620. Directed Studies  
Fall, Winter, Spring. 1 to 6 credits. May reenroll for a maximum of 24 credits. Approval of department. Individual or group work on special problems related to biomechanics, neuromusculoskeletal system primarily.

800. Special Topics  
Fall, Winter, Spring. Summer. 1 to 4 credits. May reenroll for a maximum of 9 credits. Approval of department. Independent study in topics of biomechanics.

810. Biokinematics  
Fall. 3(3-0) Approval of department. Motion of the human body including detailed studies of body joint and linkage motion.

811. Biokinetica  
Winter. 3(3-0) BIM 810. Application of Newtonian mechanics to problems of force transmission and related motions in the muscular-skeletal system.

812. Theory of Tissue Mechanics  
Spring. 3(3-0) Approval of department. Introduces the concepts of stress and strain in tissue and the dependency of mechanical parameters on biological factors.

850. Research Seminar  
Fall, Winter, Spring. 1(1-0) May reenroll for a maximum of 3 credits. Approval of department. Discussion of current research topics in biomechanics with strong clinical application.

890. Independent Study  
Fall, Winter, Spring, Summer. 1 to 8 credits. May reenroll for a maximum of 32 credits. Approval of department. Individual or group work related to biomechanics and/or neuromusculoskeletal system.

899. Master’s Thesis Research  
Fall, Winter, Spring, Summer. Variable credit. May reenroll for a maximum of 12 credits. Approval of department. Conduct research for master’s thesis.

411. Electric Theory of Nerves  

414. Clinical Instrumentation  

424. Materials in Biomedical Engineering  
Winter. 3(3-0) PSL 240 or PSL 431 or approval of department. Basics of materials science. Biocompatibility of metals, polymers and ceramics. Internal and external prosthetic materials.

431. Biological Transport Mechanisms  
Spring. 3(3-0) MTH 315. Mechanisms which govern transport or movement, heat and mass. Application to mathematical description of transport processes in biological systems and to solution of biomedical problems.

481. Tissue Biomechanics  
Fall. 3(0-0) ANT 316 or approval of department. Fundamentals of continuum mechanics in relation to morphological classification of tissue. Mechanical properties of connective and muscle tissue.

499. Independent Study  
Fall, Winter, Spring, Summer. 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.

BIOPHYSICS  
BPY  

College of Human Medicine  
College of Natural Science  

899. Master’s Thesis Research  
Fall, Winter, Spring, Summer. Variable credit. Approval of department. Approved through Summer 1985.

990. Biophysics Seminar  
Fall, Winter, Spring, Summer. 1 credit. May reenroll for a maximum of 3 credits. Approval of department. Approved through Summer 1985.

999. Doctoral Dissertation Research  
Fall, Winter, Spring, Summer. Variable credit. Approval of department. Approved through Summer 1985.

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.

301. Introductory Plant Physiology  
Winter, Spring, 4(2-4) CEM 141 or CEM 151; CEM 161; BOT 203 or BOT 210 or LBS 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 development.

318. 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 Paleoecology  
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  
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(3-0) BOT 318 or BOT 392. 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.
Descriptions — Botany and Plant Pathology

Courses

440H. Honors Work
Fall, Winter, Spring. 3(0-0) Approval of department; Seniors.

441. Special Problems
Fall, Winter, Summer. 1 to 4 credits. May reenroll for a maximum of 16 credits. BOT 302, Seniors, approval of department. Students with special ability may carry on laboratory research or study of published literature on a selected topic.

442. Introductory Mycology
Fall, 4(2-6) 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.

443. Introductory Plant Pathology
Fall, 4(2-4) BOT 302 or B S 212 or approval of department. General principles of plant pathology including detailed study of selected diseases as examples of important groups.

444. 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 fungal diseases infecting humans. Emphasis on laboratory techniques and morphological characteristics of the various mycota.

445. Diseases of Forest and Shade Trees
Spring, 4(2-2) BOT 201 or 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.

446. 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.

447. Field Studies of Freshwater Algae
Summer. 3 credits. Students may not receive credit in both BOT 421 and BOT 447. One year of botany or zoology or approval of department. Given at W. K. Kellogg Biological Station.

448. Introduction to Aquatic and Wetland Plants
Summer. 3 credits. Students may not receive credit in both BOT 421 and BOT 447. Approval of department. Given at W. K. Kellogg Biological Station.

449. 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.

450. Cell Biology
Fall. 4(0-4) BCH 200 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.

451. Systematic Botany
Summer. 4(3-0) 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.

452. 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.

453. 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 requirements, photosynthesis, translocation, respiration, nitrogen metabolism, and structures associated with these processes.

454. 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.

455. Botany
Fall, Winter, Spring, Summer. 1 to 15 credits. May reenroll for a maximum of 6 credits if necessary. Topics may be selected from ecology, genetics, systematics, taxonomy, evolution, phytosociology, wildlife management, and others.

456. 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, parasitology, virology, disease control, phytobacteriology, nematology, epidemiology, physiology, soil microbiology, and others.

457. 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, bryology, phycology, lichenology, anatomy, morphology, genetics, and others.

458. Special Problems in Botany
Fall, Winter, Spring. 1 to 15 credits. Approval of department.

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

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

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

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

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

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

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

812. Principles of Plant Disease Epidemiology
Winter of even-numbered years. 3(4-0) BOT 402, BOT 465; or approval of department. Quantitative and qualitative analysis of pathogen, host, and environmental interactions at the individual and population level. Synthesis of these interactions into a quantitative description of the disease process.

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

816. Industrial Mycology
Fall of odd-numbered years. 2(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 490, 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.

823. 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 828 Second course of a series on classification and relationships of vascular plants.

825. 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, ecologic relations, communities and evolution in the tropics. Given in Costa Rica by Organization for Tropical Studies.

828. Cytogenetics
Winter of even-numbered years. 4(2-4) BOT 427 or ZOL 441 or approval of department. Detailed discussions of mitosis and meiosis; mechanisms of chromosome movement; fine structure of chromosomes and spindle apparatus; changes of chromosome number and structure and their genetic significance.

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

831. Plant Pathology
Spring. 4(3-4) Approval of department. Interdepartmental with and administered by the Department of Agriculture. 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 paleoecological interpretations of crust sedimentary accumulations and rocks. Includes certain algae, protozoans, similar organisms of marine affinity and associated fragments of larger organisms.

833. 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.

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

837. 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.

838. 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, transverse, printed and etched surfaces, and maceration.

839. Population Ecology
Summer of even-numbered years. 3 credits. May reenroll for a maximum of 6 credits. Approval of department. Geen at W. K. Kellogg Biological Station. Interdepartmental with and administered by the Department of Zoology. A field-experimental approach to the study of adaptations. Selected topics will deal with population growth, competition, predation, mutation, community structure and species abundance.

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

843. Plant Organelle Genetics
Winter of odd-numbered years. 3(0-0) Approval of department. Interdepartmental with Genetics and the departments of Crop and Soil Sciences, Forestry, and Horticulture. Administered by the Department of Horticulture. Organization, structure, function, heredity, molecular biology and manipulation of chloroplasts and mitochondria. Biological interactions between the nucleus and organelles.

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

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

Fall of odd-numbered years. 4(4-0) BOT 450 or ZOL 389, STT 422, 1 term of calculus. The dynamics, evolution, regulation, and distribution of plant populations; subject matter interfaces with plant genetics, plant systematics, and plant physiology.

856. Plant Genetics and Molecular Biology
Spring of even-numbered years. 3(3-0) Approval of department and a course in introductory genetics. Interdepartmental with Genetics and the Department of Biochemistry. Recent advances in genetics and molecular biology of higher plants.

858. 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, photorespiration, dark respiration; cell walls; lectins; nitrogen cycle including nitrogen fixation; sulfur cycle.
85. **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 mechanisms underlying these processes and the roles played by hormones, light, etc., in controlling them will be analyzed.

871. **Biology of Nematodes**
Spring. 4(2-6) ENT 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.

878. **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. 5(3-6)
 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 3 credits. Approval of department.
Topics will be selected from the following areas: parasitism, plant viruses, ecology, genetics, nematology, fungal action, and soil microbiology.

891. **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, bryology, phycology, ichthyology, anatomy, morphology, genetics, and others.

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

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

930. **Advanced Plant Ecology**
Winter of odd-numbered years; Summer of even-numbered years. Given at W. K. Kellogg Biological Station summer term. 3(2-4) 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, phycology, physiology, and taxonomy.

### BUILDING CONSTRUCTION MANAGEMENT

See Agricultural Engineering.

### CHEMICAL ENGINEERING CHE

#### College of Engineering

300. **Material and Energy Balances**
Fall, Winter. 4(5-2) One year general chemistry, MTH 214 or concurrently, CPS 130 or concurrently.

311. **Thermodynamics for Chemical Engineering**
Spring, Winter. 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.

340. **Transfer Processes and Separations I**
Fall. 3(2-2) 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. Design of flow systems.

341. **Transfer Processes and Separations II**
Winter. 3(2-2) CHE 340.

342. **Transfer Processes and Separations III**
Winter. 3(2-2) CHE 340.

343. **Transfer Processes and Separations IV**
Spring. 3(2-2) CHE 341, CHE 342.

### Chemical Engineering Analysis

381. **Chemical Engineering Analysis**
Fall, Spring. 3(3-0) Students may not receive credit in both CHE 381 and MTH 341. MTH 310. Interdepartmental with the Department of Mathematics.
Formulation 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(1-8) CHE 307.
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**
Winter, Spring. 3(1-4) CHE 306.
Experiments involving the transport processes and measurement of physical, chemical and thermodynamic properties of various materials. Comparison of theoretical and experimental results.

425. **Chemical Reaction Engineering**
Fall. 4(4-0) CEM 361, CHE 311, CHE 342.

442. **Polymer Science and Engineering**
Spring. 3(3-0) One year organic chemistry. CEM 361.

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. Macroscopic structure influences on physical properties. Surface phenomena. Applications.