
411. Electric Theory of Nerves
Winter of even-numbered years. 4(4-0) MTH 310; PHY 258.

414. Clinical Instrumentation
Winter of even-numbered years. 3(3-0) BME 410.

424. Materials in Biomedical Engineering
Winter. 3(3-0) PSI 240 or PSI 431 or approval of department.

431. Biological Transport Mechanisms
Spring. 3(3-0) MTH 215.
Mechanisms which govern transport or momentum, heat or mass. Application to mathematical description of transport processes in biological systems and solution of biomedical problems.

451. Tissue Biomechanics
Fall. 3(3-0) ANT 318 or approval of department.
Fundamental of continuum mechanics in relation to morphological classification of tissue. Mechanical properties of connective and muscle tissue.

499. Independent Study
Fall. Winter, Spring. 1 to 4 credits. May reenroll for a maximum of 9 credits. Approval of instructor.
Individual reading and research under the supervision of a member of the Biomedical Engineering Committee.

BOTANY AND PLANT PATHOLOGY BOT
College of Agriculture and Natural Resources
College of Natural Science

201. Plants, People and the Environment (N)
Fall, Spring. 3(3-0)
Relevance of plants to modern society. Basic botanical concepts and socially significant groups of plants. Natural resource exploitation. Plants as they relate to human population growth, food production, and energy resource depletion.

205. Plant Biology
Fall. 3(3-0) High school chemistry and high school algebra.
An introduction to plant science for students seeking a general knowledge of the principles of plant biology as well as for prospective plant science majors.

206. Plant Biology Laboratory
Fall. 1(0-3) BOT 205 or concurrently.
Physiological experiments and hands-on study of plant diversity at the cellular, tissue and whole plant level.

301. Introductory Plant Physiology
Winter, Spring. 4(2-4) CEM 141A or CEM 151; CEM 161; BOT 205 or B S 210 or LBS 141. Introductory organic chemistry recommended.
General principles of plant physiology relating plant structure to function. Topics include cell physiology, water relations, photosynthesis, mineral nutrition, and hormone action.

302. Introductory Morphology
Winter. 4(2-4) BOT 205 or B S 212 or approval of department.
Structures and life cycles of representative plant groups showing progressive evolutionary developments.

318. Introductory Plant Systematics
Spring. 3(3-0) BOT 302 or B S 212 or approval of department.
Plant diversity with emphasis on identification, classification, nomenclature, and evolutionary relationships of vascular plants.

330. Forest Protection
Fall. 4(4-0) FOR 304, FOR 305, FOR 320. Interdepartmental with the departments of Entomology and Forestry. Administered by the Department of Forestry.
Procedures used to detect and respond to pest, fire and environmental problems in a variety of forest types.

335. Fossil Plants, Their History and Paleocology
Spring. 3(3-0) One course in geology or botany or biology or approval of department. Interdepartmental with and administered by the Department of Geology.
History of plants through geologic time; their form and evolution; how and where found, identified and reconstructed; their use in determining ancient geographic patterns, paleoenvironments, paleoclimates and community structure. Field trip.

336. Economic Plants
Winter. 3(3-0) BOT 205 or B S 212 or approval of department.
Plants used by humans viewed from economic, historical, cultural, and botanical perspectives. Emphasis on food, fiber and medicinal plants. Includes plants used for herbs, dyes, perfumes, alcohol, stimulants, ornamentals, energy.

400. Aquatic Plants
Fall. 3(3-0) BOT 318 or BOT 302. Students may not receive credit in both BOT 400 and BOT 392.
Aquatic plants, their classification, ecology and economic importance. Relationships to problems in fisheries, in wildlife management, and to role in limnology. Experience for student in plant ecology, aquatic biology, and water sanitation.

400H. Honors Work
Fall, Winter, Spring. 3(0-0) Approval of department; Seniors.
401. Directed Studies
Fall, Winter, Spring, Summer. 1 to 4 credits. May renew for a maximum of 16 credits. Approval of instructor.
Directed research or study of published literature. Areas of study include (but are not limited to) plant morphology, taxonomy, anatomy, ecology, paleobotany, cell biology, genetics, mycology, plant physiology, and various areas of plant pathology.

402. Introductory Mycology
Fall. 4(2-4) B S 212 or LBS 140 or approval of department.
Survey of the fungi including characteristics, habits and diversity. Background course for biology students or those expecting to specialize in microbiology, mycology, plant pathology, or other fields involving fungi.

403. Elements of Cell Function and Structure
Spring. 4(4-0) MPH 407, BCH 453 concurrently. Interdepartmental with the Department of Microbiology and Public Health. Administered by the Department of Microbiology and Public Health.
Cell biology of eukaryotic cells, with an emphasis on the molecular mechanisms that underlie cellular processes.

405. Introductory Plant Pathology
Fall. 4(2-4) BOT 302 or B S 212 or approval of department. Students may not receive credit in both BOT 405 and BOT 407.
General principles of plant pathology including detailed study of selected diseases as examples of important groups.

406. Medical Mycology
Fall. 4(2-4) BOT 402 or approval of department. Interdepartmental with the Department of Microbiology and Public Health.
Characteristics, habits, and laboratory identification of fungus diseases infecting humans. Emphasis on laboratory techniques and morphological characteristics of the various mycenes.

407. Diseases of Forest and Shade Trees
Spring. 4(3-2) BOT 301; BOT 503; BOT 318 or FOR 204. Students may not receive credit in both BOT 405 and BOT 407.
Diseases which affect trees in forests, parks, suburbs and nurseries, and methods of control.

409. Plant Disease Control
Winter of odd-numbered years. 3(3-0) BOT 405.
Principals and methods in controlling plant diseases. Considerable emphasis is placed on the chemistry of fungicides, and their role in controlling plant diseases. Other factors affecting disease epidemiology are covered.

411. Systematic Botany
Summer. 4(2-4). B S 212, BOT 302 or approval of department. Students may not receive credit in both BOT 411 and BOT 425.
Taxonomy, classification, and evolutionary relationships of vascular plants, illustrated by the local flora; extensive field studies.

413. Environmental Plant Physiology
Winter. 3(3-0) B S 210 or LBS 141 or BOT 205.
Major topics include plant-soil-water relationships, gas exchange, and stress physiology. Minor topics include mineral nutrition and energy budgets.

414. Plant Physiology: Metabolism
Fall. 5(3-4) CEM 241; B S 210 or LBS 141 or BOT 205; BOT 301.
General principles underlying plant metabolic processes. Nutrient uptake, transport, photosynthesis, translocation, respiration, nitrogen metabolism, and structures associated with these processes.

415. Plant Physiology: Growth and Development
Spring. Summer of even-numbered years. 5(3-4) BOT 414 or approval of department.
Growth and development in plants. Topics include the chemistry and effects of hormones, tropisms, thermoperiodicity, reproduction, vernalization and photoperiodism, morphogenesis, dormancy, and biological clocks.

423. Aquatic and Wetland Plants
Summer. 3 credits. Students may not receive credit in both BOT 423 and BOT 400. BOT 302, B S 212 or approval of department. Given at W. K. Kellogg Biological Station.
Extensive exposure to plants in aquatic environments. Emphasis on systematic, morphology, evolution and community relations. Survey of diverse wetland and aquatic habitats with numerous field trips.

425. Field Plant Systematics
Summer. 4 credits. B S 212 or approval of department. Students may not receive credit in both BOT 425 and BOT 411. Given at W. K. Kellogg Biological Station.
Classification, evolution, distribution and biology of vascular plants. Emphasis on field recognition, identification. Numerous field trips to diverse habitats for common, rare, native and introduced plants.

427. Cell Biology
Fall. 4(4-0) BCH 300 and one year of general botany or general zoology.
Organization and structure of the cell, with emphasis on eukaryotes. Structure and function of the nucleus and cytoplasmic organelles. An introduction to molecular biology.

434. Plant Anatomy
Fall. 4(2-4) B S 212 or BOT 205.
Principles underlining the differentiation and growth of vegetative plant structures with special emphasis upon their functional and developmental genetic relationships.

441. Geographical Plant Ecology
Winter. 3(3-0) BOT 205 or BOT 302 or B S 212 or approval of department.

447. Fresh Water Algae
Spring. 4(2-4). Given at W. K. Kellogg Biological Station Summer term; 4 credits. B S 213, BOT 302. Students may not receive credit in both BOT 423 and BOT 447.
Identification of fresh water algae, especially those forms concerned with fish food problems, water contamination and limnology. Methods for making analyses of samples for biological survey work on lakes and streams. Economic aspects and life history of the algae.

450. Ecology
Spring. 4(2-4). Given at W. K. Kellogg Biological Station Summer term; 4 credits. BOT 319; BOT 301 or BOT 414.
Interrelationship of plants and environment. Factors which govern their distribution.

464. Comparative Limnology
Summer. 6 credits. B S 312. Given at W. K. Kellogg Biological Station. Interdepartmental with and administered by the Department of Zoology.
Theoretical concepts and methods of analysis of environmental parameters influencing productivity of freshwaters. Comparative field investigations of lakes, streams, and other aquatic habitats.

470. Nematode Diseases of Economic Plants
BOT 405. Interdepartmental with and administered by the Department of Entomology.
Major nematode diseases of economically important plants, with emphasis on diagnostic symptoms, nematode biology and principles of control.

475. Special Topics in Plant Pathology
Fall, Winter, Spring. 2 to 5 credits. May renew for a maximum of 6 credits if different topics are taken. Approval of department.
Topics may be selected from the following areas: genetics, parasitism, virology, disease control, phytobacteriology, nematology, epidemiology, physiology, soil microbiology, and others.

489. Senior Seminar
Winter. 1(1-0). May renew for a maximum of 3 credits. B S 319 and 1 course in botany or approval of department.
Reports by students, faculty, and guest lecturers, with emphasis on current developments in research.

800. Special Problems in Taxonomy
Fall, Winter, Spring. 1 to 15 credits. Approval of department.

801. Special Problems in Anatomy and Morphology
Fall, Winter, Spring. 1 to 15 credits. Approval of department.

802. Special Problems in Pathology
Fall, Winter, Spring. Summer. 1 to 15 credits. Approval of department.

803. Special Problems in Physiology
Fall, Winter, Spring. Summer. 1 to 15 credits. Approval of department.

805. Special Problems in Mycology
Fall, Winter, Spring. Summer. 1 to 15 credits. Approval of department.

807. Special Problems in Algology
Fall, Winter, Spring. Summer. 1 to 15 credits. Approval of department.

812. Ecology of Plant Pathogens
Winter of even-numbered years. 3(2-0) BOT 402, BOT 405; or approval of department.
813. Special Problems
Fall, Winter, Spring. 1 to 4 credits.
May reenroll for a maximum of 16 credits.
Approval of department.

816. Industrial Mycology
Winter of odd-numbered years. 3(2-4)
BOT 402 or approval of department.
Industrially important fungi, their uses and characteristics. Methods of commercial production, including acids, enzymes, cheeses, mushrooms, and antibiotics. Several field trips will be taken.

821. Ecology of Algae and Aquatic Plants
Summer of odd-numbered years. 6 credits.
BOT 400, BOT 447 or approval of department. Given at the W. K. Kellogg Biological Station.
Physiology and ecology of freshwater phytoplankton, sessile algae, and aquatic plants. Emphasis on physiological adaptations, mineral nutrition, growth, population dynamics, community productivity, and control measures.

523. Plant Taxonomy I
Fall of odd-numbered years. 4(3-3)
BOT 318; ZOL 441 recommended.
First course of a series on classification and relationships of vascular plants. Family characteristics, patterns, geographic distribution, and evolutionary trends are stressed. Contributions from classical taxonomy, cytotaxonomy and experimental taxonomy are discussed.

824. Plant Taxonomy II
Winter of even-numbered years. 4(3-3)
BOT 523.
Second course of a series on classification and relationships of vascular plants.

530. Paleobotany
Fall. 4(3-4) Approval of department.
Interdepartmental with Geology.
Survey of fossil plants: their preservation, occurrence, geology, paleogeography, paleoecology, evolutionary history, classification and representative taxa. One week field trip to fossil plant locality.

831. Palynology
Spring. 4(3-4) Approval of department.
Interdepartmental with Geology.
An introduction to the principles and techniques of spore and pollen analysis, both fossil and recent, and utilization of plant microfossils for stratigraphic determinations and paleoecological interpretations of most sedimentary accumulations and rocks. Includes certain algae, protists, bacteria, similar organisms of uncertain affinity and dissociated fragments of larger organisms.

836. Advanced Mycology: Biology of the Phycomycetes
Spring of even-numbered years. 3(3-0)
BOT 402 and approval of department.
Selected topics on the biology of phycymyceteous fungi.

838. Advanced Paleobotany
Winter. 3(2-4) Approval of department.
Interdepartmental with Geology.
Morphology, anatomy, phylogenetic relationships and classification of fossil plants. Microscopic analysis of tissues and organs prepared by thin section, transfers, peels, polished and etched surfaces, and macerations.
343. Transfer Processes and Separations IV
Winter. 3(2-2) CHE 341, CHE 342.

381. Chemical Engineering Analysis
Fall, Spring. 3(3-0) CHE 351, CHE 354. CHE 342 concurrently.
Application of chemical engineering principles in design calculations. Selection of the optimum design for equipment, functional units, and for the overall process. Influence of design on capital investment, operating costs, product lose, and product quality.

411. Phase and Chemical Equilibria
Spring. 3(3-0) CEM 381. CHE 311. Properties of solutions. Deviations from ideality. Liquid-vapor equilibrium. Chemical equilibria in the gas, liquid, and solid states.

423. Chemical Engineering Laboratory
Fall, Summer. 3(1-6) CHE 398 concurrently. CHE 451 concurrently. Assigned laboratory problems, requiring team effort. Experimental work, involving momentum, heat and mass transfer; separation processes, such as distillation, filtration, and drying; reactor kinetics; automatic process control.

424. Transport Phenomena and Physical Properties Laboratory
Fall. 3(1-6) CHE 398 concurrently. CHE 451 concurrently. Experiments involving the transport processes and measurement of physical, chemical and thermodynamic properties of various materials. Comparison of theoretical and experimental results.

428. Chemical Reaction Engineering
Fall. 4(4-0) CEM 381, CHE 311, CHE 342 concurrently. Quantitative treatment of mechanisms and rates of chemical reactions. Catalysts. Design and analysis of flow and non-flow reactor. Heterogeneous catalysis.

442. Polymer Science and Engineering

443. Chemical Engineering of the Solid State
Winter. 3(3-0) CEM 361. Structure and properties of inorganic and organic solids. Relation of bond type and steric configuration to mechanical, electrical, thermal, optical properties. Macromolecular structure influence on physical properties. Surface phenomena. Applications.

451. Process Systems Control
Fall. 3(3-0) CHE 343, CHE 428 concurrently. Foundation of control theory for chemical processes. Integration of present and developing practice with modern theory.

461. Process Selection and Optimization
Winter. 5(5-0) CHE 343, CHE 426. Application of chemical engineering principles in design calculations. Selection of the optimum design for equipment, functional units, and for the overall process. Influence of design on capital investment, operating costs, product lose, and product quality.

462. Process Design
Spring. 3(3-0) CHE 461. Integrated design of the complete chemical engineering process. Process engineering, project engineering, instrumentation, and layout.

465. Process Optimization Methods
Spring. 3(3-0) CHE 310. Interdepartmental with Systems Science. Methods for determining optimum design and operating policies of systems of varying complexity. Includes classical methods, mathematical programming and modern methods. Flowchart optimization with process simulation packages.

470. Theory of Nuclear Reactors
Winter. 3(3-0) PHY 269, MTH 310 or concurrent or approval of department. Theory and design of nuclear research and power reactors. Nuclear transformation, fission, and energy conversion. Derivation of chain reaction design criteria, and calculation of flux-power distribution. Analysis of reactor safety, reliability and economics.

CHEMICAL ENGINEERING CHE
College of Engineering

300. Material and Energy Balances
Fall, Winter, Spring. 4(3-2) One year general chemistry, MTH 214 or concurrently, CPS 112 or concurrently. Chemical engineering calculations. Synthesis of chemical process systems. Analysis of chemical process systems by material and energy balances. Behavior of gases. Enthalpy calculations for changes of temperature, phase changes, chemical reactions.

311. Thermodynamics for Chemical Engineering
Winter, Spring. 3(3-0) CHE 300 or concurrent or approval of department.
First and second laws. Energy, enthalpy, entropy, free energy, the mathematics of property relationships. Energy conversion processes. Thermodynamics of flow.

340. Transfer Processes and Separations I
Fall. 3(2-2) CHE 300 or concurrently. CHE 381 or concurrently or approval of department. Thermodynamics of fluid flow. Treatment of fluid flow as a momentum transfer process. Laminar and turbulent motion of compressible and incompressible fluids. Design of flow systems.

341. Transfer Processes and Separations II

342. Transfer Processes and Separations III

463. Advanced Chemical Engineering Calculations I
Fall. 3(3-0) CHE 381. Chemical engineering applications of advanced mathematical methods. Formulation and solution of mathematical equations which describe physical problems. Computer solutions.

480. Thermodynamics and Kinetics in Chemical Engineering
Spring. 3(3-0) CHE 342, CHE 381. Fundamental treatment of momentum, energy and mass transport. Use of partial differential equations and equations of change for chemical engineering applications. Analyses among the phenomena, dimensional analysis, and boundary layer theory.

801. Advanced Chemical Engineering Calculations I