INDIANA UNIVERSITY

University Graduate School 2008-2009 Academic Bulletin

University Graduate School
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Biology

College of Arts and Sciences
Bloomington

Chairperson
Distinguished Professor Jeffrey D. Palmer*

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Graduate Faculty

(An asterisk [*] denotes membership in the University Graduate School faculty with the endorsement to direct doctoral dissertations.)

Clyde Culbertson Professor
Yves V. Brun*

Distinguished Professors
Howard Gest* (Emeritus), Charles Heiser* (Emeritus), Thomas C. Kaufman*, Ellen D. Ketterson*, Michael Lynch*, Jeffrey D. Palmer*, John Preer* (Emeritus), Rudolf A. Raff*, Anthony San Pietro* (Emeritus)

Professors
Carl E. Bauer*, James José Bonner*, Edmund Darrell Brodie III*, Yves V. Brun*, Peter T. Cherbas*, Keith Clay*, Lynda F. Delph*, Thomas F. Donahue*, Mark Andrew Estelle*, Patricia L. Foster*, Roger P. Hangarter*, George Hegeman* (Emeritus), Roger William Innes*, Arthur Koch* (Emeritus), Curtis M. Lively*, Paul Mahlberg* (Emeritus), Emilia Martins*, Carlos Miller* (Emeritus), Val Nolan* (Emeritus, Law), Elizabeth C. Raff*, J. C. Randolph* (Public and Environmental Affairs), Loren H. Rieseberg*, Albert W. Ruesink*, Drew Schwartz* (Emeritus), Milton W. Taylor*, Robert Togasaki* (Emeritus), Michael J. Wade*, Maxine A. Watson*, Eugene Weinberg* (Emeritus), Meredith West* (Psychology), David White* (Emeritus), Donald Whitehead* (Emeritus), Malcolm E. Winkler*, Frank Zeller* (Emeritus), Miriam E. Zolan*

Associate Professors
Alan D. Bender*, James Bever*, Gregory E. Demas*, James T. Drummond*, Clay Fuqua*, James L. Goodson, George Hudock* (Emeritus), David M. Kehoe*, Yean Chooi Odle*, Heather L. Reynolds*, Stefan J. Surzycki*, Michael R. Tansey*

Associate Professors, untenured
Kyung-Tai Min, Gregory J. Velicer*

Assistant Professors
Justen Andrews, Lingling Chen, Viola Ellison, Spencer R. Hall*, Richard William Hardy, Ke Hu, Laura M. Hurley*, Daniel B. Kearns*, Justin P. Kumar, Melanie M. Marketon*, Scott Michaels, Armin P. Moczek, Kristi Montooth, Leonie Moyle*, Tuli Mukhopadhyay*, David E. Nelson*, Joseph R. Pomerening*, Sidney L. Shaw*, G. Troy Smith, Nicholas Sokol, Joel Alcasid Ybe, Andrew Zelhof

Senior Scientists
Lucy Cherbas, Kathy Matthews

Associate Scientists
John K. Colbourne*, Kevin R. Cook*, Marcy A. Kingsbury*, Eric Knox*, Yuen-Tsu Nicco Yu*

Assistant Scientists
Kristin Klueg*, Ellen Popodi*, James Powers*, Peggy Schultz*, Barry D. Stein*

Adjunct Professors
Richard DiMarchi* (Chemistry), James Glazier* (Physics), Elisabeth Lloyd* (History and Philosophy of Science), Anton Neff* (Medical Sciences), Roderick Suthers* (Psychology), William Timberlake* (Psychology), Nicholas Toth* (Anthropology), Ted Widlanski* (Chemistry)

Adjunct Associate Professors
David Daleke* (Medical Sciences), Vicki Meretsky* (Public and Environmental Affairs), Martha Oakley* (Chemistry), Flynn Picardal* (Public and Environmental Affairs), Henry Prange* (Medical Sciences), Martin Stone* (Chemistry)

Adjunct Assistant Professor
Thomas Tolbert* (Chemistry)

Director of Graduate Studies
Professor Roger P. Hangarter*, Myers Hall 352, (812) 855-5456

Degrees Offered

Master of Arts and Doctor of Philosophy in ecology and evolutionary biology; Doctor of Philosophy in genetics; Master of Arts and Doctor of Philosophy in microbiology; Doctor of Philosophy in molecular, cellular, and developmental biology; Master of Arts and Doctor of Philosophy in plant sciences; Master of Arts and Doctor of Philosophy in zoology; and Master of Arts for Teachers.

Special Departmental Requirements

(See also general University Graduate School requirements.)

Admission Requirements
Undergraduate major in one of the biological sciences and course work in the program in which a degree is sought. A degree in a related field (e.g., chemistry, physics, or mathematics) may suffice if appropriate biology courses were included in the student's degree program. Students seeking admission to biology degree programs may apply directly to the Department of Biology or online. Applications must include a complete entrance form, letters of recommendation, undergraduate transcripts, and scores on the Graduate Record Examination General Test. (While it is not required that applicants also submit scores on the Subject Test in Biology, it is recommended that they do so.) The TOEFL score is required if the native language is other than English.

Special Requirement for the M.A. Degree
It is a requirement of the Department of Biology that the M.A. degree be completed within five semesters, although some programs such as the M.A.T. and joint SPEA/Biology programs allow additional time.

Ph.D. Qualifying Examination
Includes written, oral, and research components. All full-time Ph.D. students must take the qualifying examination by the end of the fourth week of their fifth semester. In the event of failure or postponement, students may retake the examination once, but no later than the end of the twelfth week of their fifth semester.

Final Examination
Oral defense of the dissertation before the research committee. For additional requirements in certain programs, see below.

Other Provisions
All students enrolled in a Ph.D. program in the Department of Biology will be required to serve as associate instructors for at least one semester, regardless of their source of support; and they must complete formal instruction in teaching methods in order to enhance their teaching skills. It is the conviction of the department that teaching experience is a vital aspect of graduate education, whether or not the student intends to pursue a teaching career after attainment of the desired degree(s).

Ecology and Evolutionary Biology

Master of Arts Degree

Course Requirements
A total of 30 credit hours, of which at least 20 credit hours must be taken in approved ecology and evolutionary biology courses. The courses that each student takes must have a coherent focus within the general field of ecology and evolutionary biology. At least one seminar should be taken each year.

Thesis
Normally required; an alternative project may, however, be approved by the student's advisory committee.

Final Examination
Normally includes a public research seminar and an oral defense of the thesis or alternative project before the advisory committee.

Doctor of Philosophy Degree

Course Requirements
A total of 90 credit hours, including two courses from one concentration area listed below and one course from a second area, Z620 Biostatistics (or equivalent), and dissertation. Students must enroll in a seminar at least one semester during each of the first three years in the program.

Concentration Area Requirements

Ecology/Population Biology
E455 (SPEA) Limnology
L575 Biodiversity and Ecosystem Functioning
L578 Advanced Population Biology
L579 Community Ecology
L591 Plant Population Biology—An Experimental Approach

Evolutionary Biology
B555 Special Topics in Plant Systematics
L505 Molecular Biology of Evolution
L567 Evolution
Z540 Genetics of Populations
Z620 Molecular Evolutionary Genetics

Behavior/Physiology
L560 Physiological Ecology
L581 Behavioral Ecology
P548 Neuroethology
Z460 Ethology
Z566 Laboratory in Endocrinology

Minor
The minor may be in a separate department, an interdepartmental program, a different graduate program in the Department of Biology, or in biometrics. Requirements are as set by the unit administering the minor.

Foreign Language/Research Skill Requirements
Determined by the student's advisory committee.

Final Examination
In addition to the oral defense of the dissertation before the student's research committee, a public research seminar is required.

Genetics
Molecular, Cellular, and Developmental Biology

Doctor of Philosophy Degree

Programs leading to the Ph.D. degrees in genetics, and in molecular, cellular, and developmental biology, are administered by the Faculty Committee on Molecular Biology and Genetics (MBG), in collaboration with members of the Department of Chemistry. The Ph.D. in plant sciences can be pursued under the supervision of MBG or that of ecology and evolutionary biology, depending upon the nature of a student's research interests.

Common Requirements
During the first year, each student takes a common core program. Fall: L501, L523, L585, and B501 or another graduate-level biochemistry course; spring: L501, L586, L587. Biology L501 is a rotation course in which each student participates in research projects in at least three different laboratories prior to selecting a permanent research advisor and laboratory at the end of the first year. In addition, students whose native language is not English are expected to become sufficiently fluent to pass the university's Examination in English for Associate Instructors during the course of the first year.

At the end of the first year, each student selects a research advisor and laboratory. Together with the advisor, the student also selects the other members of an advisory committee of three or four faculty members appropriate to the student's intended degree and one from the prospective minor field (see below). This advisory committee guides and monitors the student's subsequent independent work and guides the student's selection of advanced courses. MBG requires that each student meet with the advisory committee at least once per year.

The MBG-administered degree programs require a total of 90 credit hours including the core program, two advanced courses (see below), Grant Writing (Z620), Journal Club (M850 or Z620), and Research Ethics and Careers (Z620). Grant Writing and Journal Club are taken during year two, and Research Ethics and Careers during year three. Each student must give a research talk during year three or later, and must teach for at least one semester.

Grades
Every student must maintain a minimum GPA of B (3.0) in order to remain in good standing. Courses to be counted toward the Ph.D. degree must be passed with a grade of B- (2.7) or better.
Preliminary Examination
Students in all programs take a preliminary examination at the end of the fourth semester. Students who pass this examination and complete the required course work are admitted to formal candidacy for the Ph.D.

Satisfactory Progress Toward a Degree
After passing the preliminary examination, for a student to remain in "good standing" in MBG requires that sufficient progress be made toward completing a thesis. If the research advisory committee judges progress to be unsatisfactory, probation may be recommended. At the end of the probationary period (usually a semester), probation will be lifted if the advisory committee judges the student's progress to be satisfactory.. If the advisory committee judges the student's progress to remain unsatisfactory, then the student will be required to leave the program.

Thesis
The final requirement of each program is a Ph.D. thesis, which must be defended in a public research seminar and in a meeting of the research advisory committee.

Advanced Courses and Minor
The MBG, in conjunction with the degree program committees, offers a program of half-semester advanced courses (Z620). The selection of courses changes each year. Courses are offered in all the degree subjects. Each program requires that its students take at least two of these courses, at least one of which should be certified by the student's committee as appropriate to the chosen degree.

Each student must select a minor field distinct from the chosen degree. Ordinarily a student will select as a minor one of the MBG degree programs not selected for the major. In those cases, the core program courses meet minor requirements. In some cases a student may select another minor and must meet any additional requirements set by that minor.

For students from other programs who wish to minor in one of the MBG degree areas, the requirement is 6 credit hours of work in that field. The course selection should be approved by the director of MBG.

Microbiology

Degree programs are available for students with interests in many areas of microbiology. Each student's curriculum is designed by the student in consultation with the graduate program director, the student's mentor, and an appointed advisory committee.

Master of Arts Degree with a Research Thesis

Course Requirements
A total of 30 credit hours; 12 of these must be course work not including M500, M800, or M850. Course options include B501 (4.5 cr.), L585 (4.5 cr.), C483, C484, M416, M430, M440, M460, M480, M525, L586, Z620 (Special Topics, 1.5-3 cr.). Students are expected to rotate (M500) in at least two laboratories during the fall semester and to participate in M850 Microbiology Journal Club each time it is offered in the fall and spring.

Grades
A minimum of B– (2.7) in each required course.

Thesis
Required.

Final Examination
Oral defense of thesis.

Master of Arts Degree with a Library Thesis

The department also offers a program in microbiology leading to a terminal master's degree that does not require a laboratory research project. A student enrolled in this program will write a thesis critically evaluating and reviewing some aspect of microbiology reported in the literature. All other requirements for the degree are identical to those stated above for the research-thesis Master of Arts. The degree is designed to give individuals an opportunity to pursue graduate study at the master's level without acquiring expertise in laboratory research.

Doctor of Philosophy Degree

Course Requirements
A total of 90 credit hours, including the following core courses: L585 (4.5 cr.), B501 (4.5 cr.), L523, and M500. C483 and C484 may be substituted for the core B501. Two advanced topics courses are also required. Electives include but are not limited to M430, M525, M572, L586, Z620 (Special Topics). Additional courses from this or other departments with written permission of the microbiology program director may be substituted for the electives. Also required are M850 (Microbiology Journal Club), taken each fall and spring (except for the first semester), Grant Writing (Z620), and Research Ethics and Careers (Z620). During the first year, students are required to complete three rotations (M500). Students must teach for at least one semester.

Grades
A minimum of B– (2.7) or better in each required course.

Advisory Committee
The committee will consist of the research advisor, one member of the microbiology faculty, a faculty representative of the student's minor field, and one or two additional members of the faculty.

Thesis
Required.

Final Examination
In addition to the oral defense of the dissertation before the research committee, a public seminar is required.

Plant Sciences

Master of Arts Degree

Course Requirements
A total of 30 credit hours, stressing suitable advanced courses in plant sciences and cognate areas. At least 20 of the credit hours must be in the major area.

Grades
B average (3.0) required.

Thesis
Required. An equivalent creative project may be accepted in lieu of the thesis.

Doctor of Philosophy Degree

Ph.D. students choosing a molecular approach will follow the procedures in all respects (courses, seminars, research rotations, preliminary examination, etc., of the genetics and MCDB (molecular, cellular, and developmental biology) graduate programs. Likewise, students choosing an organismal approach will follow the exact procedures of the ecology and evolutionary biology program.

Zoology

Each degree program is tailored to the specific interests and needs of the student.

Master of Arts Degree

Course Requirements
A total of 30 credit hours, of which at least 20 credit hours must be taken in the Department of Biology.

Grades
B average (3.0) required.

Thesis
Required. An alternative project may be accepted in lieu of the thesis.

Doctor of Philosophy Degree

Course Requirements
A total of 90 credit hours of advanced course work, including dissertation.

Minor
Selected in consultation with research advisor and zoology program director.

Master of Arts for Teachers Degree

The Master of Arts for Teachers in biology is offered by the University Graduate School (not the School of Education) to provide training beyond the bachelor's degree for those who intend to teach in junior or senior high school and who wish additional training in biology. Each student in the program must possess a teacher's certificate by the time the degree is conferred, with the exception of international students who intend to return to their native country.

Admission Requirements
Bachelor's degree from a regionally accredited institution with sufficient hours in biology to enable the student to take courses carrying graduate credit.

Course Requirements
A total of 36 credit hours, of which a minimum of 25 credit hours must be in courses in the biological sciences that carry graduate credit; the remaining 11 credit hours may be in education. All programs of study must be approved by the Master of Arts for Teachers program advisor.

Certification Requirements
For a complete list of courses in education and other areas that are required for provisional certification, consult the School of Education Undergraduate Program Bulletin.

Courses

B351 Fungi (3 cr.)
B352 Fungi: Laboratory (2 cr.)
B364 Summer Flowering Plants (4-5 cr.)

B368 Ethnobotany (3 cr.) P: BIOL L111. Plants in relation to man with primary emphasis on food plants. Credit given for only one of L370 or B368.

B371 Ecological Plant Physiology (3 cr.)
B372 Ecological Plant Physiology Laboratory (2 cr.)

B373 Mechanisms of Plant Development (4 cr.) P: BIOL L111, L211. Lecture and lab explore the physiological and molecular mechanisms controlling plant growth and development from germination to reproduction studies. Studies structural and functional relationships with an emphasis on how external stimuli like light, gravity, nutrition, and temperature affect gene activities and physiological processes that control growth.

B415 Phytogeography (2 cr.)
B423 Introduction to Paleobotany (3 cr.)
B445 Experimental Molecular and Cellular Biology of Eukaryotes (4 cr.)

B530 Anatomy and Morphology Seminar (cr. arr.) P: Consent of instructor. Seminars will include current research studies in plant anatomy and morphology.

B555 Special Topics in Plant Systematics (3 cr.) Topics vary from year to year. Examples of subjects to be treated: phylogeny and families of flowering plants, biology of ferns, biosystematics, molecular markers in populational biology, and systematics. Enrollment of advanced undergraduates encouraged.

B560 Seminar in Systematics (cr. arr.) P: Consent of instructor. Topics vary each semester.

B570 Seminar in Physiology and Molecular Biology of Plants (cr. arr.) P: Consent of instructor.

B572 Photobiology (3 cr.) P: S305 or L367 or CHEM C483 or equivalent. Biochemical and biophysical relationship between light and biological systems. Topics will include photosynthesis, visual processes, photorespiration, phototaxis, bioluminescence, and photomorphogenesis, with emphasis on photosynthesis.

B573 Special Topics in Plant Physiology (2-5 cr.) P: Consent of instructor. Advanced topics in plant physiology. With consent of instructor, may be taken more than once for credit.

B576 Developmental Plant Physiology (3 cr.) P: Consent of instructor. Chemically oriented; examination of substances uniquely involved in growth and development in higher plants. Application of information to lower plants only briefly discussed.

B577 Plant Biochemistry (2 cr.) A comparative treatment of selected biochemical topics, emphasizing unique or important processes in plant metabolism and development.

L313 Cell Biology Laboratory (3 cr.) P: BIOL L113 and L211, or CHEM C342, or consent of instructor. R: BIOL L312, CHEM C484.

L417 Molecular Aspects of Development (3 cr.)
L465 Advanced Field Biology (3 cr.)
L473 Ecology (3 cr.)
L474 Field and Laboratory Ecology (2 cr.)
L479 Evolution and Ecology (4 cr.)

L500 Independent Study (cr. arr.) P: Written consent of faculty member supervising research.

L501 Independent Study (1-6 cr.) P: Written consent of faculty member supervising work. Supervised work. S/F grading.

L504 Genome Biology for Physical Scientists (3 cr.) An accelerated but introductory treatment of contemporary issues in molecular biology and genetics including genome structures, gene function and regulation, mapping, proteins, and molecular evolution. Intended to meet the needs of graduate students in mathematics, physics, chemistry, computer sciences, and informatics who are considering working in biological areas or collaborating with biologists.

L505 Evolution of Development (3 cr.) P: Senior or graduate standing and consent of instructor. An integrative approach to the link between development and the evolution of morphology. Topics: evolution of developmental mechanisms and of developmental regulatory genes, production of evolutionary changes through changes in developmental processes, developmental constraints, and origins of major body plans.

L509 Field Exercises for Biology Education (1-5 cr.) L509 is a graduate course for students in biology and education with an intended career in biology education. Credits are variable (1-5) and will be arranged. Students will design field exercises based at the Indiana University Research and Teaching Preserve on topics in organismal biology and ecology appropriate for public school and other outside groups.

L510 Introduction to the Research Laboratory (3 cr.) P: Graduate standing. Objectives and techniques of biological research. Completion of a one-semester research problem with a faculty member.

L519 Bioinformatics: Theory and Application (3 cr.) Overview of theory and applications in bioinformatics, based on fundamentals of molecular biology and information sciences. Common problems, data, and tools in the field are outlined. These include biosequence analysis, alignment and assembly, genomics, proteomics and phylogenetics, biological databases and data mining, and Internet bio-information services.

L520 Seminar in Genetics (cr. arr.) P: L364 or Z420 or equivalents.

L521 Problems in Genetics—Higher Organisms (3 cr.) P: L364 or equivalent. Selected topics in the genetics of higher organisms emphasizing studies at the molecular level.

L522 Advanced Eukaryotic Molecular Genetics (3 cr.) P: Consent of instructor; beginning course in genetics. Correlation of genetic data with changes in chromosome structure and number. Mechanics of chromosome behavior in crossing over and disjunction.

L523 Critical Analysis of the Scientific Literature (1-6 cr.) Detailed analysis of current research papers in biology. Emphasis on experimental design, research methods, interpretation of results, and suitability of controls. Generally taken in the first semester of graduate residence. Topics may vary to suit specific fields (e.g., molecular, cellular, and developmental biology and genetics, or ecological and evolutionary biology).

L529 Bioinformatics in Molecular Biology and Genetics: Practical Applications (4 cr.) P: I501, I502, L519, or consent of instructor. Practical experience in a range of data analysis and software engineering methods applied to molecular biology data.

L533 Evolution of Genes and Genomes (3 cr.) Provides a broad conceptual overview of issues in molecular and genomic evolution, with an emphasis on population-genetic issues.

L555 Alternative Approaches to Teaching College Biology (2 cr.) Frameworks for teaching college biology. Addresses different teaching objectives (knowledge, applications, scientific thinking, ethical and policy considerations); different teaching methods (lectures, readings, recitations, discussions, exercises, experiments, projects); student heterogeneity (expectations, abilities, development, learning styles); evaluation and grading; course and curriculum design; and evaluation and improvement of teaching.

L560 Physiological Ecology (3 cr.) Influence of the abiotic environment on energy and material transfers in individual organisms, with emphasis on terrestrial animals.

L567 Evolution (3 cr.) P: Graduate standing in psychology or biology or consent of the instructor. Topics include quantitative genetics, population genetics, and strategic models of natural selection. Special topics include: life history theory, sex and sexual selection, kin selection, shifting-balance theory, speciation, macroevolution, and comparative methods.

L572 Microbial Ecology (3 cr.) Principles of microbial ecology with emphasis on the population, community, and ecosystem ecology of bacteria and fungi.

L573 Quantitative Genetics and Microevolution (1.5-3 cr.) Explores the fundamentals of the quantitative genetic approach to understanding evolutionary process. Topics include the conceptualization and measurement of selection and the response to selection, the measurement and consequences of genetic architecture, as well as application of these ideas to classical and modern evolutionary theory.

L575 Ecosystem Structure and Function (3 cr.) P: L473 and L474 (or equivalent) or instructor's consent. Does biodiversity matter? Analysis of relationships between biodiversity and ecosystem functioning. Emphasis on current literature, including theoretical and empirical work. Lectures will alternate with class discussion and debate.

L577 Theoretical Ecology (3 cr.) Empowers students to develop and analyze ecology-based models and use them as statistical hypotheses. Topics include nonlinear one- and multi-species dynamics; stability analysis; bifurcations; maximum likelihood; model competition and information criteria.

L578 Advanced Population Biology (3 cr.) courses in ecology, genetics, and basic calculus, and permission of instructor. A detailed assessment of population-ecological and population-genetic theory, and the factors determining the size and composition of animal populations in nature.

L579 Community Ecology (3 cr.) P: Ecology and genetics. Survey of ecological and evolutionary topics between population and ecosystem levels. Review of scientific levels of selection and speciation. Major emphasis on interactions among populations (consumer-producer, competition, symbiosis, etc.) and community analysis (island biogeography, niche, diversity, and community structure).

L580 Introduction to Research (1 cr.) Individual faculty from the various graduate programs in biology present seminars on their research programs. Discussion between students and faculty about possible thesis research projects is encouraged.

L581 Behavioral Ecology (3 cr.) Integrated elements of ethology, physiology, ecology, and evolutionary biology providing a synthetic approach to animal behavior. Emphasis on integrated studies providing new insights into both evolutionary and mechanistic questions. Students are asked to analyze the literature critically and debate controversial issues actively.

L585 Genetics and Bioinformatics (4.5 cr.) Focuses on genome organization and transmission and molecular genetics in a number of prokaryotic and eukaryotic systems. Topics include molecular mechanisms of mutation, suppression, replication,

meiosis, recombination, complementation, and approaches to identifying and analyzing genes. Introduces students to the use of databases, programs for computational analysis of DNA and protein sequence data, and high-throughput methods in genomics and proteomics.

L586 Cell Biology (variable: 3-4.5 cr.) Critical analysis of recent advances in our understanding of molecular organization and function of cellular structures. The emphasis of this course will be on eukaryotic cells. Topics include membrane organization, cytoskeleton assembly and functions, signal transduction, cell-cycle regulation, protein sorting, and vesicle trafficking.

L587 Developmental Biology (4.5 cr.) Evaluation of classical and current molecular and genetic approaches to studying development of eukaryotic organisms. A significant portion of the course is devoted to discussing recent findings from molecular genetic studies in Drosophila and C. elegans.

L590 Seminar in Molecular, Cellular, and Developmental Biology (2 cr.) P: Consent of instructor. Presentation and discussion of topics in molecular and cellular biology as seminar by students. Topics from current literature. Concentration on a particular area each semester to be announced before registration. S/F grading.

L591 Plant Population Biology—An Experimental Approach (3 cr.) P: Ecology course and evolution course. The mechanisms by which plants, as individuals, contribute to development of population structure. Experimental studies of intra- and interspecific mechanisms of population regulation, reproduction, and vegetative growth. Emphasis on development and physiological characteristics which determine mode of interaction. Greenhouse projects designed and conducted by students.

L600 Special Topics in Genetics (cr. arr.) P: L364 or equivalent. Topics not extensively treated in other courses, e.g., population genetics, human genetics, immunogenetics, biochemical genetics of clones of mammalian cells. Topic presented will not be duplicated within three to five years. L600 carries credit in plant sciences, microbiology, and zoology programs.

L800 Research (1-15 cr.)
M300 Biomedical Sciences Documentation (1 cr.)
M310 Microbiology (3 cr.)
M315 Microbiology Laboratory (2 cr.)
M430 Virology: Lecture (3 cr.)
M435 Viral-Tissue-Culture Laboratory (3 cr.) P or C: M430, or consent of instructor.
M440 Medical Microbiology (3 cr.) P: BIOL–L211, M250, and M255
M460 Biology of the Prokaryotes (3 cr.)
M465 Biology of the Prokaryotes: Laboratory (3 cr.)
M480 Microbial and Molecular Genetics (3 cr.)
M485 Microbial and Molecular Genetics Laboratory (3 cr.)

M500 Introduction to Research (Microbiology) (1-6 cr.) P: Graduate standing. Objectives and techniques of microbiological research. Assignment to a research problem with a faculty member to be completed in two semesters.

M511 Molecular Biology of Prokaryotes (3 cr.) P: CHEM C584. The course will first develop an understanding of nucleic acid structure and function to a professional level, then use these principles to explore molecular aspects of gene expression and evolution. Emphasis will be on prokaryotes.

M512 Molecular Biology of AIDS Virus (3 cr.) P: CHEM C341 and BIOL L311. A detailed consideration of the human immunodeficiency virus (HIV, causative agent of AIDS). The functions of the HIV genes and how those functions affect pathology and normal cellular mechanisms.

M525 Topics in Microbial Biochemistry and Physiology (3 cr.) P: Graduate standing and C483 or M350 or equivalent. The course will consider topics in physiology and biochemistry of eukaryotic and prokaryotic microorganisms. Subjects include membrane physiology and regulatory networks in metabolism and gene expression.

M540 Medical Microbiology and Medical Immunology (2-5 cr.) Basic concepts of immunology; microorganisms as agents of disease, host-parasite relationships, epidemiology, chemotherapy.

M545 Medical Microbiology Laboratory (1 cr.) P: M540. Laboratory experiments to illustrate material discussed in M540.

M550 Microbiology (3 cr.) P: Two semesters of college chemistry; L211 recommended prior or concurrently. Application of fundamental principles to the study of microorganisms. Significance of microorganisms to humans and their environment. Critical evaluation of current microbiological literature.

M575 Human Parasitology (4 cr.) P: BIOL M310 and M315. Biology of human parasites focusing on their etiology, epidemiology, immunology, diagnosis, and treatment. Major groups of protozoa, helminths, and medically important arthropods covered. Independent research assigned on a special topic. Lab presents both live and fixed materials complementing lecture.

M610 Recent Advances in Microbiology (1-3 cr.) P: Graduate standing in microbiology or related area. Course content changes each semester so that over a cycle of several years, major research areas are covered. May be repeated for credit.

M612 Microbial Development (3 cr.) P: Graduate standing or consent of instructor. An analysis of recent publications concerned with the biochemistry of development in viral, prokaryotic, and simple eukaryotic systems. The topics vary and emphasize the regulatory aspects of development. Cell differentiation and cell-cell interactions are discussed.

M800 Research (1-12 cr.)

M850 Seminar (1 cr.) P: Graduate standing in microbiology or consent of instructor. Reports on assigned topics of current interest. May be repeated for credit. S/F grading.

T500 Project Laboratory in Biotechnology (6 cr.) Students explore the different stages of scientific investigation by performing research using the techniques of chemistry, biochemistry, molecular biology, genetics, and cell biology on problems related to biotechnology. Students design and execute research projects under supervision of the instructor in a teaching laboratory setting on problems chosen in consultation with the instructor.

T501 Topics in Biotechnology I (2 cr.) Students read and analyze research articles from the current literature and present the articles in a journal club format. Students will practice their presentation with the instructor prior to presenting to the group and will receive feedback on the content and the presentation style. Guest lecturers from industry are invited to present on a wide range of topics relevant to biotechnology.

T502 Topics in Biotechnology II (2 cr.) Follows from BIOL T501. Students read and analyze research articles from the current literature and present the articles in a journal club format. Articles can cover any area of biotechnology or any area relevant to biotechnology. Occasionally, invited guest lecturers from industry are invited to present on a wide range of topics relevant to biotechnology.

T510 Theory and Applications of Biotechnology Lecture I (3 cr.) This advanced, graduate-level course will focus on the applications of molecular genetics and recombinant DNA in biotechnology. Fundamental concepts of relevant molecular biology and biochemistry will be covered in depth in the first portion of the class, followed by sections on recombinant DNA technology, macromolecular purification, and genomics/bioinformatics

T511 Theory and Application of Biotechnology Lecture II (3 cr.) Course continues from BIOL T510 Theory and Applications of Biotechnology Lecture I. Focuses on applications of biotechnology including genetic engineering of plants and animals, bioremediation, biopharmaceutical production, vaccine development, and molecular diagnostics. Bioengineering principles of fermentation, scale-up, and high-throughput functional screening will be an important component of this material.

T515 Theory and Applications of Biotechnology Laboratory I (3 cr.) Students will learn advanced laboratory techniques currently used in biotechnology. Course is designed to cover advanced techniques at a deep level. As far as possible the laboratory exercises will be coordinated with BIOL T510 Theory and Applications of Biotechnology Lecture I. There will be two modules, one emphasizing cell biology and one emphasizing molecular biology.

T516 Theory and Applications of Biotechnology Laboratory II (3 cr.) Continues from BIOL T515. As far as possible the laboratory exercises will be coordinated with BIOL T511 Theory and Applications of Biotechnology Lecture II. There will be two modules, one emphasizing cell biology and one emphasizing molecular biology.

T521 Research Design and Ethics (2 cr.) Fundamentals of research protocol design and planning with applications to practical problems. Problems of research ethics and the role of biotechnology in human society will be addressed in class discussion and seminars.

Z373 Entomology (3 cr.)
Z374 Invertebrate Zoology (3 cr.)
Z383 Laboratory in Entomology (2 cr.)
Z406 Vertebrate Zoology (5 cr.)
Z420 Cytology (3 cr.)
Z460 Ethology (3 cr.)
Z466 Endocrinology (3 cr.)
Z476 Biology of Fishes (3 cr.)
Z486 Standards and Techniques of Animal Experimentation (2 cr.)

Z508 Advanced Ornithology (4 cr.) P: Z406. Emphasis on avian ecology, distribution, and behavior; discussion and evaluation of recent literature. Field work includes investigation of populations of a wintering species and a breeding species.

Z540 Genetics of Populations (3 cr.) P: Consent of instructor: R: Z465, MATH M216, or equivalent. Survey of the theoretical basis of population genetics and a review of current problems and experimental findings. Content varies from year to year.

Z566 Laboratory in Endocrinology (2 cr.) P: Z466. Development and structure of major endocrine glands; their role in maintaining constancy of internal environment. Limited to 12 students.

Z576 Invertebrate Zoology Laboratory (2 cr.) P or C: Z374. Laboratory and field studies of invertebrates, with an emphasis on experiments with living specimens.

Z620 Special Topics in Zoology (cr. arr.) P: Advanced undergraduate or graduate standing. Topics not extensively treated in other courses, e.g., theoretical zoology, oceanography, reservoir limnology, human ecology, biochemistry, viruses and disease, critical analysis of the scientific literature, and other fields. Topics presented will be treated every three to five years.