881 Subatomic Physics
Fall. 3(3-0) RB: (PHY 851)
Application of conservation laws and physical principles to basic quantum mechanical problems in MeV energy range and femtometer size range. Application to nuclear data.

891 Elementary Particle Physics
Spring. 3(3-0) RB: (PHY 853)
Nonabelian gauge theory, spontaneously broken gauge theory, electroweak interaction, QCD, W and Z boson coupling to quarks and leptons, charm, top and bottom quarks, particle generations.

899 Master's Thesis Research
Fall, Spring, Summer. 1 to 6 credits. A student may earn a maximum of 36 credits in all enrollments for this course. R: Open only to graduate students in Physics.
Master's thesis research.

901 Frontiers in Physics and Astronomy
Spring. 1(1-0)
Seminar and discussions in physics. Attendance at weekly colloquium.

902 Case Studies in Physics Applications
Fall, Spring, Summer. 1 to 3 credits. RB: (PHY 471 and PHY 481)
Assessment of an application of physics; written report and oral presentation required. Projects from industry and government agencies; optional internship.

905 Special Problems
Fall, Spring. 1 to 4 credits. A student may earn a maximum of 9 credits in all enrollments for this course. R: Open only to graduate students in the Department of Physics and Astronomy.
In-depth study of a topic in physics or in astrophysics and astronomy.

961 Non-Linear Beam Dynamics
Fall, Spring. 3(3-0) A student may earn a maximum of 6 credits in all enrollments for this course. RB: (PHY 861)
Dynamics of particle beams.

962 Particle Accelerators
Fall, Spring, Summer. 3(3-0) A student may earn a maximum of 6 credits in all enrollments for this course. RB: (PHY 861)
Theory of particle accelerator design.

963 U.S. Particle Accelerator School
Fall, Spring. 3(3-0) A student may earn a maximum of 12 credits in all enrollments for this course. RB: (PHY 861) SA: PHY 962C
Participation in suitable courses offered by the U.S. Particle Accelerator School.

964 Seminar in Beam Physics Research
Fall, Spring. 3(3-0) A student may earn a maximum of 12 credits in all enrollments for this course. RB: (PHY 861) SA: PHY 962D
Presentation of current research topics in beam physics or accelerator design.

971 Atomic and Electronic Structure of Matter
Spring. 3(3-0) RB: (PHY 491 and PHY 852 and PHY 841 and PHY 831) SA: PHY 871
Atomic structure, bravais lattices, x-ray scattering. Vibrations, phonons, neutron scattering. Electron in solids, electron gas. Bloch's theorem. Metals, semiconductors and insulators. Introduction to cooperative phenomena.

972 Transport and Dynamics in Bulk and Mesoscopic Systems
Fall. 3(3-0) RB: (PHY 971 and PHY 831 and PHY 841 and PHY 852)
Transport theory. Weak and strong localization. Quantum effects in small structures. Quantum hall effects and Wigner crystal. Superconductivity and other cooperative phenomena.

973 Special Topics in Condensed Matter Physics
Fall, Spring. 3(3-0) A student may earn a maximum of 12 credits in all enrollments for this course. RB: (PHY 971 and PHY 972)
Topics vary and may include quantum optics, scattering methods and Green's functions.

980 Advanced Reading in Physics
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 4 credits in all enrollments for this course. R: Approval of department.

981 Nuclear Structure
Fall, Spring. 3(3-0) RB: (PHY 492 and PHY 831 and PHY 841 and PHY 852)
Nuclear forces, nuclear matter, nuclear-structure models, few-nucleon systems, electromagnetic and weak transitions.

982 Nuclear Dynamics
Spring. 3(3-0) RB: (PHY 492 and PHY 831 and PHY 841 and PHY 852)
Scattering theory, resonance reactions, compound nuclear decay and fission, direct and breakup reactions, time-dependent Hartree-Fock, Vlasov equation, nuclear transport equations, particle production, nuclear liquid-gas phase transition, quark-gluon plasma.

983 Nuclear Astrophysics
Fall, Spring. 3(3-0) RB: (PHY 410 and PHY 472 and PHY 482)
Low energy reaction theory, survey of astrophysics, physics of nuclei and reaction relevant to astrophysics, nuclear reaction rates in stellar environments, stellar evolution, solar neutrinos, big bang nucleosynthesis, dark matter, supernova explosions, r-process, hot CNO and rp-process, cosmochronology

992 Quantum Chromodynamics
Fall. 3(3-0) A student may earn a maximum of 6 credits in all enrollments for this course. RB: (PHY 854)
Hadron-hadron interactions, interaction of hadrons with leptons.

999 Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 120 credits in all enrollments for this course. R: Open only to graduate students in Physics.
Doctoral dissertation research.

PHYSIOLOGY PSL

Department of Physiology
College of Natural Science

101 Current Issues in Physiology
Fall. 2(2-0) Not open to students with credit in PSL 250 or PSL 431 or PSL 432.
Physiological bases of health issues of broad social significance, and new approaches for the treatment of specific disorders.

250 Introductory Physiology
Fall, Spring. 4(4-0) R: Not open to students in Physiology.
Function, regulation and integration of organs and organ systems of higher animals emphasizing human physiology.

323 Physiology and Hygiene of the Eye
Fall of odd years. Summer of even years. 3(3-0) R: Not open to Physiology majors.
Basic anatomy, physiology, and hygiene of the visual system: normal and abnormal visual function, methods of correction, and educational implications.

331 Cell Physiology: Function of Specialized Cells
Fall. 3(3-0) P: (BS 111 or LBS 145)
Functions of differentiated cells, including mechanisms of cell communication, excitable membranes, contraction, motility, transport, secretion, and extra cellular matrix.

410 Computational Problem Solving in Physiology
Fall, Spring. 3(3-0) RB: (PSL 432) R: Approval of department.
Quantitative analysis of physiological data: mathematical models, curve fitting, data analysis and interpretation. Problem solving involving exponential and logistic growth. Cerebral blood flow, convective cooling, oxygen consumption, thermoregulation, other applications.

420 Membrane Biophysics: An Introduction
Fall, Spring. 2(2-0) RB: One year of college physics or chemistry, and one year of college mathematics.
Biophysical and chemical aspects of biomembranes. Experimental model membrane systems including planar lipid bilayers and liposomes. Biotechnological applications of lipid bilayer sensors.

431 Human Physiology I
Fall. 3(3-0) RB: (BS 111 and CEM 142)
Neural function including autonomic nervous system, physiological control systems, endocrinology, reproduction and digestive function.

432 Human Physiology II
Spring. 3(3-0) RB: (PSL 431)
Continuation of PSL 431. Function and regulation of the cardiovascular, respiratory, and renal systems. Control of tissue blood flow, blood pressure, blood gases, body fluid volume and electrolytes.

440 Topics in Cell Physiology
Fall, Spring. 2(2-0) RB: (PSL 432) R: Open only to Physiology majors. Completion of Tier I writing requirement.
Critical discussion and evaluation of a selected problem of mammalian cell physiology including cell biophysics, molecular biology of the cell.

441 Topics in Endocrinology
Fall, Spring. 2(2-0) RB: (PSL 432) R: Open only to Physiology majors. Completion of Tier I writing requirement.
Selected topic on the role of hormones in the regulation of growth, metabolism, differentiation.

442 Topics in Cardiovascular Physiology
Fall. 2(2-0) RB: (PSL 432) R: Open only to Physiology majors. Completion of Tier I writing requirement.
Selected topic in blood flow physiology.

443 Topics in Respiratory Physiology
Fall of odd years. 2(2-0) RB: (PSL 432) R: Open only to Physiology majors. Completion of Tier I writing requirement.
Selected topic in the physiology of gas exchange and lung mechanics.

445 Topics in Environmental Physiology
Spring of odd years. 2(2-0) RB: (PSL 432) R: Open only to Physiology majors. Completion of Tier I writing requirement.
Selected topic in environmental physiology with an emphasis on thermoregulation.

446 Topics in Visual Physiology
Fall of even years. 2(2-0) RB: (PSL 432) R: Open only to Physiology majors. Completion of Tier I writing requirement.
Selected topic in the functioning of the visual system in health and disease.

447 Topics of Brain Function
Fall. 2(2-0) RB: (PSL 432) R: Open only to Physiology majors. Completion of Tier I writing requirement.
Selected topic on the functioning of the mammalian brain.

448 Topics in Gastrointestinal Physiology
Fall. 2(2-0) RB: (PSL 432) R: Open only to Physiology majors. Completion of Tier I writing requirement.
Selected topic in the physiology of the digestive system.

449 Developmental Neurophysiology
Fall. 2(2-0) RB: (PSL 432) R: Open only to Physiology majors. Completion of Tier I writing requirement.
Development of the nervous system in invertebrate and vertebrate animals.

473 Environmental Fish Physiology
Spring of odd years. 3(3-0) Interdepartmental with Fisheries and Wildlife. Administered by Department of Fisheries and Wildlife. P: (BS 111 or LBS 145 or LBS 149H) R: Not open to freshmen or sophomores.
Physiological adaptations of fish to environmental factors; bioenergetics, homeostasis, senses adaptations to diverse and extreme aquatic environments.

475 Capstone Laboratory in Physiology
Spring. 2(1-3) RB: (PSL 432) R: Open only to Physiology majors.
Laboratory exercises in animal physiology including osmoregulation, receptor mediated regulation, nervous and hormonal control of function.

480 Special Problems
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 5 credits in all enrollments for this course. RB: (PSL 432) R: Open only to Physiology majors.
Independent study under the auspices of a faculty member.

483 Environmental Physiology
Spring. 4(4-0) Interdepartmental with Zoology. Administered by Department of Zoology. P: (BS 110 or LBS 144 or LBS 148H) and (BS 111 or LBS 145 or LBS 149H) and (CEM 141 or CEM 151 or CEM 181H or LBS 171) and completion of Tier I writing requirement.
Aspects of physiology important to the environmental relations of vertebrates and invertebrates: energetics, thermal relations, osmotic-ionic relations, and exercise physiology.

501 Introductory Medical Physiology
Fall. 3(3-0) R: Graduate-professional students in colleges of Human and Osteopathic Medicine.
Physiological basis of medical practice.

511 Veterinary Physiology
Spring. 5(5-0) R: Completion of Semester 1 of the graduate professional program in the College of Veterinary Medicine.
Physiology of the nervous, cardiovascular, renal, respiratory, digestive, endocrine, and reproductive systems. Homeostasis.

534 Cell Biology and Physiology I
Fall. 3 credits. Interdepartmental with Human Anatomy; Biochemistry and Molecular Biology. R: Open only to graduate-professional students in the College of Human Medicine or College of Osteopathic Medicine.
Modern concepts of cell biology as a basis for understanding the physiology of human tissues and organ systems in health and disease.

535 Cell Biology and Physiology II
Spring. 4 credits. Interdepartmental with Human Anatomy; Biochemistry and Molecular Biology. R: Open only to graduate-professional students in the College of Human Medicine or the College of Osteopathic Medicine.
Modern concepts of cell biology as a basis for understanding the physiology of human tissues and organ systems in health and disease. Continuation of PSL 534.

552 Medical Neuroscience
Spring. 4(3-2) Interdepartmental with Neurology and Ophthalmology; Radiology; Human Anatomy. Administered by Department of Neurology and Ophthalmology. R: Graduate-professional students in the Colleges of Human Medicine and Osteopathic Medicine. SA: ANT 552
Correlation of normal structure and function of the human nervous system with clinical testing, classical lesions, and common diseases.

611 Research Problems in Physiology Clerkship
Fall, Spring, Summer. 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. RB: (PSL 511) Completion of Semester 5 in the graduate professional program in the College of Veterinary Medicine.
Individual work on a research problem.

825 Cell Structure and Function
Spring. 3(3-0) Interdepartmental with Biochemistry and Molecular Biology; Microbiology and Molecular Genetics. Administered by Department of Biochemistry and Molecular Biology. RB: BMB 401 or BMB 461. SA: BCH 825
Molecular basis of structure and function. Cell properties: reproduction, dynamic organization, integration, programmed and integrative information transfer. Original investigations in all five kingdoms.

827 Physiology and Pharmacology of Excitable Cells
Fall. 4(4-0) Interdepartmental with Pharmacology and Toxicology; Zoology; Neuroscience. Administered by Department of Pharmacology and Toxicology. RB: (PSL 431 or PSL 432 or BMB 401 or BMB 461 or ZOL 402)
Function of neurons and muscle at the cellular level: membrane biophysics and potentials, synaptic transmission, sensory nervous system function.

828 Cellular and Integrative Physiology
Spring. 4(4-0) RB: (PSL 827)
Cellular physiology as basis for understanding integrative functions of various body systems, including nervous, cardiovascular, respiratory, urinary, gastrointestinal, endocrine, reproductive, and immune.

839 Systems Neuroscience
Spring. 4(4-0) Interdepartmental with Neuroscience; Human Anatomy; Pharmacology and Toxicology; Psychology; Zoology. Administered by Program in Neuroscience. R: Open only to graduate students in the Colleges of Human Medicine, Osteopathic Medicine, Agriculture and Natural Resources, Natural Science, Social Science, and Veterinary Medicine. SA: ANT 839
Anatomy, pharmacology, and physiology of multicellular neural systems. Sensory, motor, autonomic, and chemo-regulatory systems in vertebrate brains.

841 Advanced Endocrine Physiology and Pharmacology
Fall. 4(4-0) Interdepartmental with Animal Science; Pharmacology and Toxicology; Psychology. RB: (BMB 461 and PSL 432) R: Open only to graduate students in the Colleges of Human Medicine, Osteopathic Medicine, Veterinary Medicine, Natural Science, and Agriculture and Natural Resources. SA: ANS 841, PHM 841, PSY 841
Basic and advanced concepts of endocrine and reproductive physiology and pharmacology.

850 Research Topics in Physiology
Spring. 1(0-2) RB: (PSL 432 and PSL 910) R: Open only to graduate students in Physiology.
Readings, presentations and discussions of selected research literature in physiology.

885 Vertebrate Neural Systems
Spring of odd years. 3(2-2) Interdepartmental with Neuroscience; Human Anatomy. Administered by Program in Neuroscience. SA: ANT 885
Comparative analysis of major component systems of vertebrate brains. Evolution, ontogeny, structure, and function in fish, amphibians, reptiles, birds and mammals.

899 Master's Thesis Research
Fall, Spring, Summer. 1 to 6 credits. A student may earn a maximum of 36 credits in all enrollments for this course.
Master's thesis research.

901 Investigating the Lung
Fall of even years. 2(2-0) Interdepartmental with Large Animal Clinical Sciences; Pathology. Administered by Department of Large Animal Clinical Sciences. R: Open only to graduate students.
Integrative biology of the lung; structure and function; molecular, cellular, and organ responses to injury.

910 Cellular and Molecular Physiology
Fall. 4(4-0) RB: BMB 802; PSL 432 or PSL 501 or PSL 511; one calculus course. R: Open only to graduate students in Physiology or Pharmacology and Toxicology.
Readings in cell physiology and physiological aspects of molecular biology.

950 Topics in Physiology
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 9 credits in all enrollments for this course. R: Approval of department.
Classical and modern concepts in selected areas of physiology.

980 Problems in Physiology
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.
Individual research problems in physiology.

999 Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 120 credits in all enrollments for this course.
Doctoral dissertation research.

PLANT BIOLOGY PLB

Department of Plant Biology
College of Natural Science

105 Plant Biology
Fall, Spring. 3(3-0) SA: BOT 105
Plant structure, function, development, genetics, diversity and ecology.

106 Plant Biology Laboratory
Fall, Spring. 1(0-3) P: (PLB 105 or concurrently) SA: BOT 106
Cell structure, anatomy, physiology, growth and development, and diversity of plants.

111L Cell and Molecular Biology Laboratory
Fall, Spring, Summer. 2(1-3) Interdepartmental with Biological Science; Microbiology and Molecular Genetics; Zoology. Administered by College of Natural Science. P: (BS111 or concurrently) Not open to students with credit in LBS 159H.
Principles and applications of common techniques used in cell and molecular biology.

202 The Plant Kingdom
Spring. 3(2-3) P: (BS 110 or BS 111 or PLB 105 or LBS 144 or LBS 148H or LBS 149H) SA: BOT 202
Morphology of the major plant groups with an emphasis on structure, reproduction and evolution. Field trips required.

203 Biology of Plants
Fall. 3(2-3) P: (BS 110 and BS 111) or (PLB 105)
Evolution and diversification of plants. Structural innovations and physiological attributes of vascular land plants.

218 Plants of Michigan
Fall. 3(2-3) P: (BS 110 or PLB 105 or LBS 144 or LBS 148H) SA: BOT 218
Plant taxa of Michigan and the Great Lakes region and the major habitats in which they occur. Principles and rationale of classification. Relationships between life histories, morphology and environment. Field trips required.

301 Introductory Plant Physiology
Fall, Spring. 3(2-3) P: (CEM 141 or CEM 151 or LBS 171 or CEM 181H) and (CEM 161 or LBS 171L) and (PLB 105 or BS 111 or LBS 145 or LBS 149H) and completion of Tier I writing requirement. SA: BOT 301
General principles of plant physiology relating plant structure to function. Cell physiology, water relations, effects of light and temperature, respiration, photosynthesis, mineral nutrition, and hormone action.

316 Experiments in Plant Biology
Spring. 4(2-5) P: (CEM 142 or concurrently and CEM 161 or concurrently and CEM 251 or concurrently) or (CEM 152 or concurrently and CEM 161 or concurrently and CEM 251 or concurrently) and (PLB 203) and completion of Tier I writing requirement.
Exploration of fundamental topics in plant biology using modern techniques for studies at the molecular and organismal level.

319 Introduction to Earth System Science
Fall. 3(3-0) Interdepartmental with Entomology; Geological Sciences; Zoology; Sociology. Administered by Department of Entomology. RB: Completion of one course in biological or physical science.
Systems approach to Earth as an integration of geochemical, geophysical, biological and social components. Global dynamics at a variety of spatiotemporal scales. Sustainability of the Earth system.

335 Plants Through Time
Spring of odd years. 3(3-0) Interdepartmental with Geological Sciences. P: (BS 110 or PLB 105 or GLG 201 or LBS 144 or LBS 148H) R: Open only to juniors or seniors. SA: BOT 335
Evolutionary history of plants, development of ecosystems, and use of plant fossils in the reconstruction of ancient environments and climate.

336 Useful Plants
Fall of odd years. 3(3-0) P: (CEM 142 or CEM 143 or CEM 152 or CEM 182H) and (PLB 105 or LBS 145) or (BS 110 and BS 111 and BS 111L) or (LBS 148H and LBS 149H) SA: BOT 336
Use of plants for myriad purposes from food and construction materials to medicines and perfumes. Potential for expanding the uses of plants through biotechnology.

341 Fundamental Genetics
Fall, Spring, Summer. 4(4-0) Interdepartmental with Zoology. Administered by Department of Zoology. P: (BS 111 or LBS 145 or LBS 149H)
Principles of heredity in animals, plants and microorganisms. Classical and molecular methods in the study of gene structure, transmission, expression and evolution.

355 Ecology
Fall, Spring, Summer. 3(3-0) Interdepartmental with Zoology. Administered by Department of Zoology. P: (BS 110 or LBS 144 or LBS 148H) SA: ZOL 250
Plant and animal ecology. Interrelationships of plants and animals with the environment. Principles of population, community, and ecosystem ecology. Application of ecological principles to global sustainability.

355L Ecology Laboratory
Fall, Spring, Summer. 1(0-3) Interdepartmental with Zoology. Administered by Department of Zoology. P: (ZOL 355 or concurrently or PLB 355 or concurrently) and completion of Tier I writing requirement.
Population, community, and ecosystem ecology, utilizing plant and animal examples to demonstrate general field principles.

402 Biology of Fungi
Fall. 3(2-3) Interdepartmental with Plant Pathology. P: (BS 110 or BS 111 or PLB 105 or LBS 145 or LBS 148H or LBS 149H) SA: BOT 402
Major groups of fungi: characteristics, habitats, and diversity. Significance of fungi in nature and their economic importance.

407 Diseases and Insects of Forest and Shade Trees
Spring. 4(3-3) Interdepartmental with Plant Pathology; Entomology. Administered by Department of Plant Pathology. P: (PLB 105 or BS 110 or LBS 144 or LBS 148H) and (PLB 218 or FOR 204 or HRT 211) and completion of Tier I writing requirement. SA: BOT 407
Diseases, insects, and environmental problems affecting trees in forests, parks, suburbs, and nurseries. Methods of control.

412 Environmental Plant Physiology
Fall. 3(3-0) P: (PLB 105 or BS 111 or LBS 145 or LBS 149H) and (CEM 141 or CEM 151) and (CEM 161) SA: BOT 412
Concepts underlying interactions between plants and the environment. Light sensing and utilization. Energy budgets. Water uptake and utilization. Mineral nutrition.

414 Plant Physiology: Metabolism
Fall. 3(3-0) P: (CEM 251 or CEM 351) and (PLB 105 or LBS 145) or (BS 110 and BS 111 and BS 111L) or (LBS 148H and LBS 149H) SA: BOT 414
Principles underlying metabolic processes of plants. Photosynthesis, translocation and water relations, nitrogen metabolism, cell wall biosynthesis, and associated structures.

415 Plant Physiology: Growth, Development and the Environment
Spring. 3(3-0) P: (PLB 105 or BS 111 or LBS 145 or LBS 149H or CEM 251) SA: BOT 415
Principles of plant growth and development. Environmental and hormonal factors that control progression of the plant through its life cycle. Tissue culture and genetic engineering in plants.