DEPARTMENT OF BIOLOGY

The Department of Biology offers Master of Science degrees in Biology and Biotechnology, as well as Doctor of Philosophy degrees in Cell and Molecular Biology and Neuroscience.

- M.S. in Biology (p. 1)
- M.S. in Biotechnology (p. 2)
- Ph.D. in Cell and Molecular Biology (p. 3)
- Ph.D. in Neuroscience (p. 5)

Master of Science Degree in Biology

The graduate program offers opportunities for advanced study and research leading to the Master of Science degree in Biology. A thesis option is offered to students who want an extended opportunity to develop expertise in research techniques and data analysis. There are three emphases within which to conduct a thesis: cell and molecular biology, microbiology and immunology, and neuroscience. The thesis option is recommended for students who plan a career in research or contemplate pursuing a doctorate in one of the life sciences. A non-thesis option is offered for those who want an extended opportunity to earn the Master of Science degree primarily through organized coursework. The non-thesis option allows students to take a wider variety of elective courses to provide a more expansive knowledge of several areas in the life sciences.

Graduate faculty research interests include biochemistry, cellular biology, developmental biology, genetics, microbiology, neuroscience, physiology, and plant sciences. The multidisciplinary nature of the program allows students the opportunity to broaden their educational background at the graduate level. Individual programs are organized around each student’s interests in consultation with the student’s graduate advisor.

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

Program Admission Requirements

To be considered for degree-seeking status, applicants must submit, along with the application, two letters of recommendation, a Statement of Future Plans, including a reason why you wish to pursue an M.S. in Biology, and scores from the Graduate Record Examination (GRE). In addition to satisfying the University-wide graduate admission requirements, applicants are expected to have completed an undergraduate major in one of the biological sciences, with coursework comparable to that required for the Bachelor of Science degree in Biology at UTSA. A minimum grade point average of 3.0 (on a 4.0 scale) is required for admission. 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 who are denied admission to the M.S. Program must reapply if interested in acceptance as a special graduate student.

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.

Program of Study

I. Thesis Option

A. Emphasis in Cell and Molecular Biology

1. 6 semester credit hours of the following core lecture courses are required:
   - BIO 5213 Principles of Molecular Biology
   - BIO 5123 Principles of Cell Biology
   - BIO 5213 Principles of Chemical Biology

2. 6 semester credit hours of research support courses are required:
   - BIO 7041 Biology Colloquium (repeated for a total of 3 hours)
   - BIO 7051 Seminar in Life Sciences (repeated for a total of 3 hours)

3. 12 semester credit hours from the following research-based courses are required:
   - BIO 5973 Directed Research or BIO 6953 Independent Study
   - BIO 6983 Master’s Thesis (repeated for a total of 6 hours)

4. 12 semester credit hours of electives from 5000-7000 BIO courses as approved by the Graduate Advisor of Record are required.

Total Credit Hours 36

B. 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 a Ph.D. in Biology with an emphasis 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 CMB Ph.D. applicant. Core coursework is directly transferable toward the Ph.D. degree (if the student is accepted into the Ph.D. program), and elective coursework may also be transferable with committee approval 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.

1. 6 semester credit hours of the following core lecture courses are required:
   - BIO 5123 Principles of Molecular Biology
   - BIO 5133 Principles of Cell Biology
   - BIO 5213 Principles of Chemical Biology

2. 6 semester credit hours of research support courses are required:
   - BIO 7041 Biology Colloquium (repeated for a total of 3 hours)
II. Non-Thesis Option

Open Emphasis

The open emphasis in Biology offers students the opportunity to acquire a sound preparation of the fundamentals in several areas of Biology, and to introduce students to recent advances in biological theory and methods. Students may take a total of 3 semester credit hours of BIO 5971-3 Directed Research or BIO 6953-3 Independent Study as electives.

1. 3 semester credit hours of the following core lecture courses are required:
   - BIO 5123 Principles of Molecular Biology
   - BIO 5133 Principles of Cell Biology
   - BIO 5213 Principles of Chemical Biology

2. 9 credit hours of research support courses are required:
   - BIO 7041 Biology Colloquium (repeated for a total of 3 hours)

3. 12 semester credit hours from the following research-based courses are required:
   - BIO 5973 Directed Research
   - BIO 6953 Independent Study
   - BIO 6983 Master’s Thesis (repeated for a total of 6 hours)

4. 12 semester credit hours of electives from 5000-7000 BIO courses as approved by the Graduate Advisor of Record are required:

Total Credit Hours 36

C. Emphasis in Neuroscience

The emphasis in Neuroscience is a thesis-track degree program designed for students who may wish to pursue a Ph.D. in Biology with an emphasis in Neuroscience at UTSA. The Master’s level Neuroscience emphasis provides a prospective student with the coursework and preliminary research background found in a successful Neuroscience Ph.D. applicant. Core and elective coursework is transferable and can count toward the Ph.D. degree (if the student is accepted into the Ph.D. program). Elective coursework may also be transferable, with the doctoral studies committee approval, 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.

1. 6 semester credit hours of the following core lecture courses are required:
   - BIO 5433 Systems Neuroscience
   - BIO 5443 Molecular Neurobiology

2. 6 credit hours of research support courses are required:
   - BIO 7041 Biology Colloquium (repeated for a total of 3 hours)
   - BIO 7051 Seminar in Life Sciences (repeated for a total of 3 hours)

3. 12 semester credit hours from the following research-based courses are required:
   - BIO 5973 Directed Research
   - BIO 6953 Independent Study
   - BIO 6983 Master’s Thesis (repeated for a total of 6 hours)

4. 12 semester credit hours of electives from 5000-7000 BIO courses as approved by the Graduate Advisor of Record are required:

Total Credit Hours 36

II. Non-Thesis Option

Open Emphasis

The open emphasis in Biology offers students the opportunity to acquire a sound preparation of the fundamentals in several areas of Biology, and to introduce students to recent advances in biological theory and methods. Students may take a total of 3 semester credit hours of BIO 5971-3 Directed Research or BIO 6953-3 Independent Study 6951-3 as electives.

1. 3 semester credit hours of the following core lecture courses are required:
   - BIO 5123 Principles of Molecular Biology
   - BIO 5133 Principles of Cell Biology
   - BIO 5213 Principles of Chemical Biology

2. 9 credit hours of research support courses are required:
   - BIO 7041 Biology Colloquium (repeated for a total of 3 hours)

Total Credit Hours 36

Comprehensive Examination

As specified by University regulations, candidates must pass a comprehensive examination administered by the student’s Graduate Committee. For non-thesis students, this examination (which has oral and written components) must be given in the semester prior to the semester during which degree requirements are to be completed. 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. Certain rules must be adhered to concerning the composition of the Master’s Thesis Committee and the Master’s Comprehensive Examination Committee. Only tenure or tenure-track faculty members from UTSA can chair these committees, and no more than one member of either committee can be a fixed-term track faculty member, or be from another institution. Students electing the thesis option must successfully defend their thesis research before their Graduate Committee prior to the submission of the thesis to the Dean of the Graduate School for approval.

Master of Science Degree in Biotechnology

The Master of Science degree in Biotechnology offers opportunities for rigorous, advanced study and research in biotechnology, in order to prepare students for employment and research in this rapidly advancing and expanding field. A broad common base of knowledge for biotechnology is provided in the Master’s degree by a comprehensive core curriculum that includes key areas in biochemistry, cell and molecular biology, and immunology. All students receive practical training through the completion of at least two laboratory courses. Additional coursework is selected from a list of approved lecture-based and laboratory courses, and can include up to 9 hours of biomedical engineering lectures, or 12 hours on aspects of management of biotechnology. The opportunity to gain research experience or develop further technical expertise is also possible through an internship in a biotechnology-based company or by conducting a Master’s thesis.

Program Admission Requirements

To be considered for degree-seeking status, applicants must submit, along with the application, two letters of recommendation, a Statement of Future Plans for a career in Biotechnology, and scores from the Graduate Record Examination (GRE). In addition to satisfying the University-wide graduate admission requirements, applicants are expected to have completed an undergraduate major in the sciences with coursework comparable to the core required for the Bachelor of Science degree in Biology at UTSA. In particular, incoming students are required to have taken, and received at least a grade of “B” in upper-division undergraduate lecture and laboratory courses in cell biology and biochemistry, and undergraduate coursework in microbiology and immunology is recommended. Students whose undergraduate preparation is deficient in one of these areas of requirements but who meet the remaining standards for admission may be conditionally admitted and required to complete specific undergraduate course(s) as a condition of admission.
In such cases, students should anticipate that additional time will be required to complete the degree. A minimum grade point average of 3.0 (on a 4.0 scale) is required for admission. Students who are denied admission to this M.S. program must reapply if interested in acceptance as a special graduate student.

**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.

**Program of Study**

A. Biotechnology lectures – core curriculum: 12

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>BIO 5001</td>
<td>Ethical Conduct in Research</td>
</tr>
<tr>
<td>BIO 5123</td>
<td>Principles of Molecular Biology</td>
</tr>
<tr>
<td>BIO 5133</td>
<td>Principles of Cell Biology</td>
</tr>
<tr>
<td>BIO 5213</td>
<td>Principles of Chemical Biology</td>
</tr>
<tr>
<td>BIO 5762</td>
<td>Fundamentals of Immunology for Biotechnology</td>
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</tbody>
</table>

B. 3 semester credit hours in basic laboratory techniques are required:

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<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>BIO 5033</td>
<td>Biotechnology Laboratory</td>
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</table>

C. A minimum of 3 semester credit hours of additional organized laboratory experience are required from the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>BIO 5143</td>
<td>Advanced Nucleic Acids Laboratory</td>
</tr>
<tr>
<td>BIO 5163</td>
<td>Recombinant Protein Biotechnology Laboratory</td>
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</tbody>
</table>

D. Applications of Biotechnology electives. 18 hours of Biotechnology electives are required. These can be from 5000-7000 BIO courses. Alternatively, up to 9 hours of electives can be 5000-7000 Biomedical Engineering (BME) courses, or up to 12 hours of electives can be 5000-7000 Management of Technology (MOT) courses. All non-BIO courses must be approved by the Graduate Advisor of Record.

**Total Credit Hours** 36

**Biotechnology Internship**

(Subject to availability.) The internship (Practicum in Biotechnology BIO 7563) will require prior arrangement with biotechnology-based companies and approval of the Graduate Advisor of Record. May be repeated for credit, but no more than 9 hours will be approved and applied toward program of study. Students may not take an internship if they select the thesis option.

**Thesis Option**

Students electing the thesis option must complete 6 semester credit hours of BIO 5973 Directed Research and 6 semester credit hours of BIO 6983 Master’s Thesis.

**Comprehensive Examination**

As specified by University regulations, degree candidates must pass a comprehensive examination administered by the student’s Graduate Committee. For non-thesis students, this examination (which has oral and written components) must be given in the semester prior to the summer during which degree requirements are to be completed. Students electing to do a thesis must successfully defend their thesis research before their Graduate Committee prior to the submission of the thesis to the Dean of the Graduate School for approval. Certain rules must be adhered to concerning the composition of the Master’s Comprehensive Examination Committee and the Master’s Thesis Committee. Only tenured or tenure-track faculty members from UTSA can chair the Committee, and no more than one member of the Committee may be fixed-term track faculty or from another institution. Students who do not achieve the criteria (or necessary expectations) to pass the Comprehensive Examination can retake the comprehensive exam one additional time.

**Doctor of Philosophy Degree in Cell and Molecular Biology**

The Department of Biology offers opportunities for advanced study and research leading to the Doctor of Philosophy degree in Cell and Molecular Biology. In addition, the Cell and Molecular Biology degree offers specialized tracks in Molecular Microbiology and Immunology and Stem Cell Biology. The Ph.D. in Cell and Molecular Biology is awarded to candidates who have displayed an in-depth understanding of the subject matter and demonstrated the ability to make an original contribution to knowledge in their specialized area of study.

The regulations for this degree comply with the general University regulations (refer to Student Policies, General Academic Regulations, and the Graduate Catalog, Doctoral Degree Regulations).

**Admission Requirements**

Applicants must have a Bachelor of Arts or a Bachelor of Science degree, preferably in biology, from an accredited university and a minimum grade point average of 3.0 in upper-division or graduate work. Applicants must submit, along with the application, transcripts describing previous undergraduate and graduate coursework, three letters of recommendation, and a Statement of Future Plans. Applicants whose native language is not English must score at least 60 on the Test of English as a Foreign Language (TOEFL) paper version or 79 on the Internet version. Admission is accompanied by appointment to a teaching assistantship, research assistantship, or research fellowship. The Doctoral Studies Committees is comprised of members selected from the graduate faculty who are responsible for reviewing applications for admission.

**Degree Requirements**

The degree requires a minimum of 79 semester credit hours beyond the baccalaureate degree for the Ph.D. in Cell and Molecular Biology. The curriculum consists of core courses, courses in scientific writing and scientific teaching, elective courses, seminars, research, and completion of the dissertation following advancement to candidacy. Any grade lower than “B” in a graduate course or in remedial coursework at the undergraduate level will not count toward the Ph.D. degree. Students matriculating with a Master’s degree may transfer up to 30 semester credit hours toward the Ph.D. degree provided the courses are comparable to required core or elective courses and are approved by the appropriate Doctoral Studies Committee.

A. Core curriculum (19 semester credit hours required):

<table>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>BIO 5123</td>
<td>Principles of Molecular Biology</td>
</tr>
<tr>
<td>BIO 5133</td>
<td>Principles of Cell Biology</td>
</tr>
<tr>
<td>BIO 5213</td>
<td>Principles of Chemical Biology</td>
</tr>
<tr>
<td>BIO 7113</td>
<td>Principles of Biological Scientific Teaching</td>
</tr>
<tr>
<td>BIO 7143</td>
<td>Principles of Biological Scientific Writing</td>
</tr>
<tr>
<td>BIO 7572</td>
<td>Experimental Techniques in Biology</td>
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</table>
cells, epigenetic programming in stem cells, maintenance of genetic integrity in stem cells, and the use of stem cells to study disease etiology, and will be based on studies of embryonic stem cells, induced pluripotent stem cells, germline stem cells, neural stem cells, mesenchymal stem cells or other tissue-specific stem cells, as well as stem cells from non-mammalian organisms including lower vertebrates, microorganisms and/or plants.

Students in this track will follow the standard curriculum and program of study for the concentration in Cell and Molecular Biology. However, their Doctoral Dissertation topic, proposal and research must be in an area related to Stem Cell Biology. In addition, students are encouraged to take elective courses closely related to stem cell biology. Finally, students in the Stem Cell Biology track will be required to enroll in colloquia that address topics related to Stem Cell Biology. The overall program of study for this track must be approved by the student’s Dissertation Advisor, a subcommittee that will oversee the Stem Cell Biology Track, and the Cell and Molecular Biology Doctoral Studies Committee.

**Advancement to Candidacy**

Advancement to candidacy requires a student to complete University and program requirements and to pass written and oral qualifying examinations following completion of course requirements. The written qualifying exam is administered in connection with the Principles of Cell Biology and Principles of Molecular Biology core courses. The oral qualifying exam is based on the dissertation research proposal and is administered by a five-member Oral Qualifying Exam Committee made up of tenured, tenure-track or adjunct faculty. The qualifying exam is conducted as outlined in the Handbook of Academic Policies and Procedures for the Cell and Molecular Biology concentration. No more than two attempts to pass qualifying examinations are allowed. Results of the written and oral examinations must be reported to the Doctoral Studies Committee and the Dean of the Graduate School. Admission into the Doctoral program does not guarantee advancement to candidacy.

**Dissertation**

Candidates must demonstrate their ability to conduct independent research by completing and defending an original dissertation. The research topic is determined by the student in consultation with their supervising professor and a Dissertation Committee. The Dissertation Committee is selected by the student and supervising professor and a Dissertation Committee. The Dissertation Committee conducts a closed oral examination dealing primarily with the relation of the dissertation to the general field of specialty. Results of the oral examination must be reported to the Dean of the Graduate School. Awarding of the degree is based on the approval of the Dissertation Committee, which is approved by relevant Doctoral Studies Committee, the Department Chair, and the Dean of the Graduate School. The Dean of the Graduate School certifies the completion of all University-wide requirements.

**Final Oral Examination**

Following an open presentation of the dissertation findings, the Dissertation Committee conducts a closed oral examination dealing primarily with the relation of the dissertation to the general field of specialty. Results of the oral examination must be reported to the Dean of the Graduate School. Awarding of the degree is based on the approval of the Dissertation Committee, which is approved by relevant Doctoral Studies Committee, the Department Chair, and the Dean of the Graduate School. The Dean of the Graduate School certifies the completion of all University-wide requirements.
Doctor of Philosophy Degree in Neuroscience

The Department of Biology offers opportunities for advanced study and research leading to the Doctor of Philosophy degree in Neuroscience. The Ph.D. in Neuroscience is awarded to candidates who have displayed an in-depth understanding of the subject matter and demonstrated the ability to make an original contribution to knowledge in their specialized area of study.

The regulations for this degree comply with the general University regulations (refer to Student Policies, General Academic Regulations, and the Graduate Catalog, Doctoral Degree Regulations).

Admission Requirements

Applicants must have a Bachelor of Arts or a Bachelor of Science degree, preferably in biology, from an accredited university, and a minimum grade point average of 3.0 in upper-division and graduate work. Applicants must submit, along with the application, three letters of recommendation, and a Statement of Future Plans. Applicants whose native language is not English must score at least 60 on the Test of English as a Foreign Language (TOEFL) paper version or 79 on the Internet version. The Doctoral Studies Committees is comprised of members selected from the graduate faculty and are responsible for reviewing applications for admission.

Degree Requirements

The degree requires a minimum of 79 semester credit hours beyond the baccalaureate degree for the Ph.D. in Neuroscience. The curriculum consists of core courses, elective courses, seminars, required teaching, research, and completion of the dissertation following advancement to candidacy. Any grade lower than “B” in a graduate course or in remedial coursework at the undergraduate level will not count toward the minimum number of required hours. Students matriculating with a Master’s degree may use up to 30 semester credit hours toward the degree provided the courses are comparable to core and elective courses and are approved by the Doctoral Studies Committee.

A. Core curriculum (17 semester credit hours required):

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>BIO 5433</td>
<td>Systems Neuroscience</td>
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<tr>
<td>BIO 5443</td>
<td>Molecular Neurobiology</td>
</tr>
<tr>
<td>BIO 6233</td>
<td>Quantitative Biology</td>
</tr>
<tr>
<td>BIO 7113</td>
<td>Principles of Biological Scientific Teaching</td>
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<tr>
<td>BIO 7143</td>
<td>Principles of Biological Scientific Writing</td>
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<tr>
<td>BIO 7571</td>
<td>Experimental Techniques in Biology</td>
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B. Colloquia (8 semester hours minimum):

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<th>Course Code</th>
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<tbody>
<tr>
<td>BIO 7041</td>
<td>Biology Colloquium</td>
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</table>

C. Doctoral research (45 semester credit hours minimum):

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>BIO 7211</td>
<td>Doctoral Research (before admission to candidacy)</td>
</tr>
<tr>
<td>BIO 7212</td>
<td>Doctoral Research (before admission to candidacy)</td>
</tr>
<tr>
<td>BIO 7213</td>
<td>Doctoral Research (before admission to candidacy)</td>
</tr>
<tr>
<td>BIO 7311</td>
<td>Doctoral Dissertation (for Ph.D. candidates)</td>
</tr>
<tr>
<td>BIO 7312</td>
<td>Doctoral Dissertation (for Ph.D. candidates)</td>
</tr>
<tr>
<td>BIO 7313</td>
<td>Doctoral Dissertation (for Ph.D. candidates)</td>
</tr>
</tbody>
</table>

D. Electives (19 semester credit hours minimum):

These can be selected from any 5000–7000 level lecture courses offered in Biology or from any 5000–7000 level lecture courses offered in other departments with the approval of the Neuroscience Doctoral Studies Committee.

Total Credit Hours 89

1 Enroll in BIO 7571 Experimental Techniques in Biology is required in the Fall and Spring semesters of the first year.

The entire program of study must be approved by the student’s dissertation advisor, dissertation committee, and the Neurobiology Doctoral Studies Committee, and must be submitted to the Dean of the Graduate School for final approval.

Advancement to Candidacy

Advancement to candidacy requires a student to complete University and program requirements and to pass written and oral qualifying examinations following completion of course requirements. The examination is administered by the Doctoral Studies Committee of each concentration and is conducted as outlined in the Handbook of Academic Policies and Procedures for each concentration. No more than two attempts to pass qualifying examinations are allowed. Results of the written and oral examinations must be reported to the appropriate Doctoral Studies Committee and the Dean of the Graduate School. Admission into the Doctoral program does not guarantee advancement to candidacy.

Dissertation

Candidates must demonstrate their ability to conduct independent research by completing and defending an original dissertation. The research topic is determined by the student in consultation with their supervising professor and a Dissertation Committee. The Dissertation Committee is selected by the student and supervising professor and approved by 1) the Doctoral Studies committee; 2) the Department Chair; 3) the Dean of the College; and 4) the Dean of the Graduate School. The Dissertation Committee guides and critiques the candidate’s research. The Committee is composed of four program faculty and one outside member. The Dissertation Committee must approve the completed dissertation.

Final Oral Examination

Following an open presentation of the dissertation findings, the Dissertation Committee conducts a closed oral examination dealing primarily with the relation of the dissertation to the general field of specialty. Results of the oral examination must be reported to the Dean of the Graduate School. Awarding of the degree is based on the approval of the Dissertation Committee, which is approved by relevant Doctoral Studies Committee, the Department Chair, and the Dean of the Graduate School. The Dean of the Graduate School certifies the completion of all University-wide requirements.

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). (Credit cannot be earned for both BIO 5001 and BIO 7413.) Differential Tuition: $50. Course Fees: GS01 $30.
BIO 5003. Epigenetics and Metabolism. (3-0) 3 Credit Hours.
Scientific overview and discussion course related topics including stem cells, diseases, and interaction between metabolism and different epigenetic mechanisms. Differential Tuition: $150. Course Fees: GS01 $90.

BIO 5033. Biotechnology Laboratory. (0-6) 3 Credit Hours.
Prerequisite: Graduate standing. Concurrent enrollment in BIO 5323 is strongly recommended for M.S. in Biotechnology students. An organized course offering an introduction to routine procedures employed in the modern research laboratory. Differential Tuition: $150. Course Fees: GS01 $90; IUB1 $10; L001 $30.

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. Differential Tuition: $150. Course Fees: GS01 $90.

BIO 5133. Principles of Cell Biology. (3-0) 3 Credit Hours.
Prerequisites: 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. Differential Tuition: $150. Course Fees: GS01 $90.

BIO 5143. Advanced Nucleic Acids Laboratory. (0-6) 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. (Formerly titled "Advanced Molecular Biology Laboratory – DNA Techniques") Differential Tuition: $150. Course Fees: GS01 $90; IUB1 $10; L001 $30.

BIO 5163. Recombinant Protein Biotechnology Laboratory. (0-6) 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. (Formerly BIO 7542 and BIO 7543. Credit cannot be earned for both BIO 5163 and BIO 7542 or BIO 7543.) Differential Tuition: $150. Course Fees: GS01 $90; IUB1 $10; L001 $30.

BIO 5213. Principles of Chemical Biology. (3-0) 3 Credit Hours.
Prerequisites: BIO 3513 and BIO 3813, or equivalents. The role of chemistry in prokaryotic and eukaryotic biological systems. Topics will cover the probing and controlling biological systems using chemical methods and the manipulation of biological systems via novel chemistries to advance fundamental knowledge which serve as a basis for translational approaches. Differential Tuition: $150. Course Fees: 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, and pharmacology of some of our most important plant-derived pharmaceuticals. Differential Tuition: $150. Course Fees: GS01 $90.

BIO 5343. Proteins and Nucleic Acids. (3-0) 3 Credit Hours.
Prerequisite: BIO 3513 or equivalent. Protein sequences, domains, folding, proteomics, glycoproteins, protein-DNA interaction, RNA conformations. Differential Tuition: $150. Course Fees: GS01 $90.
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. Differential Tuition: $150. Course Fees: 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.) Differential Tuition: $150. Course Fees: GS01 $90.

BIO 5733. Advanced Medical Mycology. (3-0) 3 Credit Hours.
Prerequisites: 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. Differential Tuition: $150. Course Fees: 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") Differential Tuition: $150. Course Fees: GS01 $90.

BIO 5753. Conservation Biology. (3-0) 3 Credit Hours.
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.) Differential Tuition: $150. Course Fees: 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. Differential Tuition: $100. Course Fees: GS01 $60.

BIO 5783. Introduction to Good Manufacturing Practices and Good Laboratory Practices. (3-0) 3 Credit Hours.
Review of FDA and U.S. Pharmacopia 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. Differential Tuition: $150. Course Fees: GS01 $90.

BIO 5813. Frontiers in Human Pluripotent Stem Cells. (3-0) 3 Credit Hours.
Integrates the fundamental aspects of developmental biology with emerging concepts in embryonic and adult stem cells and regenerative medicine. A discussion of various stem cell applications in industry, military, medicine, and ethics of regenerative medicine is presented. Differential Tuition: $150. Course Fees: GS01 $90.

BIO 5833. Membrane Structure and Function. (3-0) 3 Credit Hours.

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. Differential Tuition: $150. Course Fees: GS01 $90.

BIO 5971. Directed Research. (0-0) 1 Credit Hour.
Prerequisites: 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. Differential Tuition: $50. Course Fees: GS01 $30.

BIO 5972. Directed Research. (0-0) 2 Credit Hours.
Prerequisites: 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. Differential Tuition: $100. Course Fees: GS01 $60.

BIO 5973. Directed Research. (0-0) 3 Credit Hours.
Prerequisites: 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. Differential Tuition: $150. Course Fees: GS01 $90.

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.) Differential Tuition: $150. Course Fees: GS01 $90.

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.) Differential Tuition: $150. Course Fees: GS01 $90.

BIO 6233. Quantitative Biology. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. 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. Differential Tuition: $150. Course Fees: GS01 $90.
BIO 6313. Molecular Biology and Biophysics of Ion Channels. (3-0) 3 Credit Hours.
Prerequisites: BIO 5433 and BIO 5443, or permission of instructor. A study of the molecular composition and biophysical properties of ion channels. The course emphasizes three families of ion channels: voltage-gated, ligand-gated and metabotropically-stimulated channels. Their structure and function will be related to how ion channels mediate cellular actions in excitable cells. Differential Tuition: $150. Course Fees: GS01 $90.

BIO 6323. Essentials of Biostatistics for Biotechnology. (3-0) 3 Credit Hours.
Basic, intermediate, and advanced (but not bioinformatics) statistical vocabulary, concepts, and methods commonly used in the biotechnology industry. A focus on tests for quality control and assurance of equipment and test systems to assess accuracy, precision, and bias related to test validations. Concepts and appropriate selections of test/study design using power analyses and estimations of sample sizes; also for clinical trials. Analytical calibration curves, frequency distributions, descriptive statistics, measures of central tendency and dispersion/error, probability, paired and unpaired, one-tailed and two-tailed t-tests, correlations, regression, one-way and two-way analysis of variance with repeated measures, parametric and nonparametric tests, post hoc tests for significance, reporting and interpretations of statistical results, validations of clinical tests for specificity, sensitivity, predictive values, likelihood ratios, receiver operating characteristic curves. Differential Tuition: $150. Course Fees: GS01 $90.

BIO 6483. Animal Behavior. (3-0) 3 Credit Hours.
Prerequisite: BIO 3413 or consent of instructor. An examination of neural, endocrine, genetic, and environmental determinants of behavior. Differential Tuition: $150. Course Fees: GS01 $90.

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. Differential Tuition: $150. Course Fees: GS01 $90.

BIO 6543. Vaccine Development. (3-0) 3 Credit Hours.
Prerequisites: 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. Differential Tuition: $150. Course Fees: 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. Differential Tuition: $150. Course Fees: 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. Differential Tuition: $150. Course Fees: GS01 $90.

BIO 6883. Bacterial Pathogenesis. (3-0) 3 Credit Hours.
Prerequisites: 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. Differential Tuition: $150. Course Fees: GS01 $90.

BIO 6913. 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. Differential Tuition: $150. Course Fees: GS01 $90.
BIO 6981. Master's Thesis. (0-0) 1 Credit Hour.
Prerequisites: 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. Differential Tuition: $50. Course Fees: GS01 $30.

BIO 6982. Master's Thesis. (0-0) 2 Credit Hours.
Prerequisites: 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. Differential Tuition: $100. Course Fees: GS01 $60.

BIO 6983. Master's Thesis. (0-0) 3 Credit Hours.
Prerequisites: 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. Differential Tuition: $150. Course Fees: 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.) Differential Tuition: $50. Course Fees: 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). Differential Tuition: $50. Course Fees: GS01 $30.

BIO 7113. Principles of Biological Scientific Teaching. (0-0) 3 Credit Hours.
Prerequisite: Admission to candidacy for the Doctoral degree. Required course for Biology doctoral students. The student will be responsible for all aspects of leading a discussion section or laboratory course. Approval by the chair of the appropriate Doctoral Studies committee required. Differential Tuition: $150. Course Fees: GS01 $90.

BIO 7143. Principles of Biological Scientific Writing. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing. This course will provide an overview of scientific grant and manuscript preparation. The class will be directed toward producing a Ph.D. dissertation proposal and a predoctoral fellowship application. Differential Tuition: $150. Course Fees: GS01 $90.

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. Differential Tuition: $50. Course Fees: 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. Differential Tuition: $100. Course Fees: GS01 $60.

BIO 7213. Doctoral Research. (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. Differential Tuition: $150. Course Fees: GS01 $90.

BIO 7311. Doctoral Dissertation. (0-0) 1 Credit Hour.
Prerequisites: 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. Differential Tuition: $50. Course Fees: GS01 $30.

BIO 7312. Doctoral Dissertation. (0-0) 2 Credit Hours.
Prerequisites: 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. Differential Tuition: $100. Course Fees: GS01 $60.

BIO 7313. Doctoral Dissertation. (0-0) 3 Credit Hours.
Prerequisites: 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. Differential Tuition: $150. Course Fees: GS01 $90.

BIO 7563. Practicum in Biotechnology. (0-0) 3 Credit Hours.
Prerequisites: 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. Differential Tuition: $150. Course Fees: GS01 $90.

BIO 7571. Experimental Techniques in Biology. (0-2) 1 Credit Hour.
Prerequisite: Consent of instructor. Topics include research methods in cell and molecular biology, molecular neurobiology, and microbiology. May be repeated for credit as topics vary. (Formerly BIO 5571.) Differential Tuition: $50. Course Fees: GS01 $30.

BIO 7572. Experimental Techniques in Biology. (0-4) 2 Credit Hours.
Prerequisite: Consent of instructor. Topics include research methods in cell and molecular biology, molecular neurobiology, and microbiology. May be repeated for credit as topics vary. (Formerly BIO 5572.) Differential Tuition: $100. Course Fees: GS01 $60.