

DEPARTMENT OF BIOLOGY, HEALTH, AND THE ENVIRONMENT

Mission Statement

The Department of Biology, Health, and the Environment's mission is to educate, inspire, and assist students and regional diverse populations through a comprehensive curriculum, emergent pedagogy, and collaborative research. We focus on the complexity and factors that influence life, and we strive to understand how the processes that sustain life and enable biological innovation operate and interact within and across different scales of organization: from molecules to cells, tissues to organisms, species, ecosystems, biomes, and the Earth.

General Information

Faculty conduct research related to how environments affect cells, microbes, plants, animals, and ecosystems. Researchers' interests range from cell growth, development, and reproduction to the effects of hormones on plant growth and development to signaling between plants and ecology. The department also has a strong core of faculty interested in conserving and restoring our natural resources, including soil health, river restoration, and wildlife habitat.

Degrees

The Department of Biology, Health, and the Environment offers the following graduate degrees:

- Master of Science degree in Biology
 - Thesis option
 - Emphasis in Developmental and Regenerative Sciences
 - Emphasis in Ecology
 - Emphasis in Microbiology and Immunology
 - Emphasis in Neuroscience
 - Non-thesis options
 - Open Emphasis
 - Pre-professional human health emphasis
- Master of Science degree in Environmental Science
 - Thesis Option
 - Non-thesis option
- Certificate in Environmental Science
- Certificate in Environmental Sustainability
- Doctor of Philosophy in Environmental Science and Engineering with the School of Civil and Environmental Engineering, and Construction Management.
- M.S. in Biology (p. 1)
- M.S. in Environmental Science (p. 5)
- Ph.D. in Environmental Science and Engineering (p. 7)

Master of Science Degree in Biology

The graduate program offers advanced study and research opportunities leading to the Master of Science degree in Biology. The Master's degree allows students to take a wide variety of elective courses,

providing an expansive knowledge base across many life sciences areas. A thesis option is offered to students who want an extended opportunity to develop expertise in research techniques and data analysis and is recommended for those who plan a research career or contemplate pursuing a doctorate in one of the life sciences. There are four emphases within which to conduct a thesis: Developmental and Regenerative Sciences, Ecology, Microbiology and Immunology, and Neuroscience. There are also two non-thesis options, including one pre-professional human health emphasis.

Qualified students are encouraged to apply for teaching assistantships and fellowships.

Program Outcomes

Graduates of the M.S. Degree in Biology program will be able to:

- Explain advanced concepts in biology, including evolution, cell theory, the chemical basis of life, expression, and transmission of genetic information, energy transfer and transformation, integration of living systems, and species diversity.
- Explain the relationship between structure and function at all levels of biological organization, including molecular, cellular, organismal, population, and ecosystem levels.
- Apply the process of scientific inquiry.
- Use appropriate quantitative and qualitative methods to collect and/or evaluate biological data.
- Demonstrate critical thinking skills in relation to biological issues.
- Effectively communicate scientific information and the relationship between science and society to a diverse audience through oral, written, and visual means.

Program Admission Requirements

To be considered for degree-seeking status, applicants must submit, along with the application, two letters of recommendation and a Statement of Future Plans, including a reason why the student wishes to pursue an M.S. in Biology and why the student wishes to participate in a particular thesis or non-thesis option (described below). In addition to satisfying the University-wide graduate admission requirements, applicants are expected to have completed coursework equivalent to that required for a bachelor's degree in Biology or a related subject at UTSA. A minimum grade point average of 3.0 (on a 4.0 scale) is required for admission, with the exception of the pre-professional human health emphasis, which will require a minimum grade point average of 3.3 (on a 4.0 scale) in science courses. Students whose undergraduate preparation is deficient in certain areas but who meet the minimum University standards for admission may be conditionally admitted and required to complete specific undergraduate or graduate courses as conditions of admission. In such cases, students should anticipate that additional time will be required to complete the degree. Students denied admission to the M.S. program must reapply if interested in acceptance as a special graduate student.

For students considering a thesis option, emphasis-specific requirements are listed below:

A. Developmental and Regenerative Sciences: Successful applicants normally have their undergraduate degree in a biological/life science discipline and have earned upper-division course credit in biochemistry, cell biology, and molecular biology. Applicants with undergraduate academic performance that does not meet these requirements are encouraged to consider pursuing a year of post-baccalaureate studies

to demonstrate an ability to achieve satisfactory academic progress in graduate-level courses.

B. Ecology: Successful applicants normally have their undergraduate degree in a biological/life science discipline and have earned upper-division course credit in ecology and statistics. The faculty strongly encourages students interested in the thesis option with an emphasis in ecology to contact potential faculty to serve as their thesis advisor before completing the application.

C. Microbiology and Immunology: Successful applicants normally have an undergraduate degree in a biological/life science discipline and have completed upper-division courses in biochemistry, cell biology, microbiology, and immunology with grades of "A" or "B." Applicants who do not meet these requirements are encouraged to consider completing a year of post-baccalaureate studies in which they will address any deficiencies in coursework and demonstrate their ability to succeed in graduate-level courses.

D. Neuroscience: Successful applicants normally have their undergraduate degree in a biological/life science discipline or experimental psychology. Students with degrees in other fields (physical sciences, mathematics, engineering) and a strong interest in the foundations of neuroscience and behavior are also encouraged to apply. Applicants with undergraduate academic performance that does not meet these requirements are encouraged to consider pursuing a year of post-baccalaureate studies to demonstrate an ability to achieve satisfactory academic progress in graduate-level courses. Students interested in this thesis option should contact potential faculty to serve as their thesis advisor before completing the application.

Students interested in one of these thesis options should contact potential faculty mentors during their first semester after admission.

For students considering a non-thesis option (II A and B), upper-division courses credit with a grade of B or better in at least three of the following courses is expected: biochemistry, cell biology, ecology, immunology, neuroscience, microbiology, molecular biology, physiology, or statistics.

Degree Requirements

Degree-seeking students are required to complete a minimum of 36 semester credit hours that must be approved by the student's Graduate Advisor and Comprehensive Examination Committee, as well as the Graduate Advisor of Record. Students are expected to meet with their assigned Graduate Advisor early in the first semester of study to prepare a course degree plan and organize a committee as early as possible. Students must work closely with their Advisor and Committee to gain maximum benefit from this program.

I. Thesis Option

A. Emphasis in Developmental and Regenerative Sciences

The emphasis in Developmental and Regenerative Sciences (DRS) is a thesis-track program designed to develop new understanding through research and creativity. Coursework and laboratory research afford training in fundamental concepts and methods, emphasizing interdisciplinary and integrative approaches that are seen as central to major advances in the field. The program also emphasizes the development of research skills that will position students to be competitive in academic and research-oriented careers.

Students who wish to pursue a Ph.D. in Developmental and Regenerative Sciences at UTSA after successfully completing their master's work at UTSA are encouraged to apply. Once accepted into the Ph.D. program, students can petition to transfer 6 core credit hours, 1 credit hour

of NDRB 5001, and elective coursework if it was not used to fulfill requirements for the M.S. degree pending approval from the Graduate Program Committee, academic College, and Dean of the Graduate School, and provided the credit has not been used toward another doctoral degree. Core and elective coursework must have a grade of B or higher in order to transfer to the Ph.D. program.

| Code | Title | Credit Hours |
|---|--|--------------|
| 1. 6 semester credit hours of the following core lecture courses are required: | | 6 |
| NDRB 5123 or NDRB 5133 | Principles of Molecular Biology Principles of Cell Biology | |
| NDRB 5223 | Principles of Developmental Biology | |
| 2. 6 semester credit hours of research support courses are required: | | 6 |
| NDRB 5001 | Ethical Conduct in Research | |
| NDRB 7041 or BIO 7041 or MMI 7041 | Colloquium (repeated for a total of 3 hours) Biology Colloquium Molecular Microbiology and Immunology Colloquium | |
| NDRB 7051 | Seminar (repeated for a total of 2 hours) | |
| 3. 12 semester credit hours from the following research-based courses are required: | | 12 |
| NDRB 5973 or NDRB 6953 | Directed Research (repeated for a total of 6 hours) Independent Study | |
| NDRB 6983 | Master's Thesis (repeated for a total of 6 hours) | |
| 4. 12 semester credit hours of electives from 5000-7000 BIO/NDRB/ MMI courses as approved by the Graduate Advisor of Record are required. | | 12 |
| Total Credit Hours | | 36 |

B. Emphasis in Ecology

The emphasis in Ecology is a thesis-track degree that provides students with training and experience in the scientific investigation of ecological processes. In addition to taking courses, students work with faculty to develop a rigorous research program resulting in a thesis of sufficient quality to be published in a reputable peer-reviewed journal. Students who complete this degree gain experience in critical thinking, problem-solving, research methodology (e.g. experimental design, sampling techniques, and analysis), and both written and oral communication. This emphasis prepares students for doctoral degree programs and for professional positions in both academic and non-academic organizations in both the private and public sectors.

| Code | Title | Credit Hours |
|---|--|--------------|
| 1. 6 semester credit hours of the following core lecture courses are required | | 6 |
| BIO 5013 or ES 5013 | Survey Topics in Ecology Survey Topics in Environmental Science | |
| BIO 5853 or ES 5023 | Biostatistics Environmental Statistics | |
| 2. 3 semester credit hours of research support courses are required | | 3 |
| BIO 5001 | Ethical Conduct in Research | |
| BIO 5981 | Graduate Seminar in Ecology | |
| BIO 6941 | Ecology Colloquium | |

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|---|---|
| 3. 12 semester credit hours from the following research-based courses are required: | 12 |
| BIO 6953 | Independent Study (repeated for a total of 6 hours) |
| or BIO 5973 | Directed Research |
| BIO 6983 | Master's Thesis (repeated for a total of 6 hours) |
| 4. 15 semester credit hours of electives from 5000-7000 BIO/ES/MMI/NDRB courses as approved by the Graduate Advisor of Record are required. | 15 |
| Total Credit Hours | 36 |

C. Emphasis in Microbiology and Immunology

The emphasis in Microbiology and Immunology is a thesis-track degree program designed to prepare students who may wish to pursue careers in medical and public health services, education, research, and industry.

The program is also designed for students interested in a Ph.D. in Microbiology and Immunology at UTSA or elsewhere. This emphasis provides a prospective student with the coursework and preliminary research background found in a successful Ph.D. applicant. Core coursework is transferable toward the Molecular Microbiology and Immunology Ph.D. degree (if the student applies for and is accepted into the Ph.D. program), and elective coursework may also be transferable if it was not used to fulfill requirements for the M.S. degree. Core and elective coursework must have a grade of B or higher in order to transfer to the Ph.D. program.

| Code | Title | Credit Hours |
|--|--|--------------|
| 1. 6 semester credit hours of the following lecture courses are required: | | 6 |
| MMI 5513 | Genes, Microbes and Disease | |
| MMI 5553 | Principles of Immunology | |
| MMI 5573 | Principles of Microbiology | |
| 2. 6 semester credit hours of research support courses are required: | | 6 |
| MMI 7041 | Molecular Microbiology and Immunology Colloquium (repeated for a total of 3 hours) | |
| or BIO 7041 | Biology Colloquium | |
| or NDRB 7041 | Colloquium | |
| MMI 7051 | Molecular Microbiology and Immunology Seminar (repeated for a total of 3 hours) | |
| 3. 12 semester credit hours from the following research-based courses are required: | | 12 |
| MMI 5973 | Directed Research (repeated for a total of 6 hours) | |
| or MMI 6953 | Independent Study | |
| MMI 6983 | Master's Thesis (repeated for a total of 6 hours) | |
| 4. 12 semester credit hours of electives from 5000-7000 BIO/MMI/NDRB courses as approved by the Graduate Advisor of Record are required: | | 12 |
| Total Credit Hours | | 36 |

D. Emphasis in Neuroscience

The Neuroscience emphasis is a thesis-track program designed to develop new understanding through research and creativity. Coursework and laboratory research affords training in fundamental concepts and methods in modern neuroscience, emphasizing interdisciplinary and

integrative approaches that are seen as central to major advances in the field. The program also emphasizes the development of research skills that will position students to be competitive in academic and research-oriented careers.

Students who may wish to pursue a Ph.D. in Neuroscience at UTSA after successfully completing their master's work at UTSA are encouraged to apply. Once accepted into the Ph.D. program, students can petition to transfer 6 core credit hours, 1 credit hour of NDRB 5001, and elective coursework not used to fulfill requirements for the M.S. degree, pending approval from the Graduate Program Committee, academic College, and Dean of the Graduate School, provided the credit has not been used toward another doctoral degree. Core and elective coursework must have a grade of B or higher in order to transfer to the Ph.D. program.

| Code | Title | Credit Hours |
|--|---|--------------|
| 1. 6 semester credit hours of the following core lecture courses are required: | | 6 |
| NDRB 5443 | Molecular and Cellular Neurobiology | |
| NDRB 5453 | Neurophysiology | |
| 2. 6 credit hours of research support courses are required: | | 6 |
| NDRB 5001 | Ethical Conduct in Research | |
| NDRB 7041 | Colloquium (repeated for a total of 3 hours) | |
| or BIO 7041 | Biology Colloquium | |
| or MMI 7041 | Molecular Microbiology and Immunology Colloquium | |
| NDRB 7051 | Seminar (repeated for a total of 2 hours) | |
| 3. 12 semester credit hours from the following research-based courses are required: | | 12 |
| NDRB 5973 | Directed Research (repeated for a total of 6 hours) | |
| or NDRB 6953 | Independent Study | |
| NDRB 6983 | Master's Thesis (6 credit hours) | |
| 4. 12 semester credit hours of electives from 5000-7000 BIO/MMI/NDRB courses as approved by the Graduate Advisor of Record are required: | | 12 |
| Total Credit Hours | | 36 |

II. Non-thesis Options

A. Open Emphasis

The open emphasis M.S. in Biology offers students the opportunity to acquire a strong knowledge base across several areas of biology and an introduction to recent advances in biological theory and methods. Students may take a total of 3 semester credit hours of BIO 5971, BIO 5972, or BIO 5973 Directed Research; BIO 6951, BIO 6952, or BIO 6953 Independent Study; or BIO 5693 Practicum in Biology Practicum/internship as electives.

| Code | Title | Credit Hours |
|---|---------------------------------|--------------|
| 1. 6 semester credits hours of the following core lecture courses are required: | | 6 |
| BIO 5013 | Survey Topics in Ecology | |
| BIO 5853 | Biostatistics | |
| MMI 5553 | Principles of Immunology | |
| MMI 5573 | Principles of Microbiology | |
| NDRB 5123 | Principles of Molecular Biology | |

| | |
|-----------|-------------------------------------|
| NDRB 5133 | Principles of Cell Biology |
| NDRB 5443 | Molecular and Cellular Neurobiology |
| NDRB 5453 | Neurophysiology |

2. 6 credit hours of research support courses are required: 6

No more than 3 hours of seminar and 3 hours of colloquium can count towards the degree.

| | |
|--|--|
| BIO 5001 or NDRB 5001 | Ethical Conduct in Research |
| BIO 5253 | Technical Writing for Ecologists |
| BIO 7051 or BIO 5981 or ES 5981 | Seminar in Life Sciences Graduate Seminar in Ecology Graduate Seminar in Environmental Science and Engineering |
| or MMI 7031 | Graduate Student Seminar: Acquiring Presentation Skills |
| or MMI 7051 | Molecular Microbiology and Immunology Seminar |
| or NDRB 7051 | Seminar |
| BIO 7041 or BIO 6941 or MMI 7041 | Biology Colloquium Ecology Colloquium Molecular Microbiology and Immunology Colloquium |
| or NDRB 7041 | Colloquium |

3. Students must take at least 3 credit hours of the following: 3

| | |
|--------------------------|--|
| BIO 5033 or NDRB 5033 | Biotechnology Laboratory Biotechnology Laboratory |
| BIO 5143 or NDRB 5143 | Advanced Nucleic Acids Laboratory Advanced Nucleic Acids Laboratory |
| BIO 5163 or NDRB 5163 | Recombinant Protein Biotechnology Laboratory Recombinant Protein Biotechnology Laboratory |
| BIO 5571 | Experimental Techniques in the Life Sciences |
| BIO 5572 | Experimental Techniques in the Life Sciences |
| BIO 5971 | Directed Research |
| BIO 5972 | Directed Research |
| BIO 5973 | Directed Research |
| BIO 6133 | Methods in Field Biology |
| BIO 6142 | Methods in Field Ecology Laboratory |
| BIO 6222 | Advanced Plant Ecology Laboratory |
| BIO 6262 | Advanced Animal Ecology Laboratory |
| BIO 6951 | Independent Study |
| BIO 6952 | Independent Study |
| BIO 6953 | Independent Study |

4. 21 Credit hours can be selected from 5000 to 7000 level courses offered in BIO/MMI/NDRB. Up to 6 credit hours of electives may be taken outside of the discipline in related UTSA graduate programs, with approval of the Graduate Advisor of Record (GAR). 21

Total Credit Hours 36

B. Pre-professional Human Health Emphasis

The pre-professional human health emphasis non-thesis M.S. degree in Biology is a three-semester program that prepares students for the rigors

of professional school and produces students with a more sophisticated understanding of biological sciences.

Entry into a reputable medical, dental, or veterinary program is highly competitive. Good academic performance and experience may not be enough for admissions, but if you can benefit from intensive coursework, this program could be what you need to make that challenging next step in your career.

Admittance into this emphasis requires a minimum overall GPA of 3.3 (on a 4.0 scale) and a minimum science GPA of 3.3 (on a 4.0 scale). Entry into the program is for fall semesters only.

| Code | Title | Credit Hours |
|---|--|--------------|
| 1. Required Courses | | 22 |
| BIO 5603 | Critical Analysis and Reasoning Skills Related to Human Health | |
| BIO 5202 | Clinical Anatomy Laboratory I | |
| BIO 5203 | Advanced Clinical Physiology I | |
| BIO 5292 | Clinical Anatomy Laboratory II | |
| BIO 5293 | Advanced Clinical Physiology II | |
| HTH 5083 | Epidemiology | |
| MMI 6613 | Introduction to Clinical Medicine and Pathology | |
| MMI 6713 | Advanced Clinical Medicine and Pathology | |
| 2. Choose three of the following | | 9 |
| BIO 5853 or ES 5023 | Biostatistics Environmental Statistics | |
| BIO 5133 | Principles of Cell Biology | |
| BIO 5543 | Pharmacology | |
| MMI 5553 | Principles of Immunology | |
| MMI 5573 | Principles of Microbiology | |
| CHE 5313 | Advanced Biochemistry | |
| HTH 5423 | Epidemiology II: Application and Interpretation | |
| 3. Choose one of the following | | 3 |
| HTH 5393 | Health Disparities, Equity and Social Justice | |
| SOC 6063 | Health and Health Disparities | |
| HTH 5063 | Health Behavior Theory | |
| SOC 6733 | The Social Psychology of Health and Illness | |
| HTH 5303 | Community Health | |
| PSY 5313 | Seminar in Psychopathology | |
| PSY 5363 | Health Psychology | |
| PSY 5383 | Biological Psychology | |
| SOC 5133 | Sociology of Health and Health Care | |
| SOC 6713 | Health Care System in the United States | |
| 4. 2 credit hours of colloquia: | | 2 |
| BIO 7041 or BIO 6941 or MMI 7041 | Biology Colloquium Ecology Colloquium Molecular Microbiology and Immunology Colloquium | |

or NDRB 7041

Colloquium

Total Credit Hours**36**

Comprehensive Examination and Thesis Defense

As university regulations specify, candidates must pass a comprehensive examination administered by the student's Graduate Committee (Comprehensive Examination Committee). This examination will have oral and written components. Students who do not achieve the criteria (or necessary expectations) to pass the exam will be required to retake the comprehensive exam after consultation with the student's graduate committee.

Students electing the thesis option do not take the comprehensive exam. They must successfully defend their thesis research before their approved Graduate Committee prior to the submission of the thesis to the Dean of the Graduate School.

Certain institutional rules must be adhered to with regard to the composition of Comprehensive Examination and Thesis Defense Committees. Only tenured or tenure-track faculty members from UTSA can chair these committees, and no more than one member of either committee can be fixed-term-track faculty or faculty from another institution.

Master of Science Degree in Environmental Science

The College of Sciences offers advanced study and research opportunities leading to the Master of Science degree in Environmental Science. The regulations for this degree comply with the general University regulations as outlined in this catalog and indicated below.

The Master of Science in Environmental Science program is multidisciplinary and draws on faculty from many departments, including Biology, Health, and the Environment, Chemistry, Civil and Environmental Engineering, Construction Management, and Earth and Planetary Sciences. Specific information about faculty research can be found through departmental websites or by contacting individual faculty members. The nature of the environmental science program allows students to broaden their scientific background at the graduate level. Individual programs are organized around each student's interests in consultation with the student's Graduate Advisor and Graduate Committee.

Program Outcomes

Graduates of the M.S. Degree in Environmental Science program will be able to:

- Describe the advanced structure, functions, and processes of environmental systems.
- Critically analyze past, present, and future environmental issues.
- Critically assess multi-disciplinary approaches to the interaction of scientific and socio-legal factors in response to environmental challenges.
- Evaluate and create experimental designs relevant to environmental science literature and current research.
- Perform and/or justify quantitative techniques employed in environmental research.

- Apply professional and interpersonal cooperation, collaboration, negotiation, and team decision-making skills by working effectively with others from diverse disciplines and backgrounds.
- Effectively communicate scientific information to a diverse audience through oral, written, and visual means at the college graduate level.

Program Admission Requirements

In addition to satisfying the University-wide graduate admission requirements, all prospective students must have a Bachelor of Arts or Bachelor of Science degree from an accredited university and a minimum grade point average of 3.0 (on a 4.0 scale) in upper-division and graduate work. The degree should be in biology, ecology, environmental science, chemistry, geology, engineering, or other related scientific disciplines. Additionally, applicants are required to have taken coursework in the following areas: 1) one semester in general statistics and 2) one semester in environmental science. Applicants lacking these requirements will be asked to complete these deficiencies within the first 12 credit hours. Students who have not had any undergraduate coursework in Environmental Law will be required to take ES 5133 Fundamentals of Environmental Law during their first semester, which can be applied to the degree. Applications for admission will be considered on a case-by-case basis.

Applicants whose native language is not English must score at least 79 on the Test of English as a Foreign Language (TOEFL) iBT, or 6.5 on the International English Language Testing System (IELTS). Applicants must submit at least two letters of recommendation from persons familiar with the applicant's academic record, a personal statement of research interest and professional and academic goals, and a résumé. All supporting documents should be sent to Graduate Admissions. Incomplete applications will not be considered until all required items are in an applicant's file.

The Graduate Studies Committee, comprised of members selected from the graduate faculty, will recommend acceptance into the program.

All new students are admitted into the Non-Thesis Option. Students interested in the Thesis Option should reach out to graduate faculty to explore research opportunities. Students may transfer to the Thesis Option during the first year after obtaining a faculty thesis supervisor. A thesis supervisor is not guaranteed.

Some teaching assistantships, research assistantships, or research fellowships are available but require a separate application; requests should be addressed to the Graduate Advisor of Record (GAR) for the Environmental Science program.

Degree Requirements

The Master of Science degree requires at least 36 semester credit hours beyond the baccalaureate degree (excluding coursework or other study required to remove deficiencies). The Thesis Option is recommended for students planning a career in environmental education or research, or planning to earn a doctorate.

A professional (Non-Thesis) Option is also available for those interested in developing skills and knowledge to assume professional research and/or managerial positions within public, private, and nonprofit organizations. The program is designed to develop skills in data analysis, oral and written communication, and interdisciplinary teamwork. This option is considered a terminal degree and is not recommended for those

students who want to consider earning a doctorate in environmental science.

Degree candidates must complete a minimum of 36 semester credit hours approved by the student's Graduate Advisor and Graduate Committee. The Graduate Advisor of Record makes final approval. These credit hours are subject to the following conditions:

I. Thesis Option

| Code | Title | Credit Hours |
|---|--|--------------|
| A. Required Organized Courses | | 12 |
| ES 5011 | Graduate Studies in Environmental Science | |
| ES 5013 | Survey Topics in Environmental Science ¹ | |
| ES 5023 | Environmental Statistics | |
| ES 5233 | Experimental Design and Analysis | |
| ES 5981 | Graduate Seminar in Environmental Science and Engineering (may be repeated) ² | |
| ES 6941 | Environmental Science Colloquium (may be repeated) ² | |
| B. Organized courses within the College of Sciences in consultation with the student's Graduate Advisor and Graduate Committee | | 12 |
| Up to 6 semester credit hours of approved upper-division undergraduate coursework may be applied. If approved to enroll in undergraduate coursework, students must complete the Permission for Enrolling in Undergraduate Courses form and receive all approvals. | | |
| C. 12 semester credit hours of research: | | 12 |
| ES 6953 | Independent Study ³ | |
| or ES 6951 | Independent Study | |
| ES 6983 | Master's Thesis (a total of 6 hours of Master's Thesis is required.) | |
| Total Credit Hours | | 36 |

¹ This course must be taken in the first two semesters of the program.

² A total of 2 semester credit hours in graduate seminar or colloquium, in any combination, is required.

³ A total of 6 hours of independent study may be applied in any combination from ES 6951 and ES 6953.

Candidates for the Master of Science degree electing the Thesis Option must pass a research proposal examination before their Graduate Committee. The student should schedule the research proposal examination during the second semester (no later than the third semester) of graduate work. The research proposal examination will be oral and will cover a written document that includes the thesis topic, objectives, and research proposed by the student, and will take one to two hours to complete. The research proposal examination may only be taken twice. It may be scheduled again in the following semester if it is not passed the first time. Finally, candidates in the Thesis Option must successfully defend their thesis before their Graduate Committee. The thesis defense will take two to three hours to complete. The thesis defense is normally scheduled in the last semester before the degree requirements are to be completed. Part of the thesis defense will be a public presentation in an open, advertised forum.

II. Professional (Non-Thesis) Option

| Code | Title | Credit Hours |
|--|---|--------------|
| A. Required Organized Courses | | 24 |
| ES 5011 | Graduate Studies in Environmental Science | |
| ES 5013 | Survey Topics in Environmental Science ¹ | |
| ES 5023 | Environmental Statistics | |
| ES 5143 | Technical Writing for Environmental Scientists | |
| ES 5233 | Experimental Design and Analysis | |
| ES 5503 | Policy and Principles of Environmental Law | |
| ES 6103 | Environmental Assessment | |
| ES 6723 | Application of Federal Environmental Law at the State Level | |
| And 2 hours of the following in any combination: | | |
| ES 5981 | Graduate Seminar in Environmental Science and Engineering | |
| ES 6941 | Environmental Science Colloquium | |
| B. An additional 12 semester credit hours of approved graduate credit is required. This may include 6 hours of ES 6953 Independent Study. Up to 6 semester credit hours of approved upper-division undergraduate coursework and a maximum of 3 semester credit hours in a graduate seminar or 3 semester credit hours in colloquium (ES 5981 Graduate Seminar in Environmental Science and Engineering or ES 6941 Environmental Science Colloquium) may be applied to the degree. ² | | 12 |
| Total Credit Hours | | 36 |

¹ This course must be taken in the first two semesters of the program.

² If approved to enroll in undergraduate coursework, students must complete the Permission for Enrolling in Undergraduate Courses While a Graduate form and receive all approvals.

Professional students should consult the Graduate Advisor of Record on their program of study and organize a Graduate Committee during the first semester of residence. Candidates must pass a written comprehensive examination covering 1) fundamentals of environmental science, 2) data analyses and experimental design, 3) environmental law, and 4) an additional topic to be determined by the Graduate Committee. The student should arrange this written examination with the Graduate Advisor of Record and their Graduate Committee. In addition, an oral examination will be administered by the student's Graduate Committee. The oral examination will focus on academic material that the student is expected to have mastered during his or her course of study. The examinations are taken after the student has completed at least 30 semester credit hours of coursework. The written and oral examination may only be taken twice. It may be scheduled again in the following semester if it is not passed the first time. If ES 6961 Comprehensive Examination is taken, it does not contribute toward the 36-semester-credit-hour minimum (refer to the Course Descriptions section).

Graduate Committee

According to the Graduate School Policy, for the Professional (Non-Thesis) student, each comprehensive examination is developed, administered, and scored under the guidance of a supervising committee with two or more members, one of whom is designated as chair. The chair must be a member of the Graduate Faculty in the major area of study.

For Thesis students, the supervising committee must have three or more members. According to the Graduate School Policy, all committee members must be members of the Graduate Faculty in the major area of study. Occasionally, scholars who hold nontenured or nontenure-track faculty appointments at the University, such as research professors or adjunct faculty members, or off-campus scholars, are appointed because their expertise would be valuable to the student. The composition of the committee is subject to approval by the Dean of the Graduate School.

Doctor of Philosophy Degree in Environmental Science and Engineering

UTSA offers a graduate-studies program leading to the Ph.D. degree in Environmental Science and Engineering. This program is administered by the School of Civil and Environmental Engineering, & Construction Management. Most of the participating graduate faculty are in the College of Sciences (including Department of Earth and Planetary Sciences) and Klesse College of Engineering and Integrated Design (School of Civil and Environmental Engineering, & Construction Management); additional faculty in this interdisciplinary program are from other colleges. Please refer to the School of Civil and Environmental Engineering, & Construction Management (<https://catalog.utsa.edu/graduate/engineeringintegrateddesign/civilenvironengr-constructionmgt/#degreestext>) section of this catalog for details about this program.

- Graduate Certificate in Environmental Science (p. 7)
- Graduate Certificate in Environmental Sustainability (p. 7)

Graduate Certificate in Environmental Science

This 15-hour Graduate Certificate in Environmental Science is designed to meet the needs of prospective students interested in developing skills in environmental science. The purpose of this certificate is to provide professionals who already have undergraduate degrees with graduate instruction in environmental science as a means of maintaining and promoting their professional development. Environmental science is an interdisciplinary subject; therefore, the certificate program is designed to provide graduates with coursework in environmental science in appropriate areas outside of their undergraduate major. The certificate provides students with a post-baccalaureate educational opportunity that is narrower in scope and shorter in duration than the M.S. in Environmental Science.

Description of Certificate Program

The Graduate Certificate in Environmental Science is a 15-semester-credit-hour program. The prerequisites for this program are a bachelor's degree with a current status as a degree-seeking or special student in a graduate-level program. To maintain enrollment in the certificate program, students must maintain a 3.0 grade point average throughout tenure in the program. No more than 3 semester credit hours may be transferred from another institution.

Certificate Program Requirements

To earn the Graduate Certificate in Environmental Science, students must complete 15 semester credit hours of required courses:

| Code | Title | Credit Hours |
|---|--|--------------|
| Required Courses (15 semester credit hours): | | 15 |
| ES 5013 | Survey Topics in Environmental Science | |

| | |
|---------------------------|---|
| ES 5103 | Applied Ecology |
| ES 5133 or ES 5503 | Fundamentals of Environmental Law Policy and Principles of Environmental Law |
| ES 5143 | Technical Writing for Environmental Scientists |
| ES 6103 | Environmental Assessment |
| Total Credit Hours | 15 |

Graduate Certificate in Environmental Sustainability

This 15-hour Graduate Certificate in Environmental Sustainability is designed to meet the needs of prospective students interested in developing knowledge in environmental sustainability. The purpose of this certificate is to provide professionals who already have undergraduate degrees with graduate instruction in environmental sustainability as a means of maintaining and promoting their professional development. The goal of this certificate is to fill specific gaps in knowledge for environmental professionals who are seeking advanced knowledge and skills in environmental sustainability. The certificate also builds a strong foundation for participants to obtain a master's degree at a future date.

Description of Certificate Program

The Graduate Certificate in Environmental Sustainability is a 15-semester-credit-hour program. The prerequisites for this program are a bachelor's degree with a current status as a degree-seeking or special student in a graduate-level program. To maintain enrollment in the certificate program, students should maintain a 3.0 grade point average throughout tenure in the program. No more than 3 semester credit hours may be transferred from another institution.

Certificate Program Requirements

To earn the Graduate Certificate in Environmental Sustainability, students must complete 15 semester credit hours of required courses:

| Code | Title | Credit Hours |
|---|---|--------------|
| Required Courses (15 semester credit hours): | | 15 |
| ES 5043 | Global Change | |
| ES 5133 or ES 5503 | Fundamentals of Environmental Law Policy and Principles of Environmental Law | |
| ES 5153 | Urban Environmental Planning and Sustainability | |
| ES 5753 | Conservation Ecology | |
| ES 6053 | Sustainability and Renewable Energy | |
| Total Credit Hours | | 15 |

Biology (BIO) Courses

BIO 5001. Ethical Conduct in Research. (1-0) 1 Credit Hour.

Prerequisite: Graduate standing. This course provides a basic overview of the requirements for ethical conduct within the research laboratory. The grade report for this course is either "CR" (satisfactory completion) or "NC" (unsatisfactory completion). (Formerly BIO 7413. Credit cannot be earned for both BIO 5001 and BIO 7413.) This course has Differential Tuition. Course Fee: GS01 \$30.

BIO 5003. Epigenetics and Metabolism. (3-0) 3 Credit Hours.

This course offers a scientific overview and discussion of course-related topics including stem cells, diseases, and interaction between metabolism and different epigenetic mechanisms. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5013. Survey Topics in Ecology. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing. This course provides an overview of ecology from the individual organism to populations, communities, and ecosystems. It examines the physical, chemical, and biological components of ecological interactions, and includes a comparative treatment of terrestrial and aquatic ecosystems. (Same as ES 5013. Credit cannot be earned for both ES 5013 and BIO 5013.) May require field trips. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5033. Biotechnology Laboratory. (0-9) 3 Credit Hours.

Prerequisite: Graduate standing. An organized course offering an introduction to routine procedures employed in the modern research laboratory. (Same as NDRB 5033. Credit cannot be earned for both BIO 5033 and NDRB 5033.) This course has Differential Tuition. Course Fees: GS01 \$90; IUS1 \$15; L001 \$30.

BIO 5043. Global Change. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing in the program or consent of instructor. Changes in the global distribution of plants and animals and the causes of the changes will be examined. Factors that are apparently coupled to changes in the atmosphere and environmental temperature will be examined. (Formerly EES 5043. Same as CE 6383. Credit can be earned for only one of the following: CE 6113, CE 6383, EES 5043, or ES 5043.) This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5063. Environmental Microbiology. (3-0) 3 Credit Hours.

Prerequisite: BIO 3713 or consent of instructor. To provide a basic understanding of environmental microbiology primarily from two aspects: microbial interactions with chemical pollutants in the environment and the fate of microbial pathogens in the environment. Topics covered include microbial environments, detection of bacteria and their activities in the environment, microbial biogeochemistry, bioremediation, and water quality. (Same as ES 5063. Credit cannot be earned for both BIO 5063 and ES 5063.) This course has Differential Tuition. Course Fees: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

BIO 5083. Mammalogy. (3-0) 3 Credit Hours.

Prerequisite: Graduate Standing. An advanced course covering various aspects of the biology of mammals, including anatomy, physiology, systematics, evolution, behavior, ecology, and biogeography. Field trips may be required. Same as ES 5083. Credit cannot be earned for both ES 5083 and BIO 5083. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5093. Herpetology. (3-0) 3 Credit Hours.

Prerequisite: Graduate Standing. An advanced course covering various aspects of the biology of herpetofaunal, including anatomy, physiology, systematics, evolution, behavior, ecology, and biogeography. Field trips may be required. (Same as ES 5093. Credit cannot be earned for both ES 5093 and BIO 5093.) This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5103. River Ecosystems. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing in biology or environmental science, or consent of instructor. This course examines the physical, chemical, and biological factors that determine biodiversity and the distribution of freshwater ecosystems. Key ecological and hydrogeomorphology concepts and their application to environmental concerns are covered. Field trip required. (Same as ES 5113. Credit cannot be earned for both BIO 5103 and ES 5113.) This course has Differential Tuition. Course Fees: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

BIO 5123. Principles of Molecular Biology. (3-0) 3 Credit Hours.

Prerequisite: BIO 3513 or an equivalent. Molecular structure and function of genes and nucleic acids, and the processes of DNA replication, mutation and repair, as well as transcription and translation of genetic material. Genome projects, functional genomics and the genetic control of development will also be covered. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5133. Principles of Cell Biology. (3-0) 3 Credit Hours.

Prerequisite: BIO 3513 and BIO 3813, or their equivalents. Basic structure, organization, and differentiation of cells. Cell cycle, signaling, growth, and movement of cells, as well as cellular immunology and cellular aspects of infectious disease will also be covered. Same as NDRB 5133. Credit cannot be earned for both NDRB 5133 and BIO 5133. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5143. Advanced Nucleic Acids Laboratory. (0-9) 3 Credit Hours.

Prerequisite: BIO 3913 or an equivalent, BIO 5033 recommended. An introduction to advanced techniques of molecular biology dealing with manipulations and analyses of DNA, including preparation and analysis of genomic DNA, genomic cloning, the polymerase chain reaction (PCR), Southern blotting, DNA sequencing and computational analysis of DNA sequence data. Same as NDRB 5143 credit cannot be earned for both BIO 5143 and NDRB 5143. Formerly titled "Advanced Molecular Biology Laboratory – DNA Techniques." This course has Differential Tuition. Course Fee: GS01 \$90; IUS1 \$15; L001 \$30.

BIO 5163. Recombinant Protein Biotechnology Laboratory. (0-9) 3 Credit Hours.

Prerequisite: Satisfactory completion of BIO 5033. Small- to large-scale growth of microorganisms and eukaryotic cells followed by downstream processing of supernatants and/or cell pellets, protein purification, and protein analysis. Same as NDRB 5163. Formerly BIO 7542 and BIO 7543. Credit can only be earned for one of the following: BIO 5163, BIO 7542, BIO 7543, or NDRB 5163. This course has Differential Tuition. Course Fee: GS01 \$90; IUS1 \$15; L001 \$30.

BIO 5202. Clinical Anatomy Laboratory I. (0-6) 2 Credit Hours.

Prerequisite: Completion of an undergraduate physiology course with at least a 'B-'. Corequisites: BIO 5203. This is the first laboratory course in a two-part series that teaches the structure of the human body at a level required for clinical medicine. Generally offered: Fall. This course has Differential Tuition. Course Fee: GS01 \$60; L001 \$30.

BIO 5203. Advanced Clinical Physiology I. (3-0) 3 Credit Hours.

Prerequisite: Completion of an undergraduate physiology course with at least a 'B-'. Corequisites: BIO 5202. This is the first lecture course in a two-part series that teaches the structure and functions of the human body at a level required for clinical medicine. The course covers normal physiology, as well as selected diseases. This course will cover foundational basics on the cell, body fluids, the autonomic nervous system, and endocrine system. The goal is for students to develop an understanding of the integrated functions of the normal body and problem-solving and critical thinking skills in evaluating clinical situations. Generally offered: Fall. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5213. Principles of Chemical Biology. (3-0) 3 Credit Hours.

Prerequisite: BIO 3513 and BIO 3813, or equivalents. This course covers cell- and organism-level functions viewed from a chemical perspective. Studies of molecular interactions of metabolites, pharmaceuticals, proteins, polysaccharides, lipids, and nucleic acids, including protein folding and unfolding, protein modification, ligand binding, proteomics, metabolomics, lipidomics, glycoproteins, and nucleotide modification. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5223. Applied Ecology. (3-0) 3 Credit Hours.

Prerequisite: Graduate Standing. This course covers the impact of humanity's activities on the environment: their effect on water, land, animal, and human resources. An evaluation of present and future strategies to preserve a healthy environment. (Formerly EES 5103. Same as ES 5103. Credit can only be earned for one of the following: EES 5103, ES 5103, or BIO 5223.) This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5233. Medicinal Plants. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing in Biology or Chemistry. An overview of plant secondary metabolism, and the ethnobotany, biochemistry, pharmacology, and current production of some of our most important plant-derived pharmaceuticals, including metabolic engineering of plants and microbes. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5243. Advanced Plant Ecology. (3-0) 3 Credit Hours.

Prerequisites: BIO 3283 and BIO 3292, or consent of instructor. A study of the major biomes of the world, including North America and Texas, and the factors that influence the development of these biomes. Special consideration is given to species interactions that lead to high and low density species. (Same as ES 5243. Credit cannot be earned for both BIO 5243 and ES 5243.) This course has Differential Tuition. Course Fees: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

BIO 5253. Technical Writing for Ecologists. (3-0) 3 Credit Hours.

Prerequisite: Graduate Standing. This course focuses on rhetoric, ecology, and technical/scientific communication in order to develop interdisciplinary, team-based, and applied research projects. This advanced professional writing and rhetoric course will examine ecological communications as an archetypal example of specialized technical communication. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5292. Clinical Anatomy Laboratory II. (0-6) 2 Credit Hours.

Prerequisite: Completion of an undergraduate physiology course with at least a 'B-'. Corequisites: BIO 5293. This is the second laboratory course in a two-part series that teaches the structure of the human body at a level required for clinical medicine. Generally offered: Spring. This course has Differential Tuition. Course Fee: GS01 \$60; L001 \$30.

BIO 5293. Advanced Clinical Physiology II. (3-0) 3 Credit Hours.

Prerequisite: Completion of an undergraduate physiology course with at least a 'B-'. Corequisites: BIO 5292. This is the second lecture course in a two-part series that teaches the structure and functions of the human body at a level required for clinical medicine. The course covers cardiovascular, respiratory, renal, and gastrointestinal systems, with a final integration section that applies the physiological principles learned to special situations. The ultimate goal is for students to develop an understanding of the integrated functions of the normal body and "problem solving" and "critical thinking" skills in evaluating clinical situations. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5303. Animal Behavior. (3-0) 3 Credit Hours.

This course will introduce various approaches to studying animals and their behavior in natural habitats. The course will examine basic principles derived from studying the evolution, ecology, and development of animals, and use these principles to explain how and why animals behave as they do in particular situations. Generally offered: Fall, Summer, Spring. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5383. Aquatic Ecology. (3-0) 3 Credit Hours.

Prerequisite: Graduate Standing. Study of aquatic ecosystems including streams, wetlands, and lakes. Topics include watershed processes, biological communities, physical habitats, nutrient cycling, energy flow, and management issues. The course culminates with individual research projects focused on local watersheds. Field trips may be required. (Same as ES 5513. Credit cannot be earned for both ES 5513 and BIO 5383.) This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5393. Evolutionary Biology. (3-0) 3 Credit Hours.

A discussion of theories and possible mechanisms for evolutionary changes at various levels of organization. Generally offered: Spring. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5543. Pharmacology. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing in Biology. Mechanisms of action of major classes of therapeutic drugs. Clinical uses, drug comparisons, beneficial and adverse effects involved in clinical therapeutics. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5553. Environmental Toxicology. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing or consent of instructor. This course will focus on the molecular mechanisms by which toxic compounds in the environment affect animal and plant biological systems. Risk Assessment procedures will provide the scientific context to quantify and evaluate the environmental impact of hazards associated with toxins including heavy metals, pesticides, and plasticizers on human health. The potential risk associated with exposure to endocrine disruptors and carcinogens will also be considered. (Same as ES 5413. Credit cannot be earned for both ES 5413 and BIO 5553.) This course has Differential Tuition. Course Fee: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

BIO 5571. Experimental Techniques in the Life Sciences. (0-3) 1 Credit Hour.

Prerequisite: Consent of Instructor. Course topics include research methods in cell and molecular biology, molecular neurobiology, microbiology, and ecology. May be repeated for credit as topics vary. (Formerly BIO 7571. Credit cannot be earned for both BIO 7571 and BIO 5571.) This course has Differential Tuition. Course Fee: L001 \$8.

BIO 5572. Experimental Techniques in the Life Sciences. (0-6) 2 Credit Hours.

Prerequisite: Consent of Instructor. Course topics include research methods in cell and molecular biology, molecular neurobiology, microbiology, and ecology. May be repeated for credit as topics vary. (Same as BIO 7572. Credit cannot be earned for both BIO 7572 and BIO 5572.) This course has Differential Tuition. Course Fee: L001 \$8.

BIO 5603. Critical Analysis and Reasoning Skills Related to Human Health. (3-0) 3 Credit Hours.

This course is designed to help students organize, interpret, and evaluate evidence and ideas within and across disciplines, draw reasoned inferences and defensible conclusions, solve problems, and make decisions based on analytical processes. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5643. Introduction to Bioinformatics. (3-0) 3 Credit Hours.

The course will cover how the ability to sequence and analyze genomes has transformed biology. The genomic revolution has been made possible by the development of bioinformatics tools that combine computation with principles of molecular biology. In this course, students will have the opportunity to learn how to use some of the major bioinformatics tools and will examine a few genomes to understand the vast amount of information present in them. This course has Differential Tuition. Course Fee: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

BIO 5663. Applications of Recombinant DNA Technology. (3-0) 3 Credit Hours.

A course on recombinant DNA technology, concentrating on major DNA manipulation methods, including their use in vaccine and bioactive protein production, gene therapy, plant genetic engineering along with ethical and safety considerations. This course has Differential Tuition. Course Fee: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

BIO 5693. Practicum in Biology. (0-0) 3 Credit Hours.

Prerequisite: Enrollment in the Master's in Biology program and at least 18 credit hours, including satisfactory completion of BIO 5033 and one other organized laboratory course if the internship is to be completed in a biomedical or biotechnology company. An internship in a company or health profession office outside UTSA. Must have approval of the Biology Graduate Studies Committee. (Same as BIO 7563. Credit cannot be earned for both BIO 7563 and BIO 5693.) This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5713. Ornithology. (3-0) 3 Credit Hours.

A course covering various aspects of the biology of birds, including anatomy, physiology, systematics, evolution, behavior, ecology, and biogeography. Field trips may be included. (Same as ES 5763. Credit cannot be earned for both BIO 5713 and ES 5763.) This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5733. Advanced Medical Mycology. (3-0) 3 Credit Hours.

Prerequisite: BIO 3522 and BIO 3722. This course is a comprehensive study of the etiological agents and host factors that lead to fungal disease in humans. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5743. Advanced Virology. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing in Biology. A detailed study of the diversity of viruses and biochemical mechanisms for their replication. (Formerly titled "Biochemical Virology.") This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5753. Conservation Biology. (3-0) 3 Credit Hours.

Prerequisite: Graduate Standing. The class topics will include the nature of the biosphere, threats to its integrity, and ecologically sound responses to these threats. Also included will be the origin and preservation of biotic diversity, how the rich variety of plant and animal life arose, how it has been maintained by natural processes, and how its destruction can be prevented. (Same as ES 5753. Credit cannot be earned for both BIO 5753 and ES 5753.) This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5762. Fundamentals of Immunology for Biotechnology. (2-0) 2 Credit Hours.

An integrated examination of the principles of immunology pertaining to the Biotechnology Industry. An emphasis on current immunological techniques, including: recombinant antibody, flow cytometry and elispot technology. Issues related to vaccine production and therapeutics will also be considered. This course has Differential Tuition. Course Fee: GS01 \$60.

BIO 5763. Ichthyology. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing. Study of fishes, and includes a wide range of topics including taxonomy, systematics, and biogeography, anatomy and physiology, and behavior and ecology. This course will focus on form and function, behavior, life history, ecology, and key taxonomic characteristics of most of the orders of fishes. Field trips may be required. (Same as ES 5743. Credit cannot be earned for both ES 5743 and BIO 5763.) This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5783. Introduction to Good Manufacturing Practices and Good Laboratory Practices. (3-0) 3 Credit Hours.

Review of FDA and U.S. Pharmacopodia regulations. Practical considerations for the implementation of GMP/GLP systems; data management and reporting, as well as problem solving and interpretive skills, will be emphasized. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5843. Wildlife Ecology. (3-0) 3 Credit Hours.

Prerequisite: Graduate Standing. Topics covered in this course include: major environmental factors affecting wildlife, structure and behavior of wildlife populations, and regional wildlife communities and their conservation. Field studies will allow students to observe and apply classroom topics. (Same as ES 5773. Credit cannot be earned for both ES 5773 and BIO 5843.) This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5853. Biostatistics. (3-0) 3 Credit Hours.

Prerequisite: Graduate Standing. This course includes the collection, analysis, presentation, and interpretation of biological data, and probability. Analysis includes descriptive statistics, correlation and regression, confidence intervals, and hypothesis testing. Use of appropriate technology, including statistical software. (Same as ES 5023. Credit cannot be earned for both ES 5023 and BIO 5853.) This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5873. Plant Biotechnology. (3-0) 3 Credit Hours.

Prerequisite: BIO 3513 or equivalent, BIO 5123 is recommended. The principles of plant physiology and genetics, and techniques used in plant modification, and principles of plant breeding and quantitative genetics as applied to plant biotechnology. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5971. Directed Research. (0-0) 1 Credit Hour.

Prerequisite: Admission to either the Biology or Biotechnology Master's program or admission as a special graduate or non-degree-seeking student, and permission in writing (form available) from the instructor and the student's Graduate Advisor of Record. The directed research course may involve either a laboratory or a theoretical problem. May be repeated for credit, but not more than 6 hours, regardless of discipline, in combination with BIO 6951-3 (Independent Study), will apply to the Master's degree. This course has Differential Tuition. Course Fee: GS01 \$30.

BIO 5972. Directed Research. (0-0) 2 Credit Hours.

Prerequisite: Admission to either the Biology or Biotechnology Master's program or admission as a special graduate or non-degree-seeking student, and permission in writing (form available) of the instructor and the student's Graduate Advisor of Record. The directed research course may involve either a laboratory or a theoretical problem. May be repeated for credit, but not more than 6 hours, regardless of discipline, in combination with BIO 6951-3 (Independent Study), will apply to the Master's degree. This course has Differential Tuition. Course Fee: GS01 \$60.

BIO 5973. Directed Research. (0-0) 3 Credit Hours.

Prerequisite: Admission to either the Biology or Biotechnology Master's program or admission as a special graduate or non-degree-seeking student, and permission in writing (form available) of the instructor and the student's Graduate Advisor of Record. The directed research course may involve either a laboratory or a theoretical problem. May be repeated for credit, but not more than 6 hours, regardless of discipline, in combination with BIO 6951-3 (Independent Study), will apply to the Master's degree. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 5981. Graduate Seminar in Ecology. (1-0) 1 Credit Hour.

Prerequisite: Graduate Standing. Topical issues of current research will be examined in this course. Presentations will be by current faculty, invited guests, and master's or doctoral candidates. May be repeated for credit but only 2 hours may be applied toward the Master's degree. The grade report for this course is either "CR" (satisfactory) or "NC" (unsatisfactory). (Formerly EES 5981 and ES 5991. Same as CE 6621. Credit can only be earned for one of the following courses: EES 5981, ES 5991, CE 6621, or BIO 5981.) This course has Differential Tuition. Course Fee: GS01 \$30.

BIO 6103. Principles of Biological Scientific Teaching. (3-0) 3 Credit Hours.

This course prepares students to teach science courses using the Scientific Teaching framework. The main idea of this framework is that teaching and learning are approached with the same rigor as science itself. The Scientific Teaching framework has three main components, Active Learning, Assessment, and Equity and Diversity. (Same as NDRB 7113. Credit cannot be earned for both BIO 6103 and NDRB 7113.) This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 6113. Plant Ecophysiology. (3-0) 3 Credit Hours.

Prerequisite: Graduate Standing. This course is a survey of physiological approaches to understanding plant-environment interactions from the functional perspective. Lectures cover physiological adaptation, limiting factors, resources acquisition/allocation, photosynthesis, carbon and energy balance, water use relations, nutrient relations, linking ecophysiology and stable isotopes, stress physiology, life history physiology, evolution of physiological performance, and ecophysiology at the population, community, and ecosystem levels. (Formerly EES 6113 and ES 6113. Same as ES 6023. Credit can only be earned for one of the following: ES 6023, ES 6113, and BIO 6113.) This course has Differential Tuition. Course Fees: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

BIO 6133. Methods in Field Biology. (3-0) 3 Credit Hours.

Prerequisite: BIO 3283 or an equivalent. Examination of techniques to collect, identify, and preserve plants and animals. Field methods used in the analysis of populations and communities are considered. (Same as ES 6133. Credit cannot be earned for both BIO 6133 and ES 6133.) This course has Differential Tuition. Course Fee: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

BIO 6142. Methods in Field Ecology Laboratory. (0-6) 2 Credit Hours.

This course introduces students to field ecology methodologies. Topics may include physiological field measurements (in situ photosynthesis, respiration, water relations), population assessment (quadrats, transects, mark-recapture), community-level assessment (measuring density and diversity, benthic analyses), and/or ecosystem process field assessment (carbon or nutrient flux, whole system metabolism, and watershed studies). This course has Differential Tuition. Course Fee: L001 \$8.

BIO 6213. Advanced Ecology. (3-0) 3 Credit Hours.

Prerequisite: BIO 3283 or an equivalent. Interaction of organisms with their environment, allelopathy, competition, distribution, succession, and factors that control growth and dispersal. Special consideration is given to the concepts of climax, succession, and land management. (Same as ES 6213. Credit cannot be earned for both BIO 6213 and ES 6213.) This course has Differential Tuition. Course Fee: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

BIO 6222. Advanced Plant Ecology Laboratory. (0-6) 2 Credit Hours.

This course includes physiological field measurements, population assessment, community-level assessment, and ecosystem process field assessment of plants. This course has Differential Tuition. Course Fee: L001 \$8.

BIO 6233. Quantitative Biology. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing or consent of instructor. This course is an introduction of quantitative analysis of biological data and design of experiments. Topics include probability theory and distributions, descriptive statistics, hypothesis testing and confidence intervals for means, variances, and proportions, chi-square statistic, categorical data analysis, linear correlation and regression model, analysis of variance, and nonparametric methods. (Same as NDRB 6233. Credit cannot be earned for both NDRB 6233 and BIO 6233.) This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 6262. Advanced Animal Ecology Laboratory. (0-6) 2 Credit Hours.

This course includes physiological field measurements, population assessment, community-level assessment, and ecosystem process field assessment of animals. This course has Differential Tuition. Course Fee: L001 \$8.

BIO 6513. Drug Development. (3-0) 3 Credit Hours.

This course will provide students with an overview of the early drug discovery process, including target identification, validation, assay development and high throughput screening up to pre-clinical trials. This course has Differential Tuition. Course Fee: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

BIO 6543. Vaccine Development. (3-0) 3 Credit Hours.

Prerequisite: BIO 5762 and permission of instructor. This course will provide students with an overview of issues about the roles of vaccines in the control of infectious diseases, vaccine development, clinical trials and implementation of vaccine programs. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 6573. Microbial Pathogenesis. (3-0) 3 Credit Hours.

The student will gain an understanding of the cellular and molecular mechanisms by which eukaryotic and viral pathogens cause disease and the host immune responses against these pathogens. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 6803. Advanced Immunology and Immunochemistry. (3-0) 3 Credit Hours.

Prerequisite: BIO 4743 or consent of instructor. The study of current concepts of humoral and cell-mediated immunity, with emphasis on molecular mechanisms. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 6883. Bacterial Pathogenesis. (3-0) 3 Credit Hours.

Prerequisite: BIO 3713 and BIO 4743, or consent of instructor. This course will present a selection of topics in the field of bacterial pathogenesis. Lectures will cover regulation of virulence; colonization and host tissue damage; vaccines, antibiotics and novel antimicrobials; evasion of the immune system; intracellular pathogens; pathogenic mechanisms of Gram-negative and Gram-positive bacteria; pathogenic mycobacteriology; and experimental tools in bacterial pathogenesis. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 6941. Ecology Colloquium. (1-0) 1 Credit Hour.

Prerequisite: Graduate Standing. This course includes discussions of current journal articles, reviews, and recent advances in specialized areas of the biological sciences. May be repeated for credit as topics vary. The grade report for this course is either "CR" (satisfactory participation in the colloquium) or "NC" (unsatisfactory participation in the colloquium). (Formerly EES 6941. Same as BIO 7041 and ES 6941. Credit can only be earned for one of the following: ES 6941, EES 6941, BIO 7041, and BIO 6941.) This course has Differential Tuition. Course Fee: GS01 \$30.

BIO 6951. Independent Study. (0-0) 1 Credit Hour.

Prerequisite: Graduate standing and permission in writing of the instructor and the student's Graduate Advisor of Record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, in combination with BIO 5971-3 Directed Research will apply to the Master's degree. This course has Differential Tuition. Course Fee: GS01 \$30.

BIO 6952. Independent Study. (0-0) 2 Credit Hours.

Prerequisite: Graduate standing and permission in writing of the instructor and the student's Graduate Advisor of Record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, in combination with BIO 5971-3 Directed Research will apply to the Master's degree. This course has Differential Tuition. Course Fee: GS01 \$60.

BIO 6953. Independent Study. (0-0) 3 Credit Hours.

Prerequisite: Graduate standing and permission in writing of the instructor and the student's Graduate Advisor of Record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, in combination with BIO 5971-3 Directed Research will apply to the Master's degree. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 6961. Comprehensive Examination. (0-0) 1 Credit Hour.

Prerequisite: Approval of the appropriate Graduate Program Committee to take the Comprehensive Examination. Independent study course for the purpose of taking the Comprehensive Examination. May be repeated as many times as approved by the Graduate Program Committee. Enrollment is required each term in which the Comprehensive Examination is taken if no other courses are being taken that term. The grade report for the course is either "CR" (satisfactory performance on the Comprehensive Examination) or "NC" (unsatisfactory performance on the Comprehensive Examination). This course has Differential Tuition. Course Fee: GS01 \$30.

BIO 6973. Special Problems. (3-0) 3 Credit Hours.

Prerequisite: Consent of instructor. An organized course offering the opportunity for specialized study not normally or not often available as part of the regular course offerings. Special Problems courses may be repeated for credit when the topics vary, but not more than 6 hours, regardless of discipline, may be applied to the Master's degree. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 6981. Master's Thesis. (0-0) 1 Credit Hour.

Prerequisite: Permission of the Graduate Advisor of Record and thesis director. Thesis research and preparation. May be repeated for credit, but not more than 6 hours will apply to the Master's degree. Credit will be awarded upon completion of the thesis. Enrollment in BIO 6981, BIO 6982, or BIO 6983 is required each term in which the thesis is in progress. This course has Differential Tuition. Course Fee: GS01 \$30.

BIO 6982. Master's Thesis. (0-0) 2 Credit Hours.

Prerequisite: Permission of the Graduate Advisor of Record and thesis director. Thesis research and preparation. May be repeated for credit, but not more than 6 hours will apply to the Master's degree. Credit will be awarded upon completion of the thesis. Enrollment in BIO 6981, BIO 6982, or BIO 6983 is required each term in which the thesis is in progress. This course has Differential Tuition. Course Fee: GS01 \$60.

BIO 6983. Master's Thesis. (0-0) 3 Credit Hours.

Prerequisite: Permission of the Graduate Advisor of Record and thesis director. Thesis research and preparation. May be repeated for credit, but not more than 6 hours will apply to the Master's degree. Credit will be awarded upon completion of the thesis. Enrollment in BIO 6981, BIO 6982, or BIO 6983 is required each term in which the thesis is in progress. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 7041. Biology Colloquium. (1-0) 1 Credit Hour.

Prerequisite: Graduate standing. Oral presentations, discussions, critical evaluation of students' research in progress, or discussions of current journal articles or reviews of recent scientific advances. May be repeated for credit. The grade report for this course is either "CR" (satisfactory participation in the colloquium) or "NC" (unsatisfactory participation in the colloquium). (Formerly BIO 5041. Same as ES 6941. Unless topic varies, credit cannot be earned for both BIO 7041 and ES 6941.) This course has Differential Tuition. Course Fee: GS01 \$30.

BIO 7051. Seminar in Life Sciences. (1-0) 1 Credit Hour.

Prerequisite: Graduate standing. Formal presentations of research by outside authorities in the biological sciences. May be repeated for credit. The grade report for this course is either "CR" (satisfactory participation in the seminar) or "NC" (unsatisfactory participation in the seminar). This course has Differential Tuition. Course Fee: GS01 \$30.

BIO 7211. Doctoral Research. (0-0) 1 Credit Hour.

Prerequisite: Admission to either the Neurobiology or Cell and Molecular Biology Doctoral program. May be repeated for credit, but no more than 52 hours may be applied to the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 \$30.

BIO 7212. Doctoral Research. (0-0) 2 Credit Hours.

Prerequisite: Admission to either the Neurobiology or Cell and Molecular Biology Doctoral program. May be repeated for credit, but no more than 52 hours may be applied to the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 \$60.

BIO 7213. Doctoral Research. (0-0) 3 Credit Hours.

Prerequisite: Admission to either the Neurobiology or Cell and Molecular Biology Doctoral program. May be repeated for credit, but no more than 52 hours may be applied to the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 7311. Doctoral Dissertation. (0-0) 1 Credit Hour.

Prerequisite: Admission to candidacy for the Doctoral degree and completion of at least 18 semester credit hours of BIO 7211-3. May be repeated for credit. This course has Differential Tuition. Course Fee: GS01 \$30.

BIO 7312. Doctoral Dissertation. (0-0) 2 Credit Hours.

Prerequisite: Admission to candidacy for the Doctoral degree and completion of at least 18 semester credit hours of BIO 7211-3. May be repeated for credit. This course has Differential Tuition. Course Fee: GS01 \$60.

BIO 7313. Doctoral Dissertation. (0-0) 3 Credit Hours.

Prerequisite: Admission to candidacy for the Doctoral degree and completion of at least 18 semester credit hours of BIO 7211-3. May be repeated for credit. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 7563. Practicum in Biotechnology. (0-0) 3 Credit Hours.

Prerequisite: Enrollment in Master's in Biotechnology program and at least 18 hours credit including satisfactory completion of BIO 5033 and one other organized laboratory course. An internship in a Biotechnology company. Must have approval of Biotechnology Graduate Studies Committee. This course has Differential Tuition. Course Fee: GS01 \$90.

BIO 7572. Experimental Techniques in Biology. (0-6) 2 Credit Hours.

Prerequisite: Consent of instructor. Course topics include research methods in cell and molecular biology, molecular neurobiology, and microbiology. May be repeated for credit as topics vary. (Same as NDRB 7272. Credit cannot be earned for both NDRB 7572 and BIO 7572.) This course has Differential Tuition. Course Fee: GS01 \$60.

Environmental Sciences (ES) Courses

ES 5011. Graduate Studies in Environmental Science. (1-0) 1 Credit Hour.

This course offers an orientation to graduate study, introducing students to the professional standards and practices of our discipline. The course also offers a survey of environmental science. Development of a tentative program of studies and other relevant requirements will be discussed. This course has Differential Tuition. Course Fee: GS01 \$30.

ES 5013. Survey Topics in Environmental Science. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing. Analysis of the basic concepts and new scientific developments in environmental science. Case studies will cover a range of relevant topics to promote a thorough understanding of the emergent issues in environmental science. Emphasis will be placed on developing both written and verbal scientific presentation skills. (Formerly EES 5013. Same as BIO 5013, EES 5013, or ES 5013.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5023. Environmental Statistics. (3-0) 3 Credit Hours.

Prerequisite: ES 1314 and MAT 1133 or their equivalents, or consent of instructor. Emphasis on methods and applications of statistics for environmental science. Measure of location, variability, and association. Interpretation of categorical data, hypothesis testing, and use of statistical software programs and applications. (Formerly EES 5023. Same as GEO 5023, BIO 5853, and CE 5043. Credit can be earned for only one of the following: BIO 5853, EES 5023, ES 5023, GEO 5023, or CE 5043.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5043. Global Change. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing in the program or consent of instructor. Changes in the global distribution of plants and animals and the causes of the changes will be examined. Factors that are apparently coupled to changes in the atmosphere and environmental temperature will be examined. (Formerly EES 5043 and CE 6113. Same as BIO 5043 and CE 6383. Credit can be earned for only one of the following: BIO 5043, CE 6113, CE 6383, EES 5043, or ES 5043.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5063. Environmental Microbiology. (3-0) 3 Credit Hours.

Prerequisite: BIO 3713 or consent of instructor. To provide a basic understanding of environmental microbiology primarily from two aspects: microbial interactions with chemical pollutants in the environment and the fate of microbial pathogens in the environment. Topics covered include microbial environments, detection of bacteria and their activities in the environment, microbial biogeochemistry, bioremediation, and water quality. (Formerly EES 5063, CE 5203, and CE 5673. Same as BIO 5063. Credit can be earned for only one of the following: BIO 5063, CE 5203, CE 5673, EES 5063, or ES 5063). This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5083. Mammalogy. (3-0) 3 Credit Hours.

Prerequisite: Graduate Standing. An advanced course covering various aspects of the biology of mammals, including anatomy, physiology, systematics, evolution, behavior, ecology, and biogeography. Field trips may be required. (Same as BIO 5083. Credit cannot be earned for both BIO 5083 and ES 5083.) This course has Differential Tuition. Course Fee: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

ES 5093. Herpetology. (3-0) 3 Credit Hours.

Prerequisite: Graduate Standing. An advanced course covering various aspects of the biology of herpetofaunal, including anatomy, physiology, systematics, evolution, behavior, ecology, and biogeography. Field trips may be required. (Same as BIO 5093. Credit cannot be earned for both BIO 5093 and ES 5093.) This course has Differential Tuition. Course Fee: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

ES 5103. Applied Ecology. (3-0) 3 Credit Hours.

The impact of humanity's activities on the environment: their effect on water, land, animal, and human resources. An evaluation of present and future strategies to preserve a healthy environment. (Formerly EES 5103. Same as BIO 5223. Credit can only be earned for one of the following: BIO 5223, EES 5103, and ES 5103.) This course has Differential Tuition. Course Fee: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

ES 5113. River Ecosystems. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing in biology or environmental science, or consent of instructor. This course examines the physical, chemical, and biological factors that determine biodiversity and the structure and function of aquatic and riparian ecosystems. Key ecological and hydrogeomorphology concepts and their application to environmental concerns are covered. Field trip required. (Same as BIO 5103. Credit cannot be earned for both BIO 5103 and ES 5113. Formerly titled "Freshwater Ecology.") This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5133. Fundamentals of Environmental Law. (3-0) 3 Credit Hours.

Prerequisite: Graduate Standing. This course exposes students to basic legal theories relevant to contemporary environmental practice, and provides an introduction to administrative law as well as six federal environmental statutes: the Clean Air Act, Clean Water Act, National Environmental Policy Act, Endangered Species Act, Resource Conservation and Recovery Act, and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5143. Technical Writing for Environmental Scientists. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing. A course designed to give graduate students the skills necessary to write a manuscript for peer review and to prepare other professional materials for presentation or publication. Topics covered in this course include: searching the scientific literature; scientific writing style; writing graduate level papers, proposals, projects, and thesis components; preparing scientific presentations; presentation of data; using visual aids; and using word processing, spreadsheet, and presentation software. This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5153. Urban Environmental Planning and Sustainability. (3-0) 3 Credit Hours.

This course examines how the concept of sustainable development applies to buildings, cities and urban regions and gives students insight into a variety of contemporary urban planning and green building issues through the sustainability lens. Ways to coordinate goals of environmental, economic, and social equity at different scales of planning are addressed, including the region, the city, the neighborhood, the site, and buildings. This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5163. Urban Wildlife Ecology. (3-0) 3 Credit Hours.

Fundamentals of urban ecology, field methods including urban wildlife and human surveys, and urban wildlife management and conservation strategies. Generally offered: Fall of even years. This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5173. Fundamental of Environmental Risk Assessment. (3-0) 3 Credit Hours.

This course will offer hands-on training in the primary areas of risk assessment (e.g., hazard identification, dose-response assessment, exposure assessment, and risk characterization). Generally offered: Fall of odd years. This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5183. Advanced Environmental Risk Assessment. (3-0) 3 Credit Hours.

This course will offer hands-on training in the advanced areas of risk assessment (e.g., hazard identification, dose-response assessment, exposure assessment, and risk characterization). Generally offered: Spring of even years. This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5213. Environmental Geology. (3-0) 3 Credit Hours.

Prerequisite: GEO 4063 or consent of instructor. Geologic materials and processes as related to their influence on the human physical environment. Effects of landscape modification and geologic hazards such as earthquakes and landslides. Properties of minerals, rocks, and soils and geologic aspects of waste disposal and water resources are examined. Course cannot be used for graduate credit by students in Geology. (Formerly EES 5213. Credit cannot be earned for both EES 5213 and ES 5213.) This course has Differential Tuition. Course Fee: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

ES 5233. Experimental Design and Analysis. (3-0) 3 Credit Hours.

Prerequisite: ES 5023 or an equivalent, or consent of instructor. Fundamental concepts of the statistical design and analysis of environmental experiments will be presented. Students will be required to design experiments and to analyze data using computer software. (Formerly EES 5233. Credit cannot be earned for both EES 5233 and ES 5233.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5243. Advanced Plant Ecology. (3-0) 3 Credit Hours.

Prerequisite: BIO 3283 and BIO 3292, or consent of instructor. A study of the major biomes of the world, including North America and Texas, and the factors that influence the development of these biomes. Special consideration is given to species interactions that lead to high and low density species. (Formerly EES 5243. Same as BIO 5243. Credit can be earned for only one of the following: BIO 5243, EES 5243, or ES 5243.) This course has Differential Tuition. Course Fee: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

ES 5413. Environmental Toxicology. (3-0) 3 Credit Hours.

This course will focus on the molecular mechanisms by which toxic compounds in the environment affect animal and plant biological systems. Risk Assessment procedures will provide the scientific context to quantify and evaluate the environmental impact of hazards associated with toxins, including heavy metals, pesticides, and plasticizers, on human health. The potential risk associated with exposure to endocrine disruptors and carcinogens will also be considered. (Same as BIO 5553. Credit cannot be earned for both ES 5413 and BIO 5553.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5493. Water Pollution Control. (3-0) 3 Credit Hours.

Principles and methods of water pollution control process design and operation; selection and optimization of total treatment processes as well as appurtenances and accessory equipments; and methods involved in the design process and the selection of the hardware. (Formerly EES 5493. Credit cannot be earned for both EES 5493 and ES 5493.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5503. Policy and Principles of Environmental Law. (3-0) 3 Credit Hours.

Prerequisite: ES 3203 or ES 5133, or equivalent. This course exposes students to advanced policies and principles relevant to contemporary environmental practice, and provides advanced knowledge of the six federal environmental statutes: the Clean Air Act, Clean Water Act, National Environmental Policy Act, Endangered Species Act, Resource Conservation and Recovery Act, and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). (Formerly PAD 5483 and EES 5503. Credit can be earned for only one of the following: EES 5503, ES 5503, or PAD 5483.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5513. Aquatic Ecology. (3-0) 3 Credit Hours.

Study of aquatic ecosystems including streams, wetlands, and lakes. Topics include watershed processes, biological communities, physical habitats, nutrient cycling, energy flow, and management issues. The course culminates with individual research projects focused on local watersheds. Field trips may be required. (Same as BIO 5383, BIO 4303, ES 4023. Credit may only be earned for one of the following: BIO 5383, BIO 4303, ES 4023, and ES 5513.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5523. Watershed Processes. (3-0) 3 Credit Hours.

This course focuses on watershed processes, watershed assessment, and watershed management. (Same as ES 3143. Credit cannot be earned for both ES 3143 and ES 5523.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5533. Planning and Response to Environmental Disasters. (3-0) 3 Credit Hours.

This course will focus on planning, response and recovery from large, complex environmental disasters and the roles and implications for Response Managers and Environmental Scientists. (Same as ES 4193. Credit cannot be earned for both ES 4193 and ES 5533.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5743. Ichthyology. (3-0) 3 Credit Hours.

Study of fishes, and includes a wide range of topics including taxonomy, systematics, and biogeography, anatomy and physiology, and behavior and ecology. This course will focus on form and function, behavior, life history, ecology, and key taxonomic characteristics of most of the orders of fishes. Field trips may be required. (Same as BIO 5763 and ES 3113. Credit can only be earned for one of the following: ES 5743, BIO 5763, and ES 3113.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5753. Conservation Ecology. (3-0) 3 Credit Hours.

Prerequisite: Graduate Standing. The class topics will include the nature of the biosphere, threats to its integrity, and ecologically sound responses to these threats. Also included will be the origin and preservation of biotic diversity, how the rich variety of plant and animal life arose, how it has been maintained by natural processes, and how its destruction can be prevented. (Same as BIO 5753. Credit cannot be earned for both BIO 5753 and ES 5753.) This course has Differential Tuition. Course Fee: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

ES 5763. Ornithology. (3-0) 3 Credit Hours.

A course covering various aspects of the biology of birds, including anatomy, physiology, systematics, evolution, behavior, ecology, and biogeography. Field trips may be included. (Same as BIO 5713. Credit cannot be earned for both BIO 5713 and ES 5763.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5773. Wildlife Ecology. (3-0) 3 Credit Hours.

Prerequisite: Graduate Standing. This course covers major environmental factors affecting wildlife, the structure and behavior of wildlife populations, and regional wildlife communities and their conservation. Field studies will allow students to observe and apply classroom topics. (Formerly BIO 5793. Same as BIO 5843. Credit can only be earned for one of the following: ES 5773, BIO 5793, or BIO 5843.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5863. Wildlife Management. (3-0) 3 Credit Hours.

Prerequisite: Graduate Standing. This course covers ways of conserving desired numbers of animals for the overall best interests of society, be they aesthetic, ecological, economic, commercial, or recreational. This course includes management of endangered species, exploited species, wildlife communities in nature reserves, and wildlife pests. (Same as BIO 5793. Credit cannot be earned for both BIO 5793 and ES 5863.) Generally offered: Spring of even years. This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5971. Directed Research. (0-0) 1 Credit Hour.

Prerequisite: Graduate standing and permission in writing (form available) from the instructor and the student's Graduate Advisor of Record. The directed research course may involve a laboratory, field-based, or theoretical problem. May be repeated for credit, but not more than 3 hours, regardless of discipline, will apply to the Master's degree. (Formerly EES 5971-3.) This course has Differential Tuition. Course Fee: GS01 \$30.

ES 5973. Directed Research. (0-0) 3 Credit Hours.

Prerequisite: Graduate standing and permission in writing (form available) from the instructor and the student's Graduate Advisor of Record. The directed research course may involve a laboratory, field-based, or theoretical problem. May be repeated for credit, but not more than 3 hours, regardless of discipline, will apply to the Master's degree. (Formerly EES 5971-3.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 5981. Graduate Seminar in Environmental Science and Engineering. (1-0) 1 Credit Hour.

Prerequisite: Graduate standing in the program or consent of instructor. Topical issues of current research will be examined. Presentations will be by current faculty, invited guests and Master's or Doctoral candidates. May be repeated for credit but only 2 hours may be applied toward the Master's degree. The grade report for this course is either "CR" (satisfactory) or "NC" (unsatisfactory). (Formerly EES 5981 and ES 5991. Same as CE 6621.) This course has Differential Tuition. Course Fee: GS01 \$30.

ES 6013. R Coding in Environmental Science and Ecology. (3-0) 3 Credit Hours.

This course will teach the management of environmental and ecological data using Program R. The focus will be on the structure and linguistics of data in R and how to integrate R in a data science workflow. (Same as ES 5013. Credit cannot be earned for both ES 5013 and ES 6013.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 6023. Plant Ecophysiology. (3-0) 3 Credit Hours.

A survey of physiological approaches to understanding plant-environment interactions from the functional perspective. Lectures cover physiological adaptation; limiting factors; resources acquisition/allocation; photosynthesis, carbon, energy balance; water use relations nutrient relations; linking ecophysiology and stable isotopes; stress physiology; life history physiology; evolution of physiological performance; ecophysiology at the population, community, ecosystem levels. This course has Differential Tuition. Course Fee: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

ES 6033. Applied Multivariate Statistics for Ecological Data. (3-0) 3 Credit Hours.

Prerequisite: ES 5023. This course provides students with a conceptual and practical understanding of the application of multivariate statistics in environmental science and ecology. Course will include analysis such as classification (creating discrete groups) and dimension reduction, as well as visualization techniques such as ordination. Applications include habitat classification, clustering (i.e., community classification), and exploring community-environment relationships. This course has Differential Tuition. Course Fee: GS01 \$90.

ES 6053. Sustainability and Renewable Energy. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing. This course provides an introduction to energy systems and renewable energy resources. It will be a scientific examination of the energy field and an emphasis on alternate energy sources, their technology, application, and how they can lead to a more sustainable future. The class will explore society's present needs and future energy demands, examine conventional energy sources and systems, and then focus on alternate, renewable energy sources and how they can lead to sustainability. This course has Differential Tuition. Course Fee: GS01 \$90.

ES 6063. Human Dimensions of Wildlife. (3-0) 3 Credit Hours.

This course will focus on the human dimensions of wildlife and will introduce students to how people's knowledge, values, opinions, and behaviors influence wildlife management. We will explore the ways that economics, politics, culture, and society shape wildlife management decisions and we will learn about conservation strategies that consider human dimensions. This course will have an emphasis on the human dimensions of wildlife management and conservation on private lands in Texas. This course has Differential Tuition. Course Fee: GS01 \$90.

ES 6103. Environmental Assessment. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing. This course evaluates the framework of an impact assessment and details regarding the environment (air, water, soil), its pollutants (atmospheric, noise, water, solid waste), their impacts (physical, social, economic), relevant regulations, and pollution minimization or management strategies. Students will use this information to prepare a hypothetical Environmental Impact Statement (EIS). (Formerly EES 6103 and ES 5203. Credit can be earned for only one of the following: EES 6103, ES 5203, or ES 6103.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 6133. Methods in Field Ecology. (3-0) 3 Credit Hours.

Prerequisite: BIO 3283 or an equivalent. Examination of techniques to collect, identify, and preserve plants and animals. Field methods used in the analysis of populations and communities are considered. (Formerly EES 6133. Same as BIO 6133. Credit can be earned for only one of the following: BIO 6133, EES 6133, or ES 6133.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 6213. Advanced Ecology. (3-0) 3 Credit Hours.

Prerequisite: BIO 3283 or an equivalent. Interaction of organisms with their environment, allelopathy, competition, distribution, succession, and factors that control growth and dispersal. Special consideration is given to the concepts of climax, succession, and land management. (Formerly EES 6213. Same as BIO 6213. Credit can be earned for only one of the following: BIO 6213, EES 6213, or ES 6213.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 6273. Analyses of Environmental Problems. (3-0) 3 Credit Hours.

Problems will be presented and potential solutions will be explored from a variety of areas including soil, air, water, coastal and marine systems. Also examined will be potential impact on biotic and abiotic resources in terrestrial, aquatic and marine systems. (Formerly EES 6273 and CE 6273. Credit can be earned for only one of the following: CE 6273, EES 6273, or ES 6273.) This course has Differential Tuition. Course Fee: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

ES 6723. Application of Federal Environmental Law at the State Level. (3-0) 3 Credit Hours.

Prerequisite: ES 5503. This course exposes students the application of federal laws at the State level. The course will provide information on how environmental laws should be enforced, and whether the state or federal government should have the final word in specific environmental debates. (Formerly EES 6723 and CE 6723. Credit can be earned for only one of the following: CE 6723, EES 6723, or ES 6723.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 6813. Water Resources. (3-0) 3 Credit Hours.

Application of management principles to the efficient use of water resources by people and their public and private institutions. Water is examined in terms of its value, use, and changing role in the context of economics, history, politics, and technology. (Formerly EES 6813. Same as GEO 6813. Credit can be earned for only for one of the following: EES 6813, ES 6813, or GEO 6813.) This course has Differential Tuition. Course Fee: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

ES 6901. Experimental Techniques in the Environmental Sciences. (0-3) 1 Credit Hour.

Prerequisite: Consent of instructor. Course topics will include various research methods in environmental science. May be repeated for credit as topics vary. (Formerly EES 6901, EES 6902, and EES 6903. Same as ES 6902 and ES 6903. Unless topic varies, credit may only be earned for one of the following: EES 6901, EES 6902, EES 5903, ES 6902, ES 6903, and ES 6901.) This course has Differential Tuition. Course Fee: GS01 \$30; LRS1 \$15.40; STSI \$7.20.

ES 6902. Experimental Techniques in the Environmental Sciences. (0-6) 2 Credit Hours.

Prerequisite: Consent of instructor. Course topics will include various research methods in environmental science. May be repeated for credit as topics vary. (Formerly EES 6901, EES 6902, and EES 6903. Same as ES 6901 and ES 6903. Unless topic varies, credit may only be earned for one of the following: EES 6901, EES 6902, EES 5903, ES 6901, ES 6903, and ES 6902.) This course has Differential Tuition. Course Fee: GS01 \$60; LRS1 \$30.80; STSI \$14.40.

ES 6903. Experimental Techniques in the Environmental Sciences. (0-9) 3 Credit Hours.

Prerequisite: Consent of instructor. Course topics will include various research methods in environmental science. May be repeated for credit as topics vary. (Formerly EES 6901, EES 6902, and EES 6903. Same as ES 6901 and ES 6902. Unless topic varies, credit may only be earned for one of the following: EES 6901, EES 6902, EES 6903, ES 6901, ES 6902, and ES 6903.) This course has Differential Tuition. Course Fee: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

ES 6941. Environmental Science Colloquium. (1-0) 1 Credit Hour.

Prerequisite: Graduate standing. Discussions of current journal articles, reviews, and recent advances in specialized areas of the biological sciences. May be repeated for credit as topics vary. The grade report for this course is either "CR" (satisfactory participation in the colloquium) or "NC" (unsatisfactory participation in the colloquium). (Formerly EES 6941. Same as BIO 7041 and BIO 6941. Unless topic varies, credit can be earned for only one of the following: BIO 7041, EES 6941, or ES 6941.) This course has Differential Tuition. Course Fee: GS01 \$30.

ES 6951. Independent Study. (0-0) 1 Credit Hour.

Prerequisite: Graduate standing and permission in writing (form available) from the instructor and the student's Graduate Advisor of Record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the Master's degree. (Formerly EES 6951-3.) This course has Differential Tuition. Course Fee: GS01 \$30.

ES 6953. Independent Study. (0-0) 3 Credit Hours.

Prerequisite: Graduate standing and permission in writing (form available) from the instructor and the student's Graduate Advisor of Record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the Master's degree. (Formerly EES 6951-3.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 6961. Comprehensive Examination. (0-0) 1 Credit Hour.

Prerequisite: Approval of the appropriate Graduate Program Committee to take the Comprehensive Examination. Independent study course for the purpose of taking the Comprehensive Examination. May be repeated as many times as approved by the Graduate Program Committee. Enrollment is required each term in which the Comprehensive Examination is taken if no other courses are being taken that term. The grade report for the course is either "CR" (satisfactory performance on the Comprehensive Examination) or "NC" (unsatisfactory performance on the Comprehensive Examination). (Formerly EES 6961.) This course has Differential Tuition. Course Fee: GS01 \$30.

ES 6963. Internship. (0-0) 3 Credit Hours.

Prerequisite: Graduate standing and consent of Graduate Advisor of Record. An opportunity for students to work in a setting that permits them to apply what they have learned in the formal instruction part of the program. May be repeated for credit, but not more than 3 hours will apply to the Master's degree. (Formerly EES 6963. Credit cannot be earned for both EES 6963 and ES 6963.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 6973. Special Problems. (3-0) 3 Credit Hours.

Prerequisite: Consent of instructor. An organized course offering the opportunity for specialized study not normally or not often available as part of the regular course offerings. Special Problems courses may be repeated for credit when the topics vary, but not more than 6 hours, regardless of discipline, will apply to a Master's degree. Field trips may be required. (Formerly EES 6973.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 6981. Master's Thesis. (0-0) 1 Credit Hour.

Prerequisite: Permission of the Graduate Advisor of Record and thesis director. Thesis research preparation. May be repeated for credit, but not more than 6 hours will apply to the Master's degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress. This course has Differential Tuition. Course Fee: GS01 \$30.

ES 6983. Master's Thesis. (0-0) 3 Credit Hours.

Prerequisite: Permission of the Graduate Advisor of Record and thesis director. Thesis research preparation. May be repeated for credit, but not more than 6 hours will apply to the Master's degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress. (Formerly EES 6983.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 7211. Doctoral Research. (0-0) 1 Credit Hour.

Prerequisite: Admission to candidacy for the Doctoral degree. May be repeated for credit, but no more than 15 hours may be applied to the Doctoral degree. (Formerly EES 7211-3.) This course has Differential Tuition. Course Fees: GS01 \$30.

ES 7212. Doctoral Research. (0-0) 2 Credit Hours.

Prerequisite: Admission to candidacy for the Doctoral degree. May be repeated for credit, but no more than 15 hours may be applied to the Doctoral degree. (Formerly EES 7211-3.) This course has Differential Tuition. Course Fee: GS01 \$60.

ES 7213. Doctoral Research. (0-0) 3 Credit Hours.

Prerequisite: Admission to candidacy for the Doctoral degree. May be repeated for credit, but no more than 15 hours may be applied to the Doctoral degree. (Formerly EES 7211-3. Same as CE 7213.) This course has Differential Tuition. Course Fee: GS01 \$90.

ES 7311. Doctoral Dissertation. (0-0) 1 Credit Hour.

Prerequisite: Admission to candidacy for the Doctoral degree. May be repeated for credit, but no more than 15 hours may be applied to the Doctoral degree. (Formerly EES 7311-3.) This course has Differential Tuition. Course Fee: GS01 \$30.

ES 7312. Doctoral Dissertation. (0-0) 2 Credit Hours.

Prerequisite: Admission to candidacy for the Doctoral degree. May be repeated for credit, but no more than 15 hours may be applied to the Doctoral degree. (Formerly EES 7311-3.) This course has Differential Tuition. Course Fee: GS01 \$60.

ES 7313. Doctoral Dissertation. (0-0) 3 Credit Hours.

Prerequisite: Admission to candidacy for the Doctoral degree. May be repeated for credit, but no more than 15 hours may be applied to the Doctoral degree. (Formerly EES 7311-3.) This course has Differential Tuition. Course Fee: GS01 \$90.