

# Biology

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We study biology in response to our Creator's call to investigate the diversity, organization, and functioning of the living world and to provide a Christian model for its study, care, and keeping. Whether our faculty and students study the biological mechanisms by which cells communicate, the flow of water and ions through roots and stems, the foraging behavior of voles, the interactions within ecosystems, or the ethical dilemmas occasioned by technology and discovery, we seek to understand the mechanisms and meaning of life. Graduates of our program are well equipped to pursue many different vocations, engaging God's world as health care providers, professors, teachers, researchers, biotechnologists, or ecologists.

Our department offers courses and programs for students interested in careers as a biologist, for students intending to pursue post-baccalaureate education, e.g., graduate, medical, dental, or other professional training, and for those interested in teaching at the elementary or secondary school levels. To do this the department offers three majors, Biology, Biotechnology, and Secondary Education Biology plus a concentration for Environmental Science majors, as well as core and pre-professional courses.

Students seeking general college core credit in Biology typically enroll in General Biology (Biology 111), Life Science for Elementary School Teachers (Biology 112), or Human Biology (Biology 115). The pre-professional courses in Anatomy (Biology 205), Physiology (Biology 206), and Microbiology (Biology 207) serve pre-nursing students as well as non-majors planning a career in medicine or an allied health field. Biology and Biotechnology majors engage fundamental biological concepts in the three biology introductory courses: Cell Biology and Genetics (Biology 141), Animal Biology (Biology 242), and Plant Biology (Biology 243). Thereafter, majors enroll in upper-level (3XX) elective courses covering such topics as Genetics, Immunology, Cell and Tissue Culture, Evolution, Ecosystem Management, Plant Physiology, and Animal Behavior. All majors perform independent research by completing internships, working directly with faculty in a research laboratory or field setting, or by completing an Investigations course. To culminate their studies, students explore complex contemporary issues in a senior capstone course.

## **BIOLOGY MAJOR**

Biology 141, 242 (or 205 and 206), and 243

Four from Biology 3XX, three of which must have laboratory components (may include one approved interim)

One from Biology 35X, 385, or 399

Biology 394, 395, or 396

Biology 295 (taken twice)

## **Cognates**

Chemistry 103-104, 253 or 261, and one course from Chemistry 201, 262, 271/281, 323/383, or Geology 151

Mathematics 132-143, or 161-162, or Physics 221-222

## **BIOLOGY MINOR**

Biology 141

Biology 242

Biology 243

Three from Biology 3XX (may include an approved interim)

## **BIOTECHNOLOGY MAJOR**

Biology 141, 242, 243, and 325

Biology 324, 334, 383, and one additional 300-level Biology course

Biology 356

Biology 394

Biology 295 (taken twice)

### **Cognates**

Chemistry 103-104, 253 or 261-2, 323

Mathematics 132 (or 161) and 143

Two courses from Information Systems 141, 151, 153, or 171 (IS 141 and 171 are recommended)

### **BIOTECHNOLOGY MINOR**

Biology 325

Biology 334

One from Biology 354, 356, 385, or 399, as approved by the biotechnology advisor (D. Koetje)

At least one from Biology 141, 242, 243, 321, 324, 331, 332, 333, 335, 336, or 364

Chemistry 253 or 261

One additional 200- or 300-level Chemistry course

The biotechnology minor is designed to complement a major concentration in Chemical Engineering, Chemistry, Biochemistry, or Biology. To satisfy overlap rules, Biochemistry majors and Chemistry majors should take two courses from Biology 141, 242, 243, 321, 324, 331, 332, 333, 335, 336 or 364. Biology majors must take one 300 level Biology course in addition to the four 300-level Biology courses required in their major. Engineering majors, and other majors not requiring Biology cognate courses, can satisfy this requirement by taking Biology 141.

### **SECONDARY EDUCATION BIOLOGY MAJOR**

Biology 141, 242, and 243

Four courses from the following two groups with at least one course from each group: Group I: Biology 311, 313, 323, 331, 332, 338, 341, 344, 345, 346, 364 and approved ASI courses. Group II: Biology 321, 324, 333, 334, 335, 336

Biology 357

Biology 395

Biology 295 (taken twice)

### **Cognates**

Chemistry 103-104, 253 or 261, and one course from Chemistry 201, 262, 271/281,

323/383, or Geology 151

IDIS 214

Mathematics 132-143 or Mathematics 161-162 or Physics 221-222

Prospective secondary teachers should complete Biology 357 (Investigations in Biology for Teachers) as part of the normal program of concentration. Programs of concentration should be prepared on the basis of current guidelines established by the National Science Teachers Association. The NSTA guidelines recommend study in zoology, botany, physiology, genetics, ecology, microbiology, cell biology/biochemistry, and evolution. A minor in physical science is recommended, and this minor may be constituted of selected cognates. Directed teaching in biology is available only during the spring semester. Prior to the teaching internship, students must have the approval of the department. Criteria for approval are found in the *Teacher Education Program Guidebook*, available in the Education Department. The advisor for biology teaching major and minor programs is C. Blankespoor.

### **SECONDARY EDUCATION BIOLOGY MINOR**

Biology 141, 242, and 243

Biology 357

Two advisor-approved electives, at least one of which must be a 300-level course

### **Cognates**

SCES 214

### **ELEMENTARY AND SECONDARY INTEGRATED SCIENCE STUDIES**

Students in an Elementary or Secondary Education Program wishing to major or minor in science should consult the Science Education section of the catalog.

### **RECOMMENDED COGNATES**

Chemistry courses should be completed by the end of the second year of the program. Computer science is also recommended. These cognates are minimum requirements. Students planning to do graduate work in cell and molecular biology are advised to complete both the physics and mathematics cognates and organic chemistry. Those planning careers in environmental biology should consider the Environmental Science major.

Other environmental courses in biology, geology, and natural resources are offered at the AuSable Institute of Environmental Studies in Mancelona, Michigan. Information on AuSable courses is available from the AuSable advisor, D. Warners.

## HONORS

To graduate with honors in the Biology Department, the student in satisfying the college honors program must complete three biology courses with honors, submit an honors thesis, and earn a minimum 3.5 GPA in the major. Of the required biology courses, one will normally be the honors section of Biology 141 or 242. (Both of these courses may be taken but only one applied to the honors program.) The second honors course will be taken from those courses numbered Biology 300-349; the details of which will be worked out by the student and instructor at the time that the student registers for the course. The third course requirement is the completion with honors of an independent research project (Biology 399) or investigations course (Biology 354-357). Normally the investigative research conducted in one of these courses will be reported in the form of a scientific research paper, which will constitute the honors thesis, and as a public presentation to a scientific audience. In addition to courses taken for honors credit, students in the honors program will enroll in the department seminar course (Biology 295) for a minimum of three semesters. Honors advisor is D. DeHeer.

## GROUP MAJORS

A group major in science and mathematics meets the needs of some students, particularly those in professional programs, such as physical therapy and physician assistant. These majors, however, are not appropriate for students planning to attend medical school or graduate school in biology. Group majors require a minimum of twelve courses in natural science and mathematics, ten of which must be from two disciplines with a minimum of four courses from each. The remaining two cognates must be chosen from a third discipline. At least two 300-level courses in one discipline must be included in the ten-course component of this group. Biology 395/396 or equivalent is required. The chairs of the departments involved must approve each program.

Prerequisite to a program of concentration in biology is a minimum average of "C" (2.0) in Biology 141, 242, and 243 or approved equivalent courses. The core requirement in biology is normally met by Biology 111, 112, or 115. In some cases Biology 141 may be appropriate.

## COURSES

### General College Courses

**111 Biological Science (4).** F, S and SS. This course is a study of the biological concepts of ecology, genetics, and evolution and their contribution to an understanding of the nature of living systems within the framework of a biblical worldview. An emphasis is placed on the application of these concepts to some important contemporary issues, such as environmental stewardship and genetic engineering. Laboratory.

**112 Life Science for Elementary School Teachers (4).** F and S. This course is designed for students in the elementary education program. In this course students use life science concepts in an inquiry-based approach to build a biological knowledge base that is appropriate to the elementary school classroom. The course covers topics in life sciences that are recommended as teaching objectives in elementary education. These include activities studying cells, classification of living organisms, reproduction and heredity, evolution, and how life forms coexist interdependently within ecosystems. Throughout the course a perspective of respect for God's creation and Christian stewardship of the creation is presented as the purpose for investigating and learning to understand life on earth. Laboratory.

**115 Human Biology (4).** F, S and SS. This is a study of the major theories of biology as applied to humans. The student is introduced to the concepts of cell, genetics, ecology, and evolution through the study of the anatomy, physiology, and development of the human body and health. Students apply these concepts to contemporary issues in human biology, society, and the environment. The laboratory utilizes methods of biological investigation, with an emphasis on human anatomy and physiology. Laboratory. Also listed as Health 115.

The following interdisciplinary course may be included in concentrations in this department:

IDIS 210 **History of Science** (3).

#### Pre-Professional Courses

205 **Human Anatomy** (4). F and SS. A study of the structure of human organ systems, including some developmental anatomy and histology. The laboratory will emphasize human anatomy and will include dissection of a cat as a representative mammal and some study of histology.

206 **Human Physiology** (4). F and S. An introduction to the physiology of the human being. Functions of the major organ systems are studied, including the circulatory, respiratory, excretory, musculoskeletal, nervous, reproductive, gastrointestinal, and endocrine systems. The laboratory introduces basic physiological techniques in an investigative setting. Prerequisites: Biology 242 or 205, Chemistry 115, 253, or equivalent.

207 **Medical Microbiology** (4). F and S. A study of microorganisms and their activities. Topics include microbial cell structure and function, metabolism, microbial genetics, viruses, and the role of microorganisms in disease, immunity, and other applied areas. Three hours of lecture and two laboratory periods per week. Prerequisite: Biology 141 and Chemistry 115, 253, or equivalent.

#### Program of Concentration Courses Basic Courses

141 **Cell Biology and Genetics** (4). F and S. This course explores the structures, functions, and evolution of prokaryotic and eukaryotic cells at the molecular, sub-cellular, and cellular level. Fundamental concepts of genetics are studied including Mendelian genetics and molecular genetics. The course introduces basic historical, philosophical, and biblical frameworks for the study of biology. Applications of course concepts to contemporary issues in biology are considered. The laboratory consists of investigations in molecular biology, cell biology, and genetics. Corequisite or prerequisite: Chemistry 103 or 115.

242 **Animal Biology** (4). S. An introduction to the biology and diversity of select groups of animals and protists. Topics include taxonomic diversity, structure, and function at the organ and tissue level, and population biology and evolution. Emphasis is placed on considering these topics in an environmental context. Lecture and laboratory. Prerequisite: Biology 141.

243 **Plant Biology** (4). F. An introduction to plant biology that includes a consideration of the structure, function, and development of plants as organisms, a consideration of the relationships of plants to each other and the other organisms in a study of selected communities within biomes, and consideration of basic ecosystem approaches, and topics in the diversity of algae, fungi, and plants. Lecture and laboratory. Prerequisite: Biology 141.

#### Advanced Courses

311S **Field Botany** (4). SS. Taxonomy and ecology of vascular plants as components of natural communities. On site examination of plants in bogs, dunes, marshes, meadows, forests, and swamps. Assigned readings, field trips, and laboratory. Offered as a summer course at AuSable Institute of Environmental Studies located near Mancelona, Michigan. Prerequisite: Biology 243, or an introductory botany course.

313 **Paleontology** (4). \* S. A study of the organisms that once lived on the Earth. Includes an examination of the processes of fossilization and methods of discovering the structure, habitat, and relationship of those organisms, and a review of their distribution and life history. A broad spectrum of organisms is studied with emphasis on invertebrate animals. Laboratory, field trip. Also listed as Geology 313. Prerequisite: Geology 152 or Biology 242 and 243.

321 **Genetics and Development** (4). \* F. A study of modern concepts of the gene and the analysis of progressive acquisition of specialized structures and functions by organisms and their components. The laboratory includes study of genetic and developmental phenomena of selected organisms. Lectures and laboratory. Prerequisites: Biology 242 and Chemistry 115, 253, or 261.

**323 Comparative Vertebrate Anatomy (4).** \* S. A comparative study of vertebrate structure and of the functional significance of these structural variations. Lectures and laboratory. Credit cannot be applied toward a biology major for both Biology 205 and 323. Prerequisite: Biology 242.

**324 Molecular Biology (4).** \* S. A study of photosynthesis, biosynthesis of macromolecular precursors, the chemistry of the storage, transmission, and expression of genetic information, biochemical dimensions of selected physiological processes, and philosophical and ethical issues related to biochemistry and molecular biology. Lectures and laboratory (Biology 383). Also listed as Chemistry 324. Prerequisite: Chemistry 323.

**325 Biotechnology (4).** S. A study of basic and advanced methodologies, current applications, and contemporary Issues In biotechnology. Theoretical and practical aspects of DNA cloning, recombination, transformation, blotting, genomics, and proteomics are taught within the context of medical, agricultural, environmental, legal, and Industrial applications. Reading assignments and discussions explore Christian and secular perspectives of biotechnology regulation, patenting, and other social concerns. Laboratory exercises facilitate development of basic lab skills (maintenance of notebooks, routine calculations, preparation of reagents and materials, and safety). Lectures and laboratories. Prerequisites: Biology 141, Chemistry 253 or 261.

**331 Comparative Animal Physiology (4).** \* S. A study of animal physiology using a comparative approach. Topics include membrane transport, nerve function, sensory mechanisms, muscle contraction, hormone action, metabolism, as well as ion, osmotic, and temperature regulation. Study of major organ systems focuses on the circulatory, respiratory, excretory, musculoskeletal, nervous, reproductive, gastrointestinal, and endocrine systems. Lectures and laboratory. Credit cannot be applied toward a biology major for both Biology 206 and 331. Prerequisites: Biology 242 or 205; Chemistry 115, 253, or 261.

**332 Plant Physiology (4).** \* S. A study of form and function in plants as whole organisms. Course topics include photosyn-

thesis and productivity, physiological and developmental responses to environmental cues, mineral nutrition, and water and solute transport. Lectures and laboratory. Prerequisites: Biology 243; Chemistry 115, 253, or 261.

**333 Immunology and Hematology (4).** \* S. A study of immunology and hematology including innate, cellular, and humoral immunity, blood composition, hemostasis, coagulation, complement, immunogenetics, the major histocompatibility complex, immunoregulation, and abnormalities of the immune and hematologic systems. Lectures and laboratory. Prerequisites: Biology 206 or 242, and Chemistry 115, 253, or 261.

**334 Cell and Tissue Culture (4).** \* F A study of the biology, methodology, and applications of in vitro cultures of animal and plant cells. Lectures and labs. Prerequisites: Biology 141, Chemistry 253 or 261.

**335 Cell Physiology (4).** \* F A study of the function of animal cells with emphasis on events occurring outside the nucleus. Major emphases include the structure of the cell membrane, functions and interrelationships of membrane transporters and ion channels, synthesis of proteins and targeting of vesicles through the secretory pathway, structure and function of cell surface receptors and their interactions with intracellular signaling pathways, mechanisms of cell motility, and interactions of cells with the extracellular matrix. Concepts will be discussed in the context of historical development, examination of experimental evidence and relationship to the function of tissues and organs. Lectures, problem-based discussions of the primary literature, laboratory. Prerequisites: Biology 242, Chemistry 253 or 261. Not offered In 2006-2007.

**336 General Microbiology (4).** \* F A study of the structure and function of microorganisms, including a consideration of their role in food production and spoilage, biogeochemical cycles and environmental quality, and as tools in genetic engineering. Lectures and laboratory. Prerequisites: Biology 242, 243, or 206; Chemistry 115, 253, or 261.

**338 Animal Behavior (4).** \* S. A study of the mechanisms and adaptive significance underlying the behavior of animals. Topics include natural and sexual selection, behavioral ecology, social behavior, orientation and navigation, animal communication, and chemical ecology. Lectures and laboratory. Prerequisites: Biology 242 and 243.

**341 Entomology (4).** \* F, alternate years. Study of the biology of insects with emphasis on systematics. Lectures, laboratory, and field trips. Prerequisites: Biology 242 and 243. Not offered in 2006-2007.

**344 Vertebrate Biology (4).** \* S, alternate years. Study of the ecology and evolution of fish, amphibians, reptiles, birds, and mammals. Lectures and laboratory. Prerequisite: Biology 242.

**345 Ecosystem Ecology and Management (4).** \* F. Detailed study of ecosystem structure and function, with special emphasis on local ecosystems, and the scientific basis for managing and restoring ecosystems. Lectures and laboratory. Prerequisites: Biology 242 and 243.

**346 Plant Taxonomy (4).** \* F. Identification, nomenclature, and classification of vascular plants. Lectures, laboratories, and field trips. Prerequisite: Biology 243.

**364 Global Health, Environment, and Sustainability (3).** \* F. Global health and food matters are best understood within their biological, ecological, and socio-economic contexts. This course explores how processes in these contexts contribute to health and disease, especially as they pertain to international and community development. Globalization presents opportunities and challenges for health and food security and for ecosystem integrity. Development models that enhance these by strengthening human-environment interconnectedness, using responsible technologies, and developing just policies are upheld as exemplars. Prerequisite: Living World core

**383 Laboratory in Biochemistry (1).** \* F and S. A laboratory course designed to teach students modern biochemical separation and analytical techniques. Included in this course are the following topics: Exclu-

sion, ion-exchange, affinity, and high performance liquid chromatography, agarose gel and polyacrylamide gel electrophoresis, ultracentrifugation, ultraviolet/visible spectroscopy, enzyme kinetics, and recombinant DNA techniques. Students will be required to carry out individual projects involving the purification and analysis of a biological macromolecule from cells or tissue. Also listed as Chemistry 383. Prerequisite or corequisite: Chemistry 323.

#### Research and Practicum Courses

Prerequisites for all investigative courses include the three basic courses in the program of concentration. **Because of enrollment limits, instructor permission must be received before registration.**

**290 Directed Research (1-3).** F, I, and S. The student enrolling in this course will be involved in laboratory or library research on a project currently being studied by one or more staff members. Application forms are available from the department office and admission will be determined by the chair and the faculty member directing the project.

**354 Investigations in Ecotoxicology (4).** \* F. Field and laboratory studies examining the impacts of environmental pollutants on animals. Interpretation of scientific literature, study design, and the collection, analysis, and presentation of data will be emphasized. Students will develop and conduct individual research projects on the effects of toxic chemicals on the ecological, organismic, and (or) cellular levels. Prerequisites: Biology 242 and permission of the instructor.

**354 Investigations in Plant Ecology (4).** \*F. Field, laboratory and greenhouse studies in plant population and community ecology. Emphasis will be given to the development of research questions, how experiments are designed, and how data are collected, analyzed and presented. Topics will include regeneration, competition, coexistence, pollination, distribution, diversity and conservation. Students will develop their own research projects and analyze and present results from their work. Prerequisites: Biology 243 and permission of instructor.

**354 Investigations in Genetics.** (4). \*S. Laboratory study of eukaryotic DNA replication and mitosis. Students will use mutant yeast strains to conduct independent projects on the yeast cell division cycle. In the process students will learn a variety of laboratory techniques to analyze suppressors of a yeast cell cycle mutant that cannot properly replicate its DNA. In addition to conducting individual and group research, students will read and discuss original literature, write literature and research summaries, and prepare a final presentation based on their projects. Prerequisites: Biology 242 and 243 and permission of instructor.

**354 Investigations in Physiological Ecology** (4). \* Not offered 2006-2007.

**354 Investigations in Microbiology.** (4). \* Not offered 2006-2007.

**354 Investigations in Inflammation** (4). Not offered 2006-2007.

**354 Investigations in Restoration Ecology** (4). \* Not offered in 2006-2007.

**354 Investigations in Developmental Cell Biology.** \* Not offered 2006-2007.

**356 Investigations in DNA Technology** (4). S. A directed investigations course in which students employ molecular biology methods to characterize DNA clones from gene libraries, analyze the expression patterns of these clones, sequence them, use bioinformatics to characterize putative gene products, and design primers for realtime RT-PCR gene expression analysis. Course projects culminate in multimedia or poster presentations of results. Two labs per week. Prerequisites: Biology 141, Chemistry 253, or 261. Recommended: Biology 256.

**357 Investigations in Biology for Teachers** (4). \* F This course, intended for biology majors and minors in the education program, is designed to train students in the use of laboratory for investigating and understanding the content of biology. Typically, all students study topics in plant and animal genetics, physiology, behavior, anatomy, and ecology. Individually, students select a content area for further exploration. Students instruct each other through investigations designed to guide their discovery and understanding of biological concepts. In doing

so, students model the investigative process that builds and critiques the content base of biology. Students use computers for data collection, analysis, and presentation. A final presentation of independent research in a selected content area is required. Prerequisites: Biology 242, 243, and permission of the instructor.

**359 Seminar in Secondary Teaching of Biology** (3). S. A course in perspectives on, principles of, and practices in the teaching of biology on the secondary level. This course should be taken concurrently with Education 346. The seminar provides a forum for the discussion of concerns that develop during directed teaching. This course is part of the professional education program and may not be included in the major or minor in biology.

**385 Internship in Biology** (0-4). F, I, S, and SS. This course is an off-campus internship that emphasizes professional application of the concepts and principles learned as part of a Biology program. A student has responsibilities in a private firm, office, laboratory, a not-for-profit organization, or a government agency. The intern works on a specific project under the direct supervision of an employer-supervisor and a faculty internship coordinator. The intern will meet with the faculty coordinator, will maintain a journal, and must present an oral or written report summarizing the internship experience. The off-campus employer-supervisor will complete an evaluation report on the work of the intern. With faculty approval, this course may satisfy the investigations requirement in the biology major or biotechnology minor. Only one Biology 385, 390, or 399 course may be used to satisfy the requirements for the biology major or biotechnology minor. Prerequisites: At least sophomore standing in Biology, a cumulative GPA of 2.0 or better, an average GPA of 2.0 or better in all credited science and mathematics courses, and approval by both the department and the off-campus employer.

**390 Independent Study** (1-4). F, I, S, and SS. This course provides the opportunity for a student to conduct library research, or under the direction of a faculty member,

to study a subject not currently offered in the biology curriculum. Permission to enroll must be obtained from the department chair and the faculty member directing the project. Requirements will be determined by the supervising faculty member. Only one Biology 390 or 399 course may be used to satisfy the requirements of the biology major.

**399 Undergraduate Research (3-4).** F, I, S, and SS. Students enrolling in this course will conduct laboratory or field research under the supervision of a faculty member. The project may be part of an ongoing research program of the supervising faculty member. A written thesis on the project will be required, as well as presentation of a poster or seminar to the department. Permission to enroll must be obtained from the department chair and the faculty member directing the project, and with their permission, this course may fulfill the requirement for an Investigations course in the biology major. Only four credit hours of Biology 390 or 399 course may be used to satisfy the requirements of the biology major. Prerequisites: Biology 242 and 243.

#### Seminar Courses

**295 Biology Seminar.** F and S. No credit. Various topics in biology and related disciplines are presented by visiting speakers, faculty, and students. During the junior and senior year, majors must attend two of the four semesters; freshman and sophomore students are encouraged to attend. Majors intending to graduate with honors must attend three of the four semesters in their junior and senior years.

**394 Perspectives in Biotechnology (3).** \* I. This course explores, within a reformed Christian framework, the historical and philosophical perspectives pertaining to the science and practice of biotechnology. Students explore the underlying assumptions of current biotechnology research as well as its

social, ethical, and legal implications. They address governmental regulations affecting laboratory safety, biohazards, and containment of genetically modified organisms and patenting. Prerequisites: Senior status in the biotechnology program of concentration, Biblical Foundations I or Theological Foundations I, Developing a Christian Mind, and Philosophical Foundations.

**395 Perspectives in Biology (3).** \* F This course examines ways in which biology has developed through conceptual and technological innovations, ways in which worldviews have informed biological concepts, the inherent limitations of the scientific enterprise, and philosophic viewpoints held by contemporary biologists. The course will also examine how a biblically informed worldview contributes to an understanding of living systems and to the application of such understanding to societal issues, such as environmental sustainability and appropriate uses of biotechnology. Prerequisites: Senior status in the biology major program, Biblical Foundations I or Theological Foundations I, Developing a Christian Mind, and Philosophical Foundations.

**396 Perspectives in Medicine (3).** \* F This course is a critical study of the historical and philosophical perspectives pertaining to the science and practice of medicine with particular emphasis on the methodology, results, and implications of current medical research. Students study the medical literature towards a critical analysis of selected representative societal and ethical issues in medicine. Prerequisites: Senior status in biology or biochemistry program or permission of the instructor, Biblical Foundations I or Theological Foundations I, Developing a Christian Mind, and Philosophical Foundations.

#### Graduate Courses

**590 Independent Study.** \* F, I, and S.