826. Cellular Biophysics
Spring of odd-numbered years. 4(4-0)
Approval of department.
Basic cell structure and function at the molecular level. Emphasis will be on genetic and molecular controls of cellular systems.

834. Membranes: Natural and Artificial
Spring of odd-numbered years. 2 to 3 credits. May reenroll for a maximum of 3 credits. Approval of department.
Emphasis is placed on the biophysical and biochemical characterization of biological membranes and their theoretical and experimental models. Presentation and discussion by students and staff of recent advances in membrane research.

990. Biophysics Seminar
Fall, Winter, Spring, Summer. 1 credit. May reenroll for a maximum of 3 credits. Approval of department.

999. Doctoral Dissertation Research
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

BOTANY AND PLANT PATHOLOGY

College of Agriculture and Natural Resources
College of Natural Science

201. Plants, People and the Environment (N)
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
Winter. 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.

301. Introductory Plant Physiology
Fall, Spring. 4(2-4) CEM 131 or CEM 141; CEM 161; BOT 305 or B S 210 or LBC 141. Introductory organic chemistry recommended. General principles of plant physiology relating plant structure to function. Topics include cell physiology, water relations, effects of light and temperature, respiration, photosynthesis, mineral nutrition, and hormone action.

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

315. Introductory Plant Systematics
Spring. 4(2-3) BOT 302 or B S 212 or approval of department.
Plant diversity with emphasis on identification, classification, nomenclature, and evolutionary relationships of vascular plants.

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 they found, identified and reconstructed; their use in determining ancient geographic patterns, paleoenvironments, paleosclines, and community structure. Field trip.

336. Economic Plants
Spring. 3(3-0)
Histories, characteristics, and origins of plants used in industrial processes, drug manufacture, and agriculture. Nontechnical to broaden student’s cultural interest in plants.
400. Aquatic Plants
Fall, 3(2-3) BOT 318 or BOT 320. Students may not receive credit in both BOT 400 and BOT 423.
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(0-6) Approval of department; Seniors.

401. Special Problems
Fall, Winter, Spring. Summer 1 to 4 credits. May reenroll for a maximum of 16 credits. BOT 305, Seniors, approval of department. Students with special ability may carry on laboratory research or study of published literature on a selected topic.

402. Introductory Mycology
Fall, 4(2-4) B 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.

405. Introductory Plant Pathology
Fall, 4(2-4) BOT 302 or B 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, Spring. 4(2-6) 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 mycoses.

407. Diseases of Forest and Shade Trees
Spring. 4(3-2) BOT 301; BOT 302; 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.

408. Freshwater Ecology
Summer. 6 credits. B S 212 or approval of department. Given at W. K. Kellogg Biological Station. Interdepartmental with Biological Science and the Department of Zoology. Administered by Biological Science.
The ecology of freshwater ecosystems, their biotic structure, and the functional interrelationships of environmental variables regulating population dynamics, productivity and community structure. Extensive field investigations.

409. Plant Disease Control
(883.) 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.

410. Terrestrial Ecology
Summer. 6 credits. B S 212 or approval of department. Given at W. K. Kellogg Biological Station. Interdepartmental with Biological Science and the Department of Zoology and administered by Biological Science. Extensive field investigations of several types of terrestrial communities. Interrelationship of plants, animals, and environment. Factors determining distribution and abundance.

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

412. Environmental Plant Physiology
Fall, 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.

413. Plant Physiology: Metabolism
Winter. Summer of odd-numbered years. 5(3-4) CET 411; 210 or LBS 141 or BOT 205; BOT 301 or BOT 413. General principles underlying plant metabolic processes. Nutrient requirements, photosynthesis, respiration, metabolic relationships, and structures associated with these processes.

414. 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 chemical and effects of hormones, tropisms, thermoperiodicity, reproduction, verticalization, and photophosphorus, dormancy, and biological clocks.

415. Field Studies of Freshwater Algae
Algae. Summer. 3 credits. Students may not receive credit in both BOT 423 and BOT 400. One year of botany or zoology or approval of department. Given at W. K. Kellogg Biological Station.

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

425. Field Plant Systematics
Summer. 6 credits. Students may not receive credit in both BOT 425 and BOT 411. One year of botany or approval of department. Given at W. K. Kellogg Biological Station. Classification, evolution, distribution and biology of vascular plants. Emphasis on field recognition, identification, collection, and research techniques. Numerous field trips to diverse habitats for common, rare, native, and introduced plants; research projects.

427. Cell Biology
Winter. Summer of odd-numbered years. 4(4) BCH 390 and one year of general botany or zoology.
Cell organization and distribution of standard inclusions. Structure and function of the nucleus and other cytoplasmic organelles.

431. Methods in Cytology-Histology
Winter. 4(2-6) BOT 302. Preparation of plant materials for microscopic analysis. Emphasis on theory and use of optical microscopy (bright-field, phase contrast, fluorescence, cytology microscopy, autoradiography, etc.) and electron microscopy (TEM and SEM).

434. Plant Anatomy
Fall. Summer of even-numbered years. 4(2-4) BOT 302. Principles underlying the differentiation and growth of vegetative plant structures with special emphasis upon their functional and developmental genetic relationships.

441. Geographical Plant Ecology
Winter. 3(4-0) BOT 205 or BOT 302 or B S 212 or approval of department. Distribution and ecology of plants and plant communities in Polar, temperate and tropical regions with emphasis on North America. Geographical history and environmental factors which influence distribution. Island biogeography.

447. Fresh Water Algae
Spring. 4(2-4) One year botany or zoology. Primarily for students in Fisheries Biology, Wildlife Management and Sanitary Engineering. Students may not receive credit in both BOT 421 and BOT 447.
Identification of fresh water algae, especially those forms concerned with fish food problems, water pollution and limnology. Methods for making samples of biological survey work on lakes and streams. Economic aspects and life histories of the algae.

450. Ecology
Spring. 4(2-4) BOT 318; BOT 301 or BOT 414.
Interrelationship of plants and environment. Factors which govern their distribution.

470. Nematode Diseases of Economic Plants
Winter. 4(3-3) B S 212 or BOT 205. Interdepartmental with and administered by the Department of Entomology.
Major nematode diseases of economically important plants, with emphasis on diagnostic symptoms, nematology biology and principles of control.

490. Special Topics in Plant Pathology
Fall, Winter, Spring. 2 to 5 credits. May reenroll 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, phytochemistry, nematology, epidemiology, physiology, soil microbiology, and others.

491. Selected Topics in Botany
Fall, Winter, Spring. 2 to 5 credits. May reenroll for a maximum of 6 credits if different topics are taken. Approval of department.
Topics may be selected from ecology, systematics, evolution, physiology, cytology, mycology, botany, phycology, lichenology, anatomy, morphology, genetics, and others.
Descriptions - Botany and Plant Pathology

Courses

499. Senior Seminar
Winter. 1(1-0) May reenroll for a maximum of 3 credits. B.S. 312 and 1 course in botany or approval of department. Report by students, faculty, and guest lecturers, with emphasis on current developments in research.

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

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

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

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

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

505. Special Problems in Cytology and Genetics
Fall, Winter, Spring, Summer. 1 to 15 credits. Approval of department.

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

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

512. Principles of Plant Disease Epidemiology
Winter of even-numbered years. 3(4-0)
BOT 402, BOT 405; or approval of department. Quantitative analysis of disease incidence, host, and environmental interactions at the individual and population level. Synthesis of these interactions into a quantitative description of the disease process.

513. Special Problems
Fall, Winter, Spring. 1 to 4 credits. May reenroll for a maximum of 16 credits. Approval of department.

516. 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.

520. Ecology of Hydrophytes
Summer of every third year; given in 1977. 3 credits. BOT 400 and BOT 447 or approval of department. Grown at W. K. Kellogg Biological Station. Physiological and ecological relationships of periphyton, macroalgae, and vascular aquatic plants; field and laboratory methods of analysis of growth factors.

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, distribution, and evolutionary trends are stressed. Contributions from classical taxonomy, cytotaxonomy and experimental taxonomy are discussed.

524. 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.

525. Tropical Biology: An Ecological Approach
Winter, Summer. 12 credits. Approval of department and acceptance by Organization for Tropical Studies. Interdepartmental with the Department of Zoology. An introduction in the field to the principles of ecology as they operate in the tropics, especially concerning the tropical environment and biota. Ecological studies, communities and evolution in the tropics. Given in Costa Rica by Organization for Tropical Studies.

528. Cytogenetics
Fall, 4(2-4) BOT 427 or ZOL 441 or approval of department. Detailed discussion of mitosis and meiosis; mechanisms of chromosome movement; fine structure of chromosomes and spindle apparatus; changes in chromosome number and structure and their genetic significance.

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

531. Palynology
Spring. 4(3-4) Approval of department. Interdepartmental with and administered by the Department of Geology. An introduction to the principles and techniques of spore and pollen analysis, both fossil and recent, and utilization of plant micro-fossils for stratigraphic determinations and paleoecologic interpretations of most sediments, rocks. Includes certain algae, protozoa and similar organisms of uncertain affinities.

532. Morphogenesis of Reproductive Structures
Spring of even-numbered years. 4(2-4)
BOT 434. Principles underlying the differentiation and growth of reproductive plant structures with special emphasis upon their functional and developmental genetic relationships.

536. Advanced Mycology: Biology of the Phycomycetes
Spring of even-numbered years. 3(3-4)
BOT 402 and approval of department. Selected topics on the biology of phycomyceteous fungi.

537. Advanced Mycology: Ascomycetes
Fall of even-numbered years. 4(2-6)
BOT 402. Morphological features and adaptations of the major groups of ascomycetous fungi and the imperfect fungi. Evolutionary trends and relationships with reference to recent classification schemes.

538. Advanced Paleobotany
Winter. 3(2-4) Approval of department. Interdepartmental with the Department of 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.

541. Physiology of the Algae
Fall of even-numbered years. 3(3-0) Approval of department. Physiology, biochemistry, and aspects of the ultra-structure of the various algal divisions. Description of use of algae for the study of classical physiological and developmental problems.

546. Seminar in Plant Pathology
Fall, Winter, Spring. 1(1-0) Approval of department.

550. Agrostology
Fall of even-numbered years. 3(1-4)
One year of botany or approval of department. Comprehensive treatment of the systematic, evolution, ecology, geography and economic significance of the grass family; including pertinent aspects of genetics, cytology, anatomy and physiology.

555. Effects of Ionizing Radiations on Plants
Spring of odd-numbered years. 3(3-0) Approval of department. Nature of ionizing radiations related to their effects upon plant growth and development including aspects of radiation sensitivity; dosimetry, direct and indirect effects, genetic, evolution and environmental implications related to modes of action at the cell, organism, and population levels.

863. Advanced Environmental Physiology
Winter. 3(3-0) BOT 413 or approval of department. The plant in relation to its environment: energy exchange, coupling between CO2 assimilation and transpiration; hydraulics in the stationary and nonstationary states; transport of ions, carbohydrates, and hormones; stress physiology.
864. Plant Biochemistry
Spring. 4(4-0) BCH 401, BOT 301 or approval of department. Interdepartmental with and administered by the Department of Biochemistry.
Metabolism of nitrogen-compounds, carbohydrates, and lipids unique to plants; cell organelles; photosynthesis; transpiration; dark respiration; cell walls; lectins; nitrogen cycle including nitrogen fixation; sulfur cycle.

865. Advanced Growth and Development
Fall. 3(3-0) BOT 415 or approval of department.
Advanced treatment of the physiological processes of growth and development. The mechanism underlying these processes and the rules by which they are controlled, will be analyzed.

871. Biology of Nematodes
Spring, 4-2(0) ENG 470 or approval of department. Interdepartmental with and administered by the Department of Entomology.
Ontogeny, taxonomy, morphology, pathology and ecology of nematodes, with special reference to plant-parasitic and phytopathogenic species.

875. Comparative Limnology
(478.) Summer of odd-numbered years. 6 credits. Approval of department. 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.

880. Plant Virology
Fall of odd-numbered years. 3(2-6) BOT 405 or approval of department.
External and internal symptomatology, transmission, interactions, purifications, assay and serology of plant viruses.

881. Pathogenesis and Disease Resistance
Winter of odd-numbered years. 4(3-2) BOT 405 and BOT 415, or approval of department.
Lectures, readings, and discussions on mechanisms of pathogenicity and infectivity; physiology and biochemistry of disease development; tumorigenesis: metabolic consequences of infection; nature of disease resistance; and parasitism.

882. Genetics of Host/Parasite Interactions
Winter of even-numbered years. 3(3-0) ZOL 441, BOT 405.
Inheritance of resistance and susceptibility, virulence and avirulence, types of resistance, aggressiveness in parasites; use of genetics in studies of host/parasite interactions, practical application in disease control.

885. Plant Diseases in the Field
Spring. 4 credits. BOT 405 and approval of department.
Diagnosis, distribution, and sequential development of plant diseases in the field. Field trips permit observation of diseases in the natural setting.

890. Selected Topics in Plant Pathology
Fall, Winter, Spring. 2 to 5 credits. Approval of department.
Topics will be selected from the following areas: parasitism, plant viruses, ecology, genetics, nematology, fungicidal action, and soil microbiology.

891. Selected Topics in Botany
Fall, Winter, Spring. 2 to 5 credits. May receive for a maximum of 6 credits if different topics are taken. Approval of department.
Topics may be selected from ecology, systematics, evolution, physiology, cytology, mycology, bryology, physiology, lichenology, anatomy, morphology, genetics, and others.

899. Master's Thesis Research
Fall, Winter, Spring, Summer. Variable credit. Approval of department.
Research in anatomy, bryology, cytology, ecologv, genetics, lichenology, morphology, mycology, paleobotany, pathology, physiology, taxonomy, and taxonomy.

918. Advanced Genetics
Winter of odd-numbered years. 3(3-0)
Approval of department.
Role of the gene in differentiation and development, with special emphasis on the genetic mechanisms responsible for the control of phenogencis.

920. Advanced Plant Taxonomy
Spring of even-numbered years. 4(0)
BOT 524, ZOL 441.
Consideration of the recent scientific developments affecting plant classification.

930. Advanced Advanced Plant Ecology
Winter of odd-numbered years; Summer of even-numbered years. Given at W. K. Kellogg Biological Station summer term. 4(3-0) or approval of department.
Fundamental theories and modern research horizons.

999. Doctoral Dissertation Research
Fall, Winter, Spring, Summer. Variable credit. Approval of department.
Research in anatomy, bryology, cytology, ecology, genetics, lichenology, morphology, mycology, paleobotany, pathology, physiology, psychology, and taxonomy.

BUILDING CONSTRUCTION
See Agricultural Engineering.

CHEMICAL ENGINEERING CHE

College of Engineering

300. Material and Energy Balances
Fall, Winter. 4(3-2) One year general chemistry, MTH 214 or concurrently, CPS 129 or concurrently.

305. Transfer Processes and Separations I
Fall. 4(3-3) MTH 215, CHE 300 or concurrently.
Thermodynamics of fluid flow. Treatment of fluid flow as a momentum transfer process. Laminar and turbulent motion of compressible and incompressible fluids. Heat transfer in solids and flowing fluids.

306. Transfer Processes and Separations II
Winter. 4(3-2) CHE 305.

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

351. Chemical Engineering Analysis
Fall, Spring. 3(2-0) Students may not receive credit in both CHE 381 and MTH 341. MTH 310. Interdepartmental with the Department of Mathematics.
Formation of ordinary and partial differential equations describing chemical systems. Boundary value problems, numerical methods, matrices, and applications, to chemical engineering systems.

411. Phase and Chemical Equilibria
Winter. 3(3-0) CEM 361, CHE 311 or concurrently.

423. Chemical Engineering Laboratory
Fall, Summer. 3(1-6) CHE 307.
Assigned laboratory problems, requiring teamwork. 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
Winter, Spring. 3(1-6) CHE 306.
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. 3(3-0) CEM 361, CHE 306
CHE 311.

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