586. Digestive System II  
Winter. 4(4-0) Eighth-term Veterinary Medicine students. 
Pathogenesis, diagnosis and treatment of diseases of the alimentary tract and digestive organs of food animals and horses.

588. Principles of Surgery II  
Winter. 3(3-0) Eighth-term Veterinary Medicine students. 
Fundamental large animal surgery. Surgical techniques and management of animals before, during and after surgery.

590. Client Communication and Jurisprudence  
Spring. 2(2-0) Ninth-term Veterinary Medicine students. 
Communication and interviewing skills for effective client relations. Communication aspects of medical records and their use in medical problem solving. Legal responsibilities of the veterinary medical profession.

591. Core of Medicine Laboratories IV  
Spring. 2(0-6) Ninth-term Veterinary Medicine students. 
Diagnosis and treatment of common toxicologic conditions, musculoskeletal disorders and orthopedic conditions in animals.

592. Musculoskeletal System II  
Spring. 4(4-0) Eighth-term Veterinary Medicine students. 
Diagnosis, prognosis and management of musculoskeletal diseases of large animals. Anatomical relationships of normal to abnormal function. Surgical procedures applicable to the equine and ruminant. Radiographic diagnosis and interpretation of various lameness conditions.

594. Veterinary Toxicology  
Spring. 4(4-0) Ninth-term Veterinary Medicine students. 
Pharmacological basis and pathological features of diseases of animals caused by common toxic chemicals with emphasis on clinical manifestations, diagnosis, prevention, and treatment.

596. Diseases of Bones and Joints  
Spring. 3(3-0) Ninth-term Veterinary Medicine students. 
Anatomy and pathophysiology of diseases of bones and joints. Diagnosis, prognosis and treatment of abnormalities involving bones and joints.

602. Veterinary Practice Management  
Spring. 2(2-0) Ninth-term Veterinary Medicine students. 
Approval of college. 
Establishment of a veterinary practice.

610. Veterinary Externship  
Fall, Winter, Spring, Summer. 6 to 12 credits. May reenroll for a maximum of 12 credits. Veterinary Medicine students, completion of preclinical courses and approval of college. Students may not receive credit in both V M 610 and LCS 210. Clinical or research experience in an off-campus setting.

ZOOLOGY  
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203. Resource Ecology  
(FDC 200.) Fall, Winter, Spring, Summer. 3(3-0) Interdepartmental with the departments of Fisheries and Wildlife, Forestry, Geography, and Resource Development. Administered by the Department of Fisheries and Wildlife. 
Basic concepts of ecology which are the unifying basis for resource management, conservation policy and the analysis of environmental quality. Extensive use of guest lecturers.

301. Nature and Homo Sapiens  
Spring. 4(4-0) Three terms of natural science; not open to zoology majors. 
A case study approach which explores the interaction of technical, social, economic and legal influences of the management of contemporary environmental issues in Michigan.

302. Vertebrate Life of the Past  
Fall. 3(3-0) One course in physical or biological science or Junior. Interdepartmental with and administered by Geology. 
Fossil vertebrates from fish to humans.

304. Biology, Behavior and Humans  
Winter. 3(3-0) Juniors; not open to zoology majors. 
Examines philosophical and biological issues which make the study of animal behavior relevant to humans. Emphasizes history of animal behavior, current theories, and experiments relating biological and environmental determinants of adaptive and non-adaptive behavior patterns.

306. Invertebrate Biology  
Fall. 4(3-3) B S 212. 
Systematics, morphology, and natural history of invertebrate animals. Laboratory includes identification of live and preserved animals and recognition of morphological characteristics of selected groups.

307. Vertebrate Biology  
Winter. 4(3-3) B S 212. 
Systematics, morphology, and natural history of vertebrate animals. Laboratory includes identification of live and preserved animals and recognition of morphological characteristics of selected groups.

313. Animal Behavior  
Spring. 4(4-0). Given at W. K. Kellogg Biological Station Summer term of odd numbered years; 4 credits. B S 211. 
Description of the known behavior of the various vertebrate and invertebrate phyla with emphasis upon adaptive significance. This, special attention will be given to mating, defensive, and nutritive behavior. The genetics and ontology of behavioral patterns will be presented where known. Behavior will be related to the ecology of various animal populations.

317. Principles of Development  
Fall, Spring. 3(3-0) B S 212. 
Development of animals, especially vertebrates. Principles are illustrated by modern experimental studies of developmental problems.

318. Principles of Development Laboratory  
Fall, Spring. 2(0-6) ZOL. 517 or concurrently. B S 212. 
Principles of development illustrated by analysis of the ontogeny of selected organisms.

337. The Fossil Record of Organic Evolution  
Spring. 3(3-0) One course in a natural science. Juniors. Interdepartmental with and administered by Geology. 
The direct evidence for organic evolution is the fossil record. Evolution of life from prebiological systems to humans. Impact of fossil discoveries on human thought.

341. Human Heredity  
Fall, Winter. 4(4-0) Sophomores. Not open to zoology majors. Students may not receive credit in more than one of the following: ZOL 341, ZOL 441. 
Inheritance of human physiological, and psychological traits. Forces that influence human evolution. Applications of heredity in fields of education, sociology, anthropology, psychology, dentistry, and medicine.

389. Animal Ecology  
Winter, Summer. Given at W. K. Kellogg Biological Station Summer term. Winter. 4(3-4) Summer; 4 credits. B S 212 or concurrently. 
Animals in relation to their environment. Factors affecting the distribution and abundance of animals. Interrelationships between climate, soils, vegetation, geologic history and animal life. Population characteristics as related to reproduction and mortality factors.

391. Zoological Problems  
Fall, Winter, Spring, Summer. 1 to 8 credits. May reenroll for a maximum of 12 credits. Juniors; B S 212; 6 credits in zoology; approval of department. 
Advanced work in morphology, field zoology, genetics, mammalogy, ornithology, or ichthyology.

400H. Honors Work  
Fall, Spring, Winter. 1 to 5 credits. May reenroll for a maximum of 15 credits. Juniors; approval of department.

401. Comparative Physiology I  
Fall. 4(3-4) PSL. 240 or B S 212; CEM 131 or CEM 141. Interdepartmental with and administered by the Department of Physiology. 
A comparison of osmoregulation, digestion, respiration, and other physiological processes in a wide range of organisms.

402. Comparative Physiology II  
Winter. 4(4-0) PSL. 401 or approval of department. Interdepartmental with the Department of Physiology. 
A comparison of sensory, motor, endocrine and other integrative mechanisms in animals.

404. Biological and Ecological Concepts for Engineers and Mathematicians  
Summer. 3(3-0) Approval of department. Interdepartmental with Systems Science. 
Biological and ecological concepts important to formal analysis of living systems, vital properties, processes, and limitations; population dynamics, selection, competition, and predation; ecological community structure and function; industrialized ecosystem.
405I. **Experiments in Zoology I**

Fall of even-numbered years. 4(0-12)
Approval of instructor.
An integrated series of selected experiments in the topics of behavior, ecology, morphology and physiology.

406. **Experiments in Zoology II**

Winter. 4(0-12) Approval of instructor.
An integrated series of selected experiments in topics of cell biology, embryology and genetics.

414. **Biological Mechanisms of Animal Behavior**

Winter. 3(3-0) or 5(3-6) ZOL 313 recommended.
Consideration of neurofugal and hormonal mechanisms controlling behavior. Emphasis will be upon mammalian systems, and will deal with the assumptions which underlie current concepts in the biology of behavior.

415. **Ecological Aspects of Animal Behavior**

Fall. 4(4-0) ZOL 313.
Consideration of orientation, navigation and hunting behavior, food preferences, habitat selection, exploration, behavioral periodicity, communication, social organization and the embryology of behavior in both vertebrates and invertebrates.

416. **General Parasitology**

Fall. Squires; given at W. K. Kellogg Biological Station Summer term. Fall. 3(3-0)
Summer: 3 credits. B 5210, B 5211, B 5212 or LS 141. Interdepartmental with and administered by the Department of Microbiology and Public Health.
Life history, host-parasite relationships (including physiology, immunology, immunopathology and pathology) and epidemiology of selected groups and species of protozoan, trematode, cestode and nematode parasites.

417. **Advanced Developmental Biology**

Fall. 3(3-0) ZOL 317.
Molecular and cellular biology of development.

418. **General Parasitology Laboratory**

(MPH 417); Fall. Summer. Given at W. K. Kellogg Biological Station Summer term. Fall. 2(0-4) Summer: 2 credits. MPH 418 or concurrently or approval of department. Interdepartmental with and administered by the Department of Microbiology and Public Health.
Identification and life histories of representative species of major groups of animal parasites. Selected concepts of host-parasite associations will be tested experimentally.

428. **Morphology of the Chordates**

314. Winter. 5(3-0) B 5212.
Comparative and functional morphology of chordates. Laboratory includes dissection of representatives of most vertebrate classes.

430. **Vertebrate Paleontology**

Winter. 4(3-3) ZOL 428, or approval of department. Interdepartmental with and administered by Geology.
Fossil vertebrates with emphasis on the evolution of major groups. Laboratories on modern techniques and on the identification and interpretation of fossils.

437. **Invertebrate Paleontology**

Spring. 4(3-4) CLG 338 or ZOL 306 or approval of department. Interdepartmental with and administered by Geology.
Systematics and paleobiology of the Porifera, Coelenterata, Bryozoa, Brachiopoda, Mollusca, Arthropoda and Echinodermata. Laboratory exercises in their comparative and functional morphology. One required weekend field trip.

438. **Evolutionary Paleocology**

Winter. 4(3-4) GLG 338 or ZOL 359 or approval of department. Interdepartmental with and administered by Geology.
Evolutionary consequences of the ecological properties of marine invertebrate populations, species, communities, and provinces. Discussion may include biogeography, diversity, and biotic interactions.

441. **Fundamental Genetics**

Fall, Spring. 3(5-0) B 212. Students may not receive credit in more than one of the following: ZOL 341, ZOL 441.
Survey of principles of heredity in animals, plants, and microorganisms. Serves as single course in genetics for majors in any of the biological sciences, and as prerequisite for further work in genetics.

442. **Advanced Genetics**

Winter. 3(3-0) ZOL 441 or approval of instructor.
Classical and molecular examination of eight to ten advanced topics and recent discoveries in genetics.

443. **Developmental Genetics**

Winter. 4(4-0) ZOL 441 and ZOL 317.
Mechanisms of gene action. Role of genes in the embryology, morphogenesis, and physiology of organisms.

445. **Evolution**

Fall. 4(4-0) B 5211.
Processes of evolutionary change including the origin of species and homosapiens, fossils and the geological record, and applications in genetic engineering, agriculture, and medicine.

450. **Comparative Histology**

Fall. 4(3-3) B 5215.
The comparative structure of cells of selected invertebrate and vertebrate organisms and their interactions to form tissues.

453. **Marine Ecology and Physiology**

Spring. 4(4-0) B 5212.

454. **Field Studies in Marine and Estuarine Biology**

Summer. 2 or 3 credits. May receive for a maximum of 5 credits. ZOL 453.
Field trip to Chesapeake Bay and Atlantic Coast. Studies of various estuarine and marine habitats. Examination of the intertidal and fish communities emphasizing ecology, behavior, physiology and resource economics.

456. **Foundations of Developmental Biology**

Winter of even-numbered years. 3(3-0) ZOL 317; ZOL 417 recommended. Interdepartmental with the Department of Natural Science.
Reading and discussion of original research which posed significant problems of modern developmental biology.

460. **Ornithology for Teachers**

Summer. 3 credits. A course in biology or approval of department. Not open to Zoology majors. Given at W. K. Kellogg Biological Station. Interdepartmental with Biological Science.
Distribution, breeding cycles, migration, food and feeding habits, voice and other important areas of avian biology. Emphasis on field identification and natural history.

461. **Ichthyology**

Principles of classification, structure, distribution, migration, population biology and life history of birds. Identification of birds by size, form and song.

464. **Comparative Limnology**

(ZOL 478; ZOL 878) Summer. 6 credits. B 5212. Given at W. K. Kellogg Biological Station. Interdepartmental with the Department of Botany and Plant Pathology.
Theoretical concepts and methods of analysis of environmental parameters influencing productivity of freshwaters. Comparative field investigations of lakes, streams, and other aquatic habitats.

478. **Stream Ecology**

Fall. 4(3-3) F 201 or ZOL 307 or ZOL 428. Interdepartmental with and administered by the Department of Fisheries and Wildlife.
Classification and natural history of fishes. Emphasis on food, game, and forage fishes.

476. **Limnology**

Winter. 3(3-0) CEM 141B, CEM 161, BOT 450 or ZOL 389. Students may not receive credit for both F W 376 and F W 476. Interdepartmental with and administered by the Department of Fisheries and Wildlife.
Ecology of lakes and streams with special reference to physical, chemical and biological factors affecting their productivity.

477. **Limnological Methods**

Winter. 3(3-0) F W 476 concurrently; ENT 301, ENT 302 recommended. Interdepartmental with and administered by the Department of Fisheries and Wildlife.
Methods and instruments of limnological field investigation on lakes and streams.

479. **Biological and Terrestrial Invertebrates**

Summer. 6 credits. B 5212 or approval of department. Given at W. K. Kellogg Biological Station. Interdepartmental with the Department of Entomology and Fisheries and Wildlife. Administered by the Department of Fisheries and Wildlife.
Biological, chemical, physical, and geological processes which determine the structure and function of stream ecosystems.

480. **Biology of Fresh-Water and Terrestrial Invertebrates**

Winter. 3(3-0) or 3(3-6) B 5212.
Structures and functions of animal-like, eukaryotic microorganisms.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZOL 804A</td>
<td>Advanced Vertebrate Paleontology</td>
<td>4(3-0)</td>
<td>Fall</td>
<td>May reenroll for a maximum of 12 credits. GLG 430 or ZOL 445 or approval of department. Interdepartmental with and administered by Geology. Recent advances and controversial issues in vertebrate paleontology including origin, classification, phylogeny, and stratigraphic relationships of fossil vertebrates.</td>
</tr>
<tr>
<td>PSY 804A</td>
<td>Behavioral Animal Populations</td>
<td>4(4-0)</td>
<td>Fall</td>
<td>ZOL 313, written approval of department. Behavior on the ecological level. Characteristics of populations rather than individuals will be stressed. Evolution will be considered on the population level.</td>
</tr>
<tr>
<td>ZOL 805A</td>
<td>Evolutionary Paleobiology</td>
<td>4(3-0)</td>
<td>Fall</td>
<td>Selection topics in paleobiology will deal with one of the following areas: microevolution, macroevolution, the importance of size and shape, the role of development, morphometrics, phylogenetic systematics, paleocology, or biogeography.</td>
</tr>
<tr>
<td>ZOL 806A</td>
<td>Advanced Invertebrate Paleontology</td>
<td>4(4-0)</td>
<td>Fall</td>
<td>ZOL 306 or ZOL 307, written approval of department. Selected topics in paleobiology, such as macroevolution, the importance of size and shape, the role of development, morphometrics, phylogenetic systematics, paleocology, or biogeography.</td>
</tr>
<tr>
<td>ZOL 807A</td>
<td>Advanced Vertebrate Zymology</td>
<td>4(4-0)</td>
<td>Fall</td>
<td>ZOL 313, written approval of department. Advanced vertebrate biology including systematics, ecology, distribution, morphology.</td>
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</tbody>
</table>

Zoology — Descriptions of Courses

540. Patterns of Diversity in Fossil Groups
Fall, Spring. 3(3-0) May reenroll for a maximum of 12 credits. GLG 335 or ZOL 435 or approval of department. Interdepartmental with and administered by Geology. Selected topics in the diversity of fossil organisms, for example, adaptive radiations, mass extinctions, patterns of clade replacement, biotic interactions and the dynamics of diversity.

541. Chromosome Structure and Genetics
Winter of even-numbered years. 4(4-0) Introductory genetics course. Interdepartmental with the Department of Botany and Plant Pathology. Administered by Genetics. Mechanisms of mitosis and meiosis, classical and molecular genetics of chromosome structure, alterations in chromosome number and structure, transposable elements, meiotic drive.

543. Ecosystem Analysis, Design and Management
Spring. 3(3-0) SYS 442 or ZOL 404. Interdepartmental with and administered by Systems Science. Groups of students from various biological and non-biological disciplines will synthesize and analyze models of selected biological systems. Projects should yield information relevant to solution of contemporary ecological problems.

544. Problems in Human Genetics
Spring. 3(3-0) ZOL 411 or approval of department. Methods used in the study of human genetics and their application to medical, physiological and social problems. Laboratory consists of field trips and independent study selected by the student in consultation with the instructor.

546. Advanced Topics in Evolution
Winter. 4(4-0) May reenroll for a maximum of 12 credits if different topics are taken. ZOL 445 or approval of instructor. Mechanistic and theoretical aspects of the evolutionary process. Topics will be drawn from the current literature and will deal with one or more of the following areas: microevolution, macroevolution, and speciation.

559. Analysis of Hormone Action
Spring. 4(4-0) ZOL 317 or approval of department. Interdepartmental with and administered by the Department of Physiology. Discussion of recent work on the molecular and developmental aspects of hormone action in vertebrates and invertebrates. Selected topics to vary from year to year.

562. Aquatic Behavioral Ecology
Fall. 4(4-0) ZOL 313, ZOL 389, ZOL 461. Theory of habitat selection. Optimal foraging theory dealing with breadth of diet, patch utilization and sampling theory, Colony, cooperation and optimal group size, and foraging systems as they apply to avian populations.

565. Advanced Neurobiology
Spring. 4(4-0) ZOL 827. Interdepartmental with the departments of Anatomy, Physiology, and Psychology. Administered by the Department of Anatomy. Basic organization, structure and function of neural networks comprising sensory, motor, and autonomic systems including examples from invertebrates and vertebrates. Attendance at neuroscience seminar is required.
### Zoology Descriptions of Courses

- **Ecology of Fishes**
  - Summer of even-numbered years. 3 credits. Approval of department. Given at the W. K. Kellogg Biological Station. Interdepartmental with the Department of Fisheries and Wildlife.
  - Exploration of ecological problems with particular emphasis on growth, food and habitat selection, population biology, and niche relations. Field and experimental investigations of fish communities.

- **Biology of the Arthropoda**
  - Winter. 5(3-6) ZOL 306 or approval of department. Interdepartmental with the Department of Entomology.
  - Ecology, life cycles, morphology, taxonomy, and distribution of arthropoda other than insects.

- **Cellular Morphogenesis**
  - Winter. 2(2-0) One course in biochemistry, approval of department.
  - Selected topics on the structure, biological processes, and differentiation of living cells.

- **Vertebrate Neural Systems I**
  - (PSY 855) Winter of odd-numbered years. 5(3-4) ANT 815. ANT 855 recommended. Interdepartmental with the departments of Anatomy, Physiology, and Psychology. Administered by the Department of Anatomy.
  - Structure and function of major component systems of vertebrate brains, their evolution, ontogeny, and comparative analysis in mammals, birds, reptiles, amphibians, and fish. Interrelation of behavioral, anatomical, and physiological studies.

- **Vertebrate Neural Systems II**
  - Spring of odd-numbered years. 5(3-4) ANT 885. Interdepartmental with the Department of Anatomy, Physiology, and Psychology. Administered by the Department of Anatomy.
  - Continuation of ANT 885. Major component systems of vertebrate brains, their evolution, ontogeny, and comparative analysis in mammals, birds, reptiles, amphibians, and fish. Interrelation of behavioral, anatomical, and physiological studies.

- **Special Problems**
  - Fall, Winter, Spring, Summer. 1 to 15 credits. Two years of undergraduate zoology. Approval of department.
  - Consideration of current problems.

- **Current Topics in Ecological Research**
  - Summer. 1 or 2 credits. May enroll for a maximum of 12 credits. Approval of department. Given at W. K. Kellogg Biological Station.
  - Discussions and special problem work; current theoretical views and investigations; treatment of the dynamics of energy and nutrients in terrestrial and aquatic ecosystems; methods of analysis.

- **Dynamics of Biologic Populations**
  - Winter. 5(4-3) One statistics course, 1 ecology course or approval of department.
  - Growth, regulation, competition, predator-prey, life history strategies and spatial dynamics of animal populations.

- **Fertilization and Early Embryogenesis**
  - Fall of odd-numbered years. 3(3-0) Developmental biology, biochemistry, approval of department.
  - Developmental biology of early stages of animal life, emphasis on physiology and biochemistry of marine invertebrate eggs.

- **Seminar Topics**
  - Fall, Winter, Spring. 1 credit per term. May enroll for a maximum of 6 credits. Approval of department.
  - Graduate level seminars on current research topics in biology.

- **Animal Community Ecology**
  - Winter of even-numbered years. 4(4-0) ZOL 892, approval of instructor.
  - Patterns and processes in animal communities with emphasis on structure, species diversity and stability.

- **Ecosystem Ecology**
  - Fall. 3(3-0) ZOL 389 or BOT 450.
  - Interdepartmental with the Department of Fisheries and Wildlife.
  - Concepts of ecosystem structure, energy flow, and nutrient cycling in representative terrestrial and aquatic ecosystems.

- **Master's Thesis Research**
  - Fall, Winter, Spring, Summer. Variable credit. Approval of department.
  - Research for the master's degree in genetics, morphology, mammalogy, wildlife management, ornithology, fisheries biology, limnology, quantitative biology, invertebrate, experimental embryology, animal behavior, herpetology.

- **Doctoral Dissertation Research**
  - Fall, Winter, Spring, Summer. Variable credit. Approval of department.
  - Research for the Ph.D. degree in genetics, morphology, mammalogy, wildlife management, ornithology, fisheries biology, limnology, quantitative biology, invertebrate, experimental embryology, animal behavior, herpetology.