. R: Open only to sophomores or juniors in College of Agriculture and Natural Resources, College of Engineering, or College of Natural Science.*
Concepts of biosystems. Hard and soft systems. Conceptual and computer modeling of components of biosystems.

***232. Food Production and Processing Systems***
*Fall. 1 credit.*
*R: Open only to students in College of Agriculture and Natural Resources or College of Engineering.*
Crop and animal production systems. Food processing systems. Field trips required.

***336. Machinery Systems for Food Production***
*Fall. 3(3-0)*
*P: MTH 235.*
Processes performed by agricultural production machines. Power systems, tillage mechanics, traction, metering, distribution, conveying, fluidization, mixing, separation, and atomization. Machinery management.
*SA: AE 336*

***337. Machinery Systems for Food Processing***
*Spring. 3(3-0)*
*P: MTH 235.*
Principles of design, operation, and performance of equipment for processing raw materials into finished or intermediate products.
*SA: AE 338, FE 338*

***350. Heat Transfer in Biosystems***
*Spring. 2(2-0)*
*P: MTH 235; CPS 101 or CPS 131. R: Not open to students with credit in CHE 311 or ME 410.*
Steady state and transient heat conduction. Radiation and convection heat transfer. Heat exchangers. Application problems in biosystems engineering.

***351. Environmental Thermodynamics***
*Spring. 3(3-0)*
*P: MTH 235. R: Not open to students with credit in CHE 321 or ME 201.*
First and Second Laws of Thermodynamics with applications in food, biosystems, and environmental engineering. Refrigeration cycles. Entropy. Thermodynamic aspects of fluid flow. Psychrometrics.

***403. Microclimate and Its Measurement***
*Fall of odd-numbered years. 4(3-3) Interdepartmental with Geography.*
*P: MTH 116 R: Not open to freshmen or sophmores.*
The climate near the Earth's surface. Energy balance, thermal radiation exchange, heat fluxes, temperature sensors, wind speed and direction, humidity and evapotranspiration and their measurement.
*SA: ATM 836*

***430. Power and Control Hydraulics***
*Spring. 3(2-2)*
*P: CE 321 or CHE 311 or ME 332. R: Open only to majors in College of Engineering.*
Hydraulic fluid properties. Pump and motor performance parameters. Control valves and hydraulic circuitry components. Analysis and design of hydraulic systems.
*SA: AE 430*

***431. Resource Optimization***
*Spring. 3(2-2)*
*P: BE 230, MTH 235 R: Not open to students with credit in BE 831.*
Optimal solutions to problems with multiple and conflicting objectives and constraints. Applications to natural and manufactured biological systems.

***438. Design of Machinery Structures***
*Fall. 3(3-0)*
*P: MSM 211. R: Open only to majors in College of Engineering. Not open to students with credit in ME 471.*
Design of structural components and systems in machines. Tension, compression, torsion, bending and combined loadings. Joint connections.
*SA: AE 438*

***453. Engineering Principles of the Plant Environment***
*Fall. 3(3-0)*
*P: BOT 105 or BS 110 or BS 111; CEM 141, BE 350, BE 351. R: Open only to majors in College of Engineering.*
Analysis of the soil-plant-atmosphere continuum. Thermodynamics effects on plant environment: water, soil heat flow, radiation, and soil water movement.
*SA: AE 353*

***456. Electric Power and Control***
*Spring. 3(2-2)*
*P: EE 200 or EE 345. R: Open only to majors in College of Engineering.*
Alternating current circuits, power distribution, electrical machines, protection, and programmable motor controllers. Design project related to food and agricultural industries.
*SA: AE 356*

***457. Postharvest Engineering***
*Fall. 3(3-0)*
*P: BE 350 or CHE 311 or ME 410. R: Open only to majors in College of Agriculture and Natural Resources or College of Engineering.*
Engineering principles involved with the storage and handling of grains and horticultural crops between harvest and processing.
*SA: FE 460*

***460. Resource and Environmental Economics***
*Spring. 3(3-0) Interdepartmental with Public Resource Management; Resource Development; and Park, Recreation and Tourism Resources. Administered by Resource Development.*
*P: RD 200; EC 201 or EC 202 or PRM 201 or RD 302.*
Economics of land and related environmental resources. Production and consumption processes. Resource allocations and scarcity. Market failure and externalities. Market and institutional remedial approaches.

***481. Agricultural and Small Watershed Hydrology***
*Spring. 3(2-2)*
*P: CPS 101 or CPS 131; CE 321 or CHE 311 or BE 350; BE 453 or CE 312. R: Open only to seniors in College of Engineering or graduate students.*
Runoff, infiltration, surface and subsurface drainage and soil erosion.
*SA: AE 481*

***486. Biosystems Design Fundamentals***
*Fall. 3(3-0)*
*P: BE 350 or BE 336 or BE 453. R: Open only to seniors in College of Engineering or graduate students.*
Concepts, methods, and procedures of the total design process from problem identification to final specifications.
*SA: AE 486*

***487. Biosystems Design Project (W)***
*Spring. 3 credits.*
*P: BE 486. R: Open only to seniors in College of Engineering. Completion of Tier I writing requirement.*
Individual or team design project selected in BE 486. Information expansion, development of alternatives, and evaluation, selection, and completion of a design project.
*SA: AE 488*

***490. Independent Study***
*Fall, Spring, Summer. 1 to 5 credits. A student may earn a maximum of 5 credits in all enrollments for this course.*
*P: BE 230 or BE 336 or BE 350 or BE 453. R: Open only to majors in College of Engineering. Approval of department; application required.*
Supervised individual student research and study in biosystems engineering.
*SA: AE 490*

***491. Special Topics in Biosystems Engineering***
*Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 12 credits in all enrollments for this course.*
*P: BE 230, BE 336 or BE 350 or BE 453. R: Open only to majors in College of Engineering. Approval of department.*
Special topics in biosystems engineering.
*SA: AE 491*

***802. Computational Methods in Biosystems Engineering***
*Summer of odd-numbered years. 3(3-0)*
*R: Open only to graduate students in the College of Agriculture and Natural Resources or College of Engineering.*
Formulation and solution of mathematical equations in biosystems engineering. Constitutive equations. Linear and nonlinear problems. Steady state and transient problems. Computer solutions.
*SA: AE 802*