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analytical bibliography, editorial theory and practice, and the economics of textual dissemination. Course is repeatable as content changes.

ENGL 289. Seminar in Genres (4) Seminar, 3 hours; outside research, 3 hours. Prerequisite(s): graduate standing or consent of instructor. Examines individual literary genres (poetry, the novel, drama, etc.) and subgenres (epic, romance, lyric, comedy, etc.) in terms of current or historical genre theories. Course is repeatable as content changes.

ENGL 290. Directed Studies (1-4) Consultation, 1-3 hours; individual study, 12 hours. Prerequisite(s): consent of instructor and graduate advisor. Advanced research study culminating in written work. Course is repeatable.

ENGL 291. Individual Study in Coordinated Areas (1-12) outside research, variable. A program of study designed to advise and assist candidates who are preparing for examinations. Repeatable under the following rules: (1) a student may take up to 12 units prior to the award of the M.A.; (2) a student may take up to 24 additional units after award of the M.A. but prior to successful completion of the Ph.D. qualifying examination. Graded Satisfactory (S) or No Credit (NC). May be repeated for credit.

ENGL 292. Concurrent Analytical Studies (1-4) Prerequisite(s): instructor approval, or approval of instructor in the field under whom the work will be carried out. Each 292 course will be taken concurrently with some 100 series course but on an individual basis. It will be devoted to research, criticism, and written work of a graduate order commensurate in amount with the number of units elected. ENGL 101 and ENGL 103 may not be used for this arrangement. Graded Satisfactory (S) or No Credit (NC). May be repeated for credit.

ENGL 296. Master's Portfolio (2) Outside research, 6 hours; consultation, 2-3 hours. Prerequisite(s): completion of five quarters of master's study in English; consent of the Graduate Advisor. Students revise, extend, and develop essays written during their master's program in preparation for the master's portfolio examination. Graded Satisfactory (S) or No Credit (NC).

ENGL 299. Research for Thesis or Dissertation (1-12) Thesis, 3-36 hours. Prerequisite(s): satisfactory completion of the Ph.D. qualifying examination; consent of instructor. Research, under the direction of a faculty member, for preparation of the thesis or dissertation. Graded Satisfactory (S) or No Credit (NC). Course is repeatable; students may enroll in a maximum of 12 units per quarter.

Professional Courses

ENGL 301. Introduction to the Teaching of English (1) individual and group conferences, 1 hour. Prerequisite(s): graduate standing. A flexible program of meetings and workshops specifically devoted to orienting apprentices and transfer TAs to the writing program at UC Riverside. Concentrates on the problem of organizing and teaching ENGL 001A, ENGL 001B, and ENGL 001C or its equivalent. Required of all apprentices and transfer TAs. Students must enroll concurrently in ENGL 302. Graded Satisfactory (S) or No Credit (NC). May be repeated for credit for a maximum of 2 units.

ENGL 302. Teaching Practicum (1-4) Seminar, 1-4 hours. Prerequisite(s): graduate standing. A flexible program of meetings and conferences on the problems and techniques of writing instruction most pertinent to Basic Writing or to ENGL 001. Required of all TAs for at least five quarters, after which the TA may, with

the permission of the Director of ENGL 001, elect to take ENGL 304 instead. Open to all graduate students. Graded Satisfactory (S) or No Credit (NC). May be repeated for credit.

ENGL 303. Advanced Teaching Practicum (1-2) Discussion, 1 hour; practicum, 1-2 hours. Prerequisite(s): graduate standing or consent of instructor. A flexible program of meetings and conferences on the problems and techniques of teaching literature, cultural studies, film studies, and related courses. Graded Satisfactory (S) or No Credit (NC). Course is repeatable as content changes.

ENGL 304. Professional Research Preparations (4) Seminar, 3 hours; outside research, 3 hours; consultation, 5 hours per quarter. Prerequisite(s): consent of instructor. Covers the procedures, preparation, and presentation of oral and written research materials, including prospectus, with individual direction from instructor. Graded Satisfactory (S) or No Credit (NC).

ENGL 380. The Teaching of Written Composition (4) Summer Seminar, 8 hours. Prerequisite(s): consent of instructor; participation in the Inland Area Writing Project Summer Workshop. A study of research and practice in the teaching of written composition in the elementary and secondary schools. Offered in summer only. Students may receive either a letter grade or Satisfactory (S) or No Credit (NC) grade. See instructor for grading basis; no petition is required.

ENGL 381. Preparing to Teach Teachers (1-4) Summer Seminar, 2-8 hours. Prerequisite(s): consent of instructor; concurrent enrollment in ENGL 380. Participation in the Inland Area Writing Project Summer Workshop. Preparation and presentation of inquiry projects. Emphasis on inquiry into pedagogical assumptions and the way they contribute to expert teaching practices. Offered in summer only. Students may receive either a letter grade or Satisfactory (S) or No Credit (NC) grade. See instructor for grading basis; no petition is required.

Entomology

Subject abbreviation: ENTM
College of Natural and Agricultural Sciences

Richard A. Redak, Ph.D., Chair
William E. Walton, Ph.D., Vice Chair
Department Office, 175 Entomology
insects.ucr.edu

Graduate Student Affairs
(800) 735-0717 or (951) 827-4116
insects.ucr.edu/programs/graduate.html

Undergraduate Faculty Advisor
(951) 827-4562
insects.ucr.edu/programs/undergraduate.html

Professors

Michael E. Adams, Ph.D. (Entomology/Cell Biology and Neuroscience)
Peter W. Atkinson, Ph.D.
Nancy E. Beckage, Ph.D. (Entomology/Cell Biology and Neuroscience)
Thomas S. Bellows, Jr., Ph.D.
Ring T. Cardé, Ph.D. *Alfred M. Boyce Chair in Entomology*
Brian A. Federici, Ph.D.
J. Daniel Hare, Ph.D.
John M. Heraty, Ph.D.
Robert F. Luck, Ph.D.
Jocelyn G. Millar, Ph.D.
Thomas A. Miller, Ph.D.

Joseph G. Morse, Ph.D.
Bradley A. Mullens, Ph.D.
Timothy D. Paine, Ph.D.
Thomas M. Perring, Ph.D.
Alexander Raikhel, Ph.D.
Richard A. Redak, Ph.D.
Michael K. Rust, Ph.D.
Richard Stouthamer, Ph.D.
S. Nelson Thompson, Ph.D.
John T. Trumble, Ph.D.
William E. Walton, Ph.D.

Professors Emeriti

Leland R. Brown, Ph.D.
Richard D. Goeden, Ph.D.
E. Fred Legner, Ph.D.
James A. McMurtry, Ph.D.
Mir S. Mulla, Ph.D.
Earl R. Oatman, Ph.D.
John D. Pinto, Ph.D.

Associate Professors

P. Kirk Visscher, Ph.D.
Gregory P. Walker, Ph.D.

Assistant Professors

Anandasankar Ray, Ph.D.
Joao Pedra, Ph.D.
Weirauch, Christiane, Ph.D.

**

Lecturers

Elizabeth Grafton-Cardwell, Ph.D.
Pest Management
Matthew Daugherty, Ph.D., *Integrative Biology*
Alec Gerry, Ph.D. *Veterinary Entomology*
Mark Hoddle, Ph.D. *Biological Control*
Marshall W. Johnson, Ph.D. *Pest Management*
John H. Klotz, Ph.D. *Urban Entomology*
Robert Krieger, Ph.D. *Toxicology*

Cooperating Faculty

Linda Walling, Ph.D., *Genetics*

Major

The Department of Entomology offers undergraduate programs leading to either the B.S. or the B.A. degree. The B.S. degree offers students with a strong interest in the natural sciences an opportunity to emphasize this aspect of their education. The B.A. degree is available to students who wish to obtain a broader background in the humanities and social sciences than is required of students in the B.S. program.

Information on the programs and course requirements is available at CNAS Academic Advising Center, 1223 Pierce Hall. Counseling, course recommendations, and information on education and career goals are provided by the Undergraduate Faculty Advisor, Dr. Thomas M. Perring, 225 Entomology.

University Requirements

See Undergraduate Studies section.

College Requirements

See College of Natural and Agricultural Sciences, Colleges and Programs section.

Some of the following requirements for the major may also fulfill some of the college's breadth requirements. Consult with a department advisor for course planning.

Major Requirements

The major requirements for both the B.A. and the B.S. degrees in Entomology are as follows:

1. Lower-division requirements (50–51 units)
 - a) BIOL 005A, BIOL 05LA, BIOL 005B, BIOL 005C
 - b) PHYS 002A, PHYS 002B, PHYS 002C, PHYS 02LA, PHYS 02LB, PHYS 02LC
 - c) MATH 008B or MATH 009A, MATH 009B
 - d) CHEM 001A, CHEM 001B, CHEM 001C, CHEM 01LA, CHEM 01LB, CHEM 01LC
2. Upper-division requirements (67 units)
 - a) ENTM 100/BIOL 100, ENTM 107, ENTM 173/BIOL 173, and 4 units in any combination of ENTM 190, ENTM 197, ENTM 199, or ENTM 199H
 - b) Twenty-four (24) additional units of entomology electives, which may include up to 2 additional units of ENTM 190, ENTM 197, or ENTM 199H
 - c) BCH 100
 - d) BIOL 102
 - e) BIOL 107A
 - f) CHEM 112A, CHEM 112B, CHEM 112C
 - g) STAT 100A

BIOL 151 and BIOL 175 are suggested in order to acquire a background in the life sciences appropriate for an Entomology major.

For students intending to specialize at the graduate level in insect toxicology or insect physiology, biochemistry, and molecular biology, it is recommended that the BCH 110A, BCH 110B, and BCH 110C sequence and BCH 102 be substituted in place of an equal number of upper-division course units in life sciences. Due to course content overlap, credit is not awarded for BCH 110A, BCH 110B, or BCH 110C if it has already been awarded for BCH 100.

Sample Program

| Freshman Year | Fall | Winter | Spring |
|---|-----------|-----------|-----------|
| BIOL 005A, BIOL 05LA; BIOL 005B | | 4 | 4 |
| CHEM 001A, CHEM 001B, CHEM 001C, CHEM 01LA, CHEM 01LB, CHEM 01LC | 4,1 | 4,1 | 4,1 |
| ENGL 001A, ENGL 001B, ENGL 001C | 4 | 4 | 4 |
| MATH 008B or MATH 009A, MATH 009B | 4 | 4 | |
| Humanities/Social Sciences | 4 | | 4 |
| Total Units | 17 | 17 | 17 |
| Sophomore Year | Fall | Winter | Spring |
| BIOL 005C | 4 | | |
| Biology/Entomology Electives CHEM 112A, CHEM 112B, CHEM 112C | 4 | 4 | 4 |
| PHYS 002A, PHYS 002B, PHYS 002C | 4 | 4 | 4 |
| PHYS 02LA, PHYS 02LB, PHYS 02LC | 1 | 1 | 1 |
| Humanities/Social Sciences, STAT 100A | 4 | 4 | 5 |
| Total Units | 17 | 17 | 14 |

| Junior Year | Fall | Winter | Spring |
|----------------------------------|-----------|-----------|-----------|
| BIOL 102 | 4 | | |
| BIOL 107A, ENTM 173/ BIOL 173 | 4 | | 4 |
| ENTM 100/BIOL 100 | 4 | | |
| ENTM 107 | | 4 | |
| Biology/Entomology Electives | | 7 | 8 |
| BCH 100, ENTM 19X | 4 | 2 | |
| Humanities/Social Sciences | | 4 | 4 |
| Total Units | 16 | 17 | 16 |
| Senior Year | Fall | Winter | Spring |
| ENTM 19X | 2 | | |
| Biology/Entomology Electives | 8 | 8 | 8 |
| Humanities/Social Sciences | 4 | 8 | 4 |
| Total Units | 14 | 16 | 12 |

Minor

The Department of Entomology offers a minor in Entomology designed to allow the student the freedom to pursue areas of particular interest.

The minor consists of no less than 20 and no more than 28 units of Entomology courses to be selected as follows:

1. ENTM 100/BIOL 100
2. Select from the following upper-division Entomology courses to complete unit requirement: ENTM 106, ENTM 107, ENTM 109, ENTM 112/BIOL 112/ BPSC 112, ENTM 114, ENTM 124, ENTM 126, ENTM 126L, ENTM 127/BIOL 127, ENTM 128, ENTM 129, ENTM 129L, ENTM 133, ENTM 162/BIOL 162, ENTM 173/BIOL 173, ENTM 190, ENTM 197, ENTM 199, ENTM 199H
3. No more than 4 units of ENTM 190, ENTM 197, ENTM 199, or ENTM 199H, either solely or in combination, may be applied toward the unit requirement.
4. Of the specified upper-division units, a minimum of 16 must be unique to the minor and may not be used to satisfy major requirements.

See Minors under the College of Natural and Agricultural Sciences in the Colleges and Programs section of this catalog for additional information on minors.

Graduate Program

The Department of Entomology offers programs leading to the M.S. (thesis plan) and Ph.D. degrees with specialization in, but not restricted to, the following areas of study:

- Arthropod vectors of plant pathogens
- Behavior
- Biochemistry and physiology
- Biological control
- Chemical ecology
- Ecology and evolution
- Integrated pest management
- Insect–plant interactions
- Medical and veterinary entomology
- Molecular entomology
- Nematology
- Neuroscience

- Pathology
- Pesticide toxicology
- Systematics
- Urban entomology

Information on participating faculty and their research specializations may be found at insects.ucr.edu. University requirements for the M.S. and Ph.D. degrees are given in the Graduate Studies section of this catalog.

Teaching Requirement Ph.D. students must fulfill a two-quarter teaching requirement.

Admission Students must have a bachelor's degree with a major in Entomology, a biological science, Chemistry, Biochemistry, or a suitable equivalent. Regardless of undergraduate major, students must have had, or complete soon after entering graduate school, the following:

1. One year of course work each in general biology, general chemistry, and organic chemistry.
2. The equivalent of a one quarter course each in genetics and biochemistry.
3. The equivalent of 30 quarter units of life sciences other than entomology. Students who wish to specialize in insect biochemistry, insect physiology, molecular entomology, neuroscience, or toxicology may substitute additional courses in physical, organic, and biological chemistry; toxicology; and pharmacology for courses in life sciences.

Credit from these courses does not count toward the unit requirement of the M.S. degree.

The department requires GRE General Test scores (verbal, quantitative, and analytical). All applicants whose first language is not English and do not have an undergraduate or graduate degree from an accredited institution where English is the exclusive language of instruction must submit a recent Test of English as a Foreign Language (TOEFL) and obtain a minimum score on the exam of 550 (paper-based), 213 (computer-based), or 80 (internet-based).

Course Work All students must take ENTM 201, ENTM 202, and ENTM 203.

Normative Time to M.S. 6 quarters

Normative Time to Ph.D. 17 quarters

Opportunities for Interdisciplinary Graduate Study

Faculty from the Department of Entomology also participate in the following additional graduate programs:

- Biochemistry and Molecular Biology
- Cell, Molecular, and Developmental Biology (CMDB)
- Neuroscience
- Chemistry
- Environmental Toxicology

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- Evolution, Ecology, and Organismal Biology (EEOB)
- Genetics, Genomics and Bioinformatics

These interdepartmental programs draw on the strengths of distinguished scientists from several units. For further information concerning work in these areas, see the respective program descriptions in the Programs and Courses section of this catalog or contact the Biological Sciences Graduate Student Affairs Center, at (800) 735-0717.

Lower-Division Courses

ENTM 010. Natural History of Insects (4) F, W, S

Lecture, 3 hours; demonstrations, 1 hour. A study of the fascinating world of insects and of their impact on man; designed for non-entomology majors. Living and preserved insects and many other visual aids are used.

ENTM 020. Bees and Beekeeping (4) S, Even Years

Lecture, 3 hours; discussion, 1 hour. Fundamentals of keeping honey bees, their fascinating social behavior, and their economic importance as pollinators of agricultural crops and as producers of honey and other products. Demonstrations of bee biology and behavior, with colonies of bees, and of beekeeping techniques, equipment, and extraction of honey. **Visscher**

Upper-Division Courses

ENTM 100. General Entomology (4) F, S Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): BIOL 005B, BIOL 005C, or equivalents; or consent of instructor. Introductory study of insects, Earth's most diverse group of animals (75 percent of animal species are insects). Lecture covers the anatomy, physiology, ecology, behavior, and diversity of insects. Laboratory focuses on insect identification. Cross-listed with BIOL 100. **Rust, Rust, Walker**

ENTM 106. Insect Evolution (3) S Lecture, 2 hours; laboratory, 3 hours. Prerequisite(s): BIOL 100/ENTM 100 or consent of instructor. Introduces principles of insect morphology, with emphasis on characters of phylogenetic and adaptive significance and insect evolution. Topics include the comparative anatomy and phylogenetic relationships of extinct and living insect groups. Laboratory emphasizes principles of comparative morphology and evolutionarily important character complexes. **Weirauch**

ENTM 107. Insect Biodiversity (3) W Lecture, 2 hours; laboratory, 3 hours. Prerequisite(s): BIOL 100/ENTM 100 or consent of instructor. Lectures introduce the science of insect systematics, stressing diagnostic characters of the major taxa and insect biodiversity. Laboratories focus on developing skills in insect identification to the family level. **Weirauch**

ENTM 109. Field Entomology (4) S Laboratory, 4 hours; field, 8 hours. Prerequisite(s): BIOL 100/ENTM 100 or equivalents or consent of instructor. Study and field collection of insects in selected ecological communities from the diversity of life zones comprising Southern California. Students prepare specimens collected to professional standards, identify specimens, and submit their collections for grading and incorporation into the Department of Entomology's teaching and research collections. **Staff**

ENTM 112. Systematics (4) W Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIOL 005C or equivalent. Principles and philosophy of classification: phylogenetic and phenetic methods, species concepts, taxonomic characters, evolution, hierarchy of categories, and nomenclature. Cross-listed with BIOL 112 and BPSC 112. **Heraty**

ENTM 114. Aquatic Insects (4) S, Even Years Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): BIOL 005A, BIOL 005B, BIOL 005C; or consent of instructor. Investigates aquatic insects as nutrient cyclers, pollution indicators, disease vectors, and fish food. Involves identification of major orders and families, morphological and physiological adaptations, and life history strategies. Laboratory emphasizes identification (collection) and includes a group field ecology project and two weekend field trips. **Mullens, Walton**

ENTM 124. Agricultural Entomology (4) F, Odd Years

Laboratory, 4 hours; field, 8 hours. Prerequisite(s): BIOL 100/ENTM 100 or equivalent or consent of instructor. Identification, life history, ecology, distribution, and management of key pest and beneficial species learned through field observation, discussions with industry representatives, and laboratory study. Detailed notes and collections from field trips to all major growing regions of Southern California form the basis for laboratory discussion. **Perring**

ENTM 126. Medical and Veterinary Entomology (4) W, Odd Years

Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): BIOL 005B, BIOL 005C; or consent of instructor. Covers biology, ecology, and management of arthropods that affect human and animal health. Considers arthropods as direct pests and vectors of notorious diseases (e.g., malaria, plague). Also addresses disease epidemiology and prevention, as well as control of pests and associated diseases. **Mullens**

ENTM 127. Insect Ecology (4) W Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIOL 005A, BIOL 05LA, BIOL 005B, BIOL 005C, CHEM 001C or CHEM 01HC, CHEM 112C, MATH 009B or MATH 09HB, PHYS 002C, PHYS 02LC, BCH 100 or BCH 110A, one course in statistics; or consent of instructor.

Introduces principles of insect ecology with examples emphasizing the Arthropoda. Topics include factors governing population growth; ecological and evolutionary interactions with hosts, competitors, and natural enemies; structure of ecological communities; and adaptations to different environments. Cross-listed with BIOL 127. **Bellows, Jr., Walton**

ENTM 128. Chemistry and Toxicology of Insecticides (3) F, Odd Years

Lecture, 3 hours. Prerequisite(s): a course in organic chemistry, BIOL 100/ENTM 100; or consent of instructor. Chemical properties and reactions of insecticides and acaricides and their modes of action and biochemical behavior in animal and plant systems. **Miller**

ENTM 129. Introduction to Biological Control (2) F

Lecture, 2 hours. Prerequisite(s): BIOL 100/ENTM 100 or consent of instructor. Principles and methods of biological control; biology and behavior of entomophagous insects; historical review and critique of important world projects. **Stouthamer**

ENTM 129L. Introduction to Biological Control Laboratory (2) F

Laboratory, 6 hours. Prerequisite(s): ENTM 129 (it is strongly recommended that ENTM 129L be taken concurrently with ENTM 129). Laboratory identification of entomophagous insects; experiments designed to illustrate various types of parasitism; familiarization with mass rearing and culture techniques for entomophagous insects. **Stouthamer**

ENTM 133. Urban Entomology (4) S, Even Years

Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): BIOL 100/ENTM 100 or consent of instructor. Biology and management of arthropod pests of the urban-industrial community with an emphasis on structural, household, and stored product pests. Exercises on the recognition and identification of these pests, their life histories, and strategies for their control. **Rust**

ENTM 162. Insect Behavior (4) F

Lecture, 4 hours. Prerequisite(s): BIOL 100 /ENTM 100; or BIOL 005A, BIOL 005B, and BIOL 005C; or consent of instructor. An analysis of the mechanisms that cause and control behavioral reactions of insects. Emphasis on ethological and physiological knowledge concerning orientation mechanisms, communication systems, learning, and the role of the nervous system in integrating behavior in insects. Cross-listed with BIOL 162. **Carde, Visscher**

ENTM 173. Insect Physiology (4) S

Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): BIOL 005A and BIOL 005B or equivalents; CHEM 112A, CHEM 112B, CHEM 112C or equivalents; or consent of instructor. Introduction to principles of insect physiology. Subjects include growth, development and hormones, cuticle, nervous system, circulation, respiration, digestion, nutrition, excretion, reproduction, water balance, and temperature relations. Prior knowledge of insects is not assumed. Cross-listed with BIOL 173. **Miller, Thompson**

ENTM 190. Special Studies (1-4) F, W, S

Individual study, 3-12 hours. Prerequisite(s): upper-division standing or consent of instructor. Directed studies by a faculty member to address specific curricular needs. Written report required. Course is repeatable as content changes to a maximum of 4 units.

ENTM 197. Research for Undergraduates (1-4) F, W, S

Outside research, 3-12 hours. Prerequisite(s): upper-division standing or consent of instructor. Original research conducted under faculty supervision. Requires a formal oral presentation, poster project, or a written report. Course is repeatable.

ENTM 199. Senior Research (1-4) F, W, S, Summer

Outside research, 3-12 hours. Prerequisite(s): senior standing; consent of instructor. Research in entomology performed under supervision of a faculty member. Requires a formal written report in the format of a research publication. Course is repeatable to a maximum of 6 units.

ENTM 199H. Senior Honors Research (1-5) F, W, S

Laboratory, 3-15 hours. Prerequisite(s): senior status and consent of instructor; a GPA of 3.5 or better in entomology courses and 3.2 in all University course work. Research in entomology under supervision of a faculty member in entomology. The student will submit a written report. Course is repeatable.

Graduate Courses

ENTM 201. Structure and Function of Insects (5) F

Lecture, 3 hours; laboratory, 3 hours; discussion, 1 hour. Prerequisite(s): BCH 100 or BCH 110A; BIOL 100/ENTM 100 (both may be taken concurrently); or consent of instructor. Introduces principles of insect physiology and morphology. Topics include insect development, reproduction, circulation, metabolism and excretion, respiration, digestion, and fundamentals of the nervous system.

ENTM 202. Molecular Biology, Systematics, and Behavior (5) W

Lecture, 3 hours; laboratory, 3 hours; discussion, 1 hour. Prerequisite(s): BCH 100 or BCH 110A; ENTM 201; or consent of instructor. Introduces

principles of molecular biology, systematics, and insect behavior. Topics include the use of molecular tools in Entomology, the application of systematics in understanding insect evolution, and behavior particular to insects and relevant to insect research in a range of subdisciplines.

ENTM 203. Ecology, Population Genetics, and Pest Management (5) S Lecture, 3 hours; laboratory, 3 hours; discussion, 1 hour. Prerequisite(s): ENTM 202, undergraduate course in ecology; or consent of instructor. Introduces principles of insect ecology, genetics, evolution, and pest management. Topics include insect population dynamics and community interactions, genetics of geographic variation, adaptation of insect populations, and the ecological, behavioral, and genetic basis for management and control of pestiferous species.

ENTM 207. Arthropod Vectors in Relation to Plant Disease (4) S, Even Years Lecture, 2 hours; laboratory, 6 hours. Prerequisite(s): BIOL 100/ENTM 100, BIOL 120/MCBL 120/PLPA 120; or consent of instructor. Detailed analyses of interacting mechanisms involved in the transmission of plant pathogens by arthropods. Emphasis on learning through extensive laboratory experimentation. **Perring**

ENTM 208. Host-Parasite Relationships (3) F, W, S Lecture, 3 hours. Prerequisite(s): BIOL 100/ENTM 100 or BIOL 157 or consent of instructor. Explores the fundamental biochemical and developmental requirements for "successful" host-parasite relationships in insects. Emphasizes wasp and nematode parasites of insects and vector-parasite interactions involved in transmission of parasites in malaria, trypanosoma, and Lyme disease. Cross-listed with BIOL 208. **Beckage**

ENTM 209. Microtechniques in Insect Morphology (3) W, Even Years Laboratory, 6 hours; outside research, 3 hours. Prerequisite(s): BIOL 005A, BIOL 005B, BIOL 100/ENTM 100; or equivalents; or consent of instructor. Development of research techniques and skills used in the study of insect morphology. Covers the principles of and provides hands-on experience with the following: optical microscopy, scanning electron microscopy, whole-mount slide preparation techniques, morphometric measurement and analysis, scientific illustration, macrophotography, and histological techniques. **Walker**

ENTM 210. Molecular Biology of Human Disease Vectors (3) Lecture, 2 hours; seminar, 1 hour. Prerequisite(s): consent of instructor. Covers the molecular aspects of vectors transmitting most dangerous human diseases. Involves lectures and student presentations about current issues in molecular biology and genomics of vector insects and pathogens they transmit. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with CMDB 210 and MCBL 210. **Raikhel**

ENTM 212. Ecological Systems in Space and Time (4) F, W, S Lecture, 3 hours; field, 30 hours per quarter. Prerequisite(s): BIOL 117 or BIOL 152/GEO 152 or equivalent or consent of instructor. Focuses on how ecological systems are interpreted and reconciled at the community, landscape, and paleontological scales. Addresses the role of extrinsic factors operating at each of these scales. Also examines the historical development of our understanding of ecological systems at various scales. Cross-listed with BIOL 212 and GEO 212.

ENTM 219. Theory of Systematics (4) F, W, S Lecture, 4 hours. Prerequisite(s): BIOL 112/BPSC 112/ENTM 112 or equivalent or consent of instructor. Examines topics developed around a series of classical and

recent papers on the principles, philosophy, and methodology of modern systematics and phylogenetic methods. Cross-listed with EEOB 219 and GEO 219.

Heraty, Springer

ENTM 227. Insect Population Ecology (3) W, Odd Years Lecture, 3 hours. Prerequisite(s): BIOL 127/ENTM 127 or consent of instructor. Recommended: ENTM 129; STAT 100A; STAT 100B or equivalent. Theory of animal population regulation. Factors affecting distribution and abundance of animals with emphasis on examples from the Arthropoda. **Luck**

ENTM 229. Advanced Biological Control (4) F, Alternate Years Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): BIOL 127/ENTM 127, ENTM 129, or equivalents, or consent of instructor. The lecture explores theory and practices relating to the use of natural enemies in the suppression of insect, weed, pathogen, and vertebrate populations. The laboratory surveys insect and other natural enemies, their attributes, collection, cultivation, quarantine handling, and field use. Normally letter graded, but students may petition the instructor for a Satisfactory (S) or No Credit (NC) grade. **Staff**

ENTM 230. Entomophagous Insects (4) F Lecture, 2 hours; laboratory, 6 hours. Prerequisite(s): BIOL 100/ENTM 100 or equivalent, graduate standing; or consent of instructor. Introduces the biology and identification of entomophagous insects. Students collect and rear parasites and prepare specimens according to professional standards. Laboratory identification focuses on the family level for parasitic insects. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. **Heraty**

ENTM 231. Insect Pathology (4) S, Even Years Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): BIOL 100/ENTM 100, at least one course in microbiology; or consent of instructor. Consideration of the principles of general insect pathology and microbiology. Detailed study of noninfectious and infectious diseases of insects, diagnosis, epizootiology, physiopathology, symptomatology, and the use of microbial agents in the control of insect pests. **Federici**

ENTM 232. Molecular Biology of Insects (4) S, Even Years Lecture, 3 hours; workshop, 1 hour. Prerequisite(s): BIOL 107A or consent of instructor. Application of molecular biology to entomology and entomological problems. Emphasizes how molecular biological tools are used to understand insect genome organization, pest resistance, transgenic insects, insect behavior, and insect systematics. **Atkinson**

ENTM 240. Research Methods in Insect Chemical Ecology (4) W, Odd Years Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIOL 127/ENTM 127 or ENTM 203 or consent of instructor. Survey of the methods used in the isolation, identification, and bioassay of biologically active natural products. Topics include bioassay design and execution, and microscale chemical separation and identification techniques. Students who present a seminar receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. **Millar**

ENTM 241. Insect-Plant Interactions (4) F, Odd Years Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIOL 127/ENTM 127 or consent of instructor. Concepts of the development and maintenance of ecological associations between plants and arthropod herbivores in ecological and evolutionary time; organization of arthropod communities on plants; phytochemical basis for the mediation of plant-arthropod associations; coevolution of plants and herbivorous insects; manipulation of plant-arthropod associations in arthropod pest management programs. **Hare, Paine, Trumble**

ENTM 242. Development of Hypotheses and Research Design (3) F, W, S Lecture, 1 hour; discussion, 1 hour; written work, 3 hours. Prerequisite(s): graduate standing or consent of instructor. Teaches fundamentals of research topic selection, development of hypotheses, and selection of experimental designs. Students prepare full-length federal grant proposals, then review and rank them in grant panel review format. **Millar, Trumble**

ENTM 243. Advanced Insect Physiology, Biochemistry, and Molecular Biology (3) W, Even Years Lecture, 2 hours; seminar, 1 hour. Prerequisite(s): BCH 211 or ENTM 232 or both ENTM 202 and ENTM 203; or consent of instructor. Explores the latest key issues of insect physiology, biochemistry, and molecular biology. **Raikhel**

ENTM 249. Special Topics in Entomology (1-6) Lecture, 1-6 hours; laboratory, 0-15 hours.

Prerequisite(s): graduate standing or consent of instructor. Explores topics in entomology within the area of specialization of each faculty member. Content emphasizes recent advances in the special topic area and varies accordingly. Students who take examinations or submit a term paper receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable as content changes.

ENTM 250. Seminar in Entomology (1) F, W, S Seminar, 1 hour. A series of lectures by visiting scientists, staff and advanced graduate students on research topics in entomology and allied fields. Graded Satisfactory (S) or No Credit (NC).

ENTM 251. Seminar in Insect-Plant Interactions (2) W Seminar, 2 hours. Prerequisite(s): ENTM 241 or consent of instructor. Rigorous examinations and interpretation of recent publications in the area of insect-plant interactions. Subject matter varies from year to year. Course may be taken more than once for credit. **Paine, Trumble**

ENTM 252. Seminar in Insect Behavior (2) S Seminar, 2 hours. Prerequisite(s): BIOL 162/ENTM 162 or consent of instructor. An analysis and interpretation of published experimental data dealing with insect behavior, and an attempt to derive general principles underlying behavior. Subject matter varies from year to year. Course is repeatable as content changes. **Carde, Millar, Visscher**

ENTM 254. Seminar in Biological Control (2) F Seminar, 2 hours. Prerequisite(s): BIOL 127/ENTM 127, ENTM 129; or consent of instructor. Concepts, questions and hypotheses in biological control. Students who present a seminar receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. **Bellows, Stouthamer**

ENTM 255. Seminar in Medical and Veterinary Entomology (2) F Seminar, 2 hours. Prerequisite(s): ENTM 126 or consent of instructor. Rigorous review and analysis of advanced topics in medical and veterinary entomology and related disciplines. Students who present a seminar receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable as content changes. **Mullens, Walton**

ENTM 256. Seminar in Systematic Entomology (2) S Seminar, 2 hours. Prerequisite(s): BIOL 112/BPSC 112/ENTM 112 or consent of instructor. Selected topics in insect systematics. Students who present a seminar receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable as content changes. **Heraty**

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ENTM 258. Seminar in Insect Pest Management (2) W Seminar, 2 hours. Prerequisite(s): consent of instructor. Selected topics in insect pest management. Students who present a seminar receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable as content changes. **Perring**

ENTM 261. Seminar in Genetics, Genomics, and Bioinformatics (1) W, S Seminar, 1 hour. Prerequisite(s): graduate standing or consent of instructor. Oral reports by visiting scholars, faculty, and students on current research topics in Genetics, Genomics, and Bioinformatics. Graded Satisfactory (S) or No Credit (NC). Course is repeatable. Cross-listed with BCH 261, BIOL 261, BPSC 261, GEN 261, and PLPA 261.

ENTM 262. Seminar in Molecular Biology and Genomics of Disease Vectors (1) Seminar, 1 hour. Prerequisite(s): graduate standing or consent of instructor. Seminar series, sponsored by the Center for Disease-Vector Research at the Institute for Integrative Genome Biology, provides an opportunity for graduate students to discuss current issues of molecular biology and genomics of vector insects and pathogens they transmit with guest speakers. Graded Satisfactory (S) or No Credit (NC). Course is repeatable. Cross-listed with MCBL 262.

ENTM 271. Research Seminar in Management of Vegetable Crop Pests (1) W Seminar, 1 hour. Prerequisite(s): consent of instructor. Seminar and critical discussion emphasizing current research and advances in management of vegetable crop pests. Graded Satisfactory (S) or No Credit (NC). Course is repeatable. **Trumble**

ENTM 272. Research Seminar in Insect Communication and Behavior (1) F, W, S Seminar, 1 hour. Prerequisite(s): consent of instructor. Seminar and critical discussion emphasizing current research and advances in insect communication and behavior. Graded Satisfactory (S) or No Credit (NC). Course is repeatable. **Carde, Millar, Visscher**

ENTM 276. Research Seminar in Medical, Urban, and Veterinary Entomology (1) F, S Seminar, 1 hour. Prerequisite(s): consent of instructor. Seminar and critical discussion emphasizing current research and advances in medical, urban, and veterinary entomology. Graded Satisfactory (S) or No Credit (NC). Course is repeatable. **Mullens, Rust, Walton**

ENTM 277. Research Seminar in Insect Biochemistry and Toxicology (1) F, W, S Seminar, 1 hour. Prerequisite(s): consent of instructor. Seminar and critical discussion emphasizing current research and advances in insect biochemistry and toxicology. Graded Satisfactory (S) or No Credit (NC). Course is repeatable. **Gill**

ENTM 289. Special Topics in Neuroscience (2) F, W, S Seminar, 2 hours. Prerequisite(s): graduate standing or consent of instructor. An interdisciplinary seminar consisting of student presentations and discussion of selected topics in neuroscience. Content and instructor(s) vary each time course is offered. Students who present a seminar receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable. Cross-listed with BCH 289, BIOL 289, CHEM 289, NRSC 289, and PSYC 289. **Hatton**

ENTM 290. Directed Studies (1-6) F, W, S Literature studies on special topics under direction of a member of the staff. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

ENTM 291. Individual Study in Coordinated Areas (1-6) F, W, S Prerequisite(s): graduate standing. Faculty assisted programs of individual study for candidates who are preparing for examinations. The following rules apply: 1) Up to 6 units may be taken prior to award of the Master's degree, such units to be in addition to minimum unit requirements for the degree; 2) Up to 12 additional units may be taken prior to advancement to candidacy for the Ph.D.; 3) The course may be repeated within these limits. Graded Satisfactory (S) or No Credit (NC).

ENTM 297. Directed Research (1-6) F, W, S Exploratory research toward the development of the dissertation problem or other research not specifically for thesis or dissertation. Graded Satisfactory (S) or No Credit (NC).

ENTM 299. Research for Thesis or Dissertation (1-12) F, W, S Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

Professional Courses

ENTM 301. Teaching Entomology at the College Level (1) F, W, S Seminar, 1 hour. Prerequisite(s): graduate standing in Entomology. A program of weekly meetings and individual formative evaluation required of new entomology Teaching Assistants. Covers instructional methods and classroom/section activities most suitable for teaching Entomology. Conducted by departmental faculty or the Teaching Assistant Development Program. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

ENTM 302. College Teaching Practicum (1-4) F, W, S practicum/consultation, 3-12 hours. Prerequisite(s): graduate standing and consent of instructor. Supervised teaching in college level classes under supervision of the course instructor. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

Environmental Engineering

See Chemical and Environmental Engineering

Environmental Sciences

Subject abbreviation: ENSC
College of Natural and Agricultural Sciences

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Professors

Christopher Amrhein, Ph.D. *Soil Chemistry*
Michael A. Anderson, Ph.D. *Environmental Chemistry*
Janet T. Arey, Ph.D. *Atmospheric Chemistry*
Roger Atkinson, Ph.D. *Atmospheric Chemistry*
David E. Crowley, Ph.D. *Soil Microbiology*
Ariel Dinar, Ph.D., *Environmental Economics*

William T. Frankenberger, Jr., Ph.D. *Soil Microbiology*
Jianying "Jay" Gan, Ph.D. *Environmental Chemistry*
Robert C. Graham, Ph.D. *Soil Mineralogy and Pedology*
Keith C. Knapp, Ph.D. *Natural Resource Economics*
David R. Parker, Ph.D. *Soil Biogeochemistry*
Roberto Sánchez-Rodríguez, Ph.D. *Environmental Policy*
Daniel Schlenk, Ph.D. *Aquatic Ecotoxicology*
Jiri Simunek, Ph.D. *Hydrology*
Laosheng Wu, Ph.D. *Soil Physics*
Marylynn V. Yates, Ph.D. *Environmental Microbiology*
Paul J. Ziemann, Ph.D. *Atmospheric Science*

Professors Emeriti

Andrew C.-S. Chang, Ph.D. *Agricultural Engineering*
Walter J. Farmer, Ph.D. *Soil Chemistry*
William A. Jury, Ph.D. *Soil Physics*
John Letey, Jr., Ph.D. *Soil Physics*
Lanny J. Lund, Ph.D. *Soil Morphology, Genesis, and Classification*
Albert L. Page, Ph.D. *Soil Chemistry*
Henry J. Vaux, Jr., Ph.D. *Natural Resource Economics*

Associate Professors

Kenneth A. Baerenklau, Ph.D. *Resource and Environmental Economics*
David M. Crohn, Ph.D. *Biosystems Engineering*
Linda Fernandez, Ph.D. *Resource and Environmental Economics*
Kurt A. Schwabe, Ph.D. *Resource and Environmental Economics*

Assistant Professors

James Sickman, Ph.D. *Watershed Hydrology and Biogeochemistry*

**

Adjunct Assistant Professors

W. Bowman Cutter, Ph.D. *Resource and Environmental Economics*
Brian Lanoil, Ph.D. *Environmental Microbiology*
Lisa Stein, Ph.D. *Environmental Microbiology*

Major

The Department of Environmental Sciences offers B.A. and B.S. degrees in Environmental Sciences. Students can choose to concentrate their studies in one of three options: Natural Science, Social Science, or Environmental Toxicology.

The necessity of maintaining an acceptable level of environmental quality is placing increasing demands upon governments and industries locally, nationally, and worldwide. To help meet those demands, the Environmental Sciences program is designed to provide training for students intending to enter environmental professions or for students preparing for graduate study in law, research, or teaching in a capacity that utilizes a background in the science of the human environment.

The structure of the Environmental Sciences curriculum provides a broad scope of instruction that enables students to explore the various disciplines and professions involved with solving environmental problems as well as opportunities for students to focus their training in accordance with their own educational and career objectives. All students majoring in Environmental Sciences