

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 Neurobiology.

- M.S. in Biology (p. 1)
- M.S. in Biotechnology (p. 3)
- Ph.D. in Cell and Molecular Biology (p. 4)
- Ph.D. in Neurobiology (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 opportunity to develop expertise in research techniques and data analysis; a non-thesis option is offered for those who want the opportunity to earn the Master of Science degree primarily through organized coursework. The thesis option is recommended for students who plan a career in research or contemplate pursuing a doctorate in one of the life sciences. The non-thesis option 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.

Graduate faculty research interests include biochemistry, cellular biology, developmental biology, ecology, genetics, microbiology, neurobiology, physiology, and plant sciences. The multidisciplinary nature of the program also 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

The emphasis in Cell and Molecular Biology (CMB) is a thesis-track degree program designed to prepare students who may wish to pursue a Ph.D. in Biology with an emphasis in Cell and Molecular Biology at UTSA or elsewhere. The Master’s level CMB 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: 6

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<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>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 7041</td>
<td>Biology Colloquium (repeated for a total of 3 hours)</td>
</tr>
<tr>
<td>BIO 7051</td>
<td>Seminar in Life Sciences (repeated for a total of 3 hours)</td>
</tr>
</tbody>
</table>

3. 12 semester credit hours from the following research-based courses are required: 12

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 5973</td>
<td>Directed Research or BIO 6953 Independent Study</td>
</tr>
<tr>
<td>BIO 6983</td>
<td>Master’s Thesis (repeated for a total of 6 hours)</td>
</tr>
</tbody>
</table>

4. 12 semester credit hours of electives from the following list are recommended. Other 5000-7000 BIO courses that are not listed below can be taken as an elective if approved by the Graduate Advisor of Record:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 5233</td>
<td>Medicinal Plants</td>
</tr>
<tr>
<td>BIO 5463</td>
<td>Reproductive Biology</td>
</tr>
<tr>
<td>BIO 5543</td>
<td>Pharmacology and Toxicology</td>
</tr>
<tr>
<td>BIO 5643</td>
<td>Bioinformatics and Computational Biology</td>
</tr>
<tr>
<td>BIO 5663</td>
<td>Applications of Recombinant DNA Technology</td>
</tr>
<tr>
<td>BIO 5833</td>
<td>Membrane Structure and Function</td>
</tr>
<tr>
<td>BIO 6313</td>
<td>Molecular Biology and Biophysics of Ion Channels</td>
</tr>
<tr>
<td>BIO 6513</td>
<td>Drug Development</td>
</tr>
<tr>
<td>BIO 6973</td>
<td>Special Problems</td>
</tr>
</tbody>
</table>

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 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 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)
   - 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 the following list are recommended. Other 5000-7000 BIO courses that are not listed below can be taken as an elective if approved by the Graduate Advisor of Record:
   - BIO 5543 Pharmacology and Toxicology
   - BIO 5643 Bioinformatics and Computational Biology
   - BIO 5663 Applications of Recombinant DNA Technology
   - BIO 5733 Advanced Medical Mycology
   - BIO 5743 Advanced Virology
   - BIO 6513 Drug Development
   - BIO 6573 Microbial Pathogenesis
   - BIO 6803 Advanced Immunology and Immunochemistry
   - BIO 6883 Bacterial Pathogenesis
   - BIO 6973 Special Problems

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 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)
   - BIO 7051 Seminar in Life Sciences (repeated for a total of 3 hours)

3. 24 credit hours can be selected from 5000–7000 level courses offered in Biology. 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).

   - BIO 5233 Medicinal Plants
   - BIO 5423 Neuroanatomy
   - BIO 5433 Neurophysiology
   - BIO 6983 Master’s Thesis (repeated for a total of 6 hours)

4. 12 semester credit hours of electives from the following list are recommended. Other 5000-7000 BIO courses that are not listed below can be taken as an elective if approved by the Graduate Advisor of Record:
   - BIO 5433 Neurophysiology
   - BIO 5443 Molecular Neurobiology
   - BIO 5473 Developmental Neurobiology
   - BIO 5483 Computational Neuroscience
   - BIO 5493 Cognitive Neuroscience
   - BIO 5503 Sensory Physiology
   - BIO 5533 Human Electrophysiology
   - BIO 6233 Quantitative Biology
   - BIO 6313 Molecular Biology and Biophysics of Ion Channels
   - BIO 6483 Animal Behavior
   - BIO 6973 Special Problems

Total Credit Hours 36

C. Emphasis in Neurobiology

The emphasis in Neurobiology is a thesis-track degree program designed for potential students who may wish to pursue a Ph.D. in Biology with an emphasis in Neurobiology at UTSA. The Master’s level Neurobiology emphasis provides a prospective student with the coursework and preliminary research background found in a successful Neurobiology 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 5423 Neuroanatomy

   - BIO 5433 Neurophysiology
   - BIO 5443 Molecular Neurobiology

2. 6 credit hours of research support courses are required: 6
   - 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 the following list are recommended. Other 5000-7000 BIO courses that are not listed below can be taken as an elective if approved by the Graduate Advisor of Record:
   - BIO 5433 Neurophysiology
   - BIO 5443 Molecular Neurobiology
   - BIO 5473 Developmental Neurobiology
   - BIO 5483 Computational Neuroscience
   - BIO 5493 Cognitive Neuroscience
   - BIO 5503 Sensory Physiology
   - BIO 5533 Human Electrophysiology
   - BIO 6233 Quantitative Biology
   - BIO 6313 Molecular Biology and Biophysics of Ion Channels
   - BIO 6483 Animal Behavior
   - BIO 6973 Special Problems
advancing and expanding field. A broad common base of knowledge for
to prepare students for employment and research in this rapidly
for rigorous, advanced study and research in biotechnology, in order
The Master of Science degree in Biotechnology offers opportunities
Biotechnology
Master of Science Degree in
the Graduate School for approval.
thesis option must successfully defend their thesis research before their
faculty member, or be from another institution. Students electing the
one member of either committee can be a nontenured or nontenure-track
Master's Comprehensive Examination Committee. Only tenured or tenure-
concerning the composition of the Master's Thesis Committee and the
semester and retake the examination. Certain rules must be adhered to
Critical Thinking & Writing for the Biological Sciences
BLN 5403
BLN 5413
BLN 5443
BLN 5453
BLN 5463
BLN 5473
BLN 5483
BLN 5493
BLN 5503
BLN 5533
BLN 5543
BLN 5643
BLN 5663
BLN 5743
BLN 5753
BLN 5763
BLN 5833
BLN 5971
BLN 5972
BLN 5973
BLN 6233
BLN 6313
BLN 6483
BLN 6513
BLN 6573
BLN 6803
BLN 6883
BLN 6973
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 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 enroll in BLN 6963
Critical Thinking & Writing for the Biological Sciences in the following
semester and retake the examination. Certain rules must be adhered to
corresponding to the composition of the Master's Thesis Committee and the
Master's Comprehensive Examination Committee. Only tenured or tenure-
track faculty members can chair these committees, and no more than
one member of either committee can be a nontenured or nontenure-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 to
have taken undergraduate courses in molecular biology and immunology.
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:
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<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>
</tr>
<tr>
<td>BIO 5803</td>
<td>Advanced Immunology and Immunobiology</td>
</tr>
<tr>
<td>BIO 5843</td>
<td>Membrane Structure and Function</td>
</tr>
<tr>
<td>BIO 5971</td>
<td>Directed Research</td>
</tr>
<tr>
<td>BIO 5972</td>
<td>Directed Research</td>
</tr>
<tr>
<td>BIO 5973</td>
<td>Directed Research</td>
</tr>
<tr>
<td>BIO 6233</td>
<td>Quantitative Biology</td>
</tr>
<tr>
<td>BIO 6803</td>
<td>Advanced Immunology and Immunobiology</td>
</tr>
<tr>
<td>BIO 6963</td>
<td>Recombinant Protein Biotechnology Laboratory</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 5033</td>
<td>Biotechnology Laboratory</td>
</tr>
</tbody>
</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>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 5143</td>
<td>Advanced Nucleic Acids Laboratory</td>
</tr>
<tr>
<td>BIO 5163</td>
<td>Recombinant Protein Biotechnology Laboratory</td>
</tr>
</tbody>
</table>

D. Applications of Biotechnology electives. Other 5000-7000 BIO
courses that are not listed below can be taken as an elective if
approved by the Graduate Advisor of Record.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
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<tbody>
<tr>
<td>BIO 5733</td>
<td>Advanced Medical Mycology</td>
</tr>
<tr>
<td>BIO 5743</td>
<td>Advanced Virology</td>
</tr>
<tr>
<td>BIO 5753</td>
<td>Advanced Immunology and Immunobiology</td>
</tr>
<tr>
<td>BIO 5763</td>
<td>Advanced Immunobiology</td>
</tr>
<tr>
<td>BIO 5833</td>
<td>Membrane Structure and Function</td>
</tr>
<tr>
<td>BIO 5971</td>
<td>Directed Research</td>
</tr>
<tr>
<td>BIO 5972</td>
<td>Directed Research</td>
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<td>BIO 6573</td>
<td>Microbial Pathogenesis</td>
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<td>BIO 6803</td>
<td>Advanced Immunology and Immunobiology</td>
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<tr>
<td>BIO 6883</td>
<td>Bacterial Pathogenesis</td>
</tr>
<tr>
<td>BIO 6973</td>
<td>Special Problems</td>
</tr>
</tbody>
</table>
Department of Biology

BIO 5343 Proteins and Nucleic Acids
BIO 5543 Pharmacology and Toxicology
BIO 5663 Applications of Recombinant DNA Technology
BIO 5673 Analysis of Next Generation Sequence Data
BIO 5783 Introduction to Good Manufacturing Practices and Good Laboratory Practices
BIO 5873 Plant Biotechnology
BIO 5971 Directed Research
BIO 5972 Directed Research
BIO 5973 Directed Research
BIO 6323 Essentials of Biostatistics for Biotechnology
BIO 6513 Drug Development
BIO 6983 Master's Thesis (repeated for a total of 6 hours)
BIO 7563 Practicum in Biotechnology
BME 6923 Tissue Engineering
BME 6933 Tissue-Biomaterials Interactions
BME 6943 Biomaterials and Cell Signaling
E. Management of Biotechnology: 0-12
MOT 5163 Management of Technology
MOT 5173 Technology Transfer: The Theory and Practice of Knowledge Utilization
MOT 5223 Management of Professional Personnel
MOT 5243 Essentials of Project and Program Management
MOT 5313 Emerging Technologies
MOT 5323 Biotechnology Industry

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 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 must be given in the semester prior to the semester 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 can chair the Committee, and no more than one member of the Committee may be nontenure-track faculty or from another institution. Students who do not achieve the criteria (or necessary expectations) to pass the Comprehensive Examination will be required to enroll in the Critical Thinking and Writing for the Biological Sciences course (BIO 6963) in the following semester and retake the examination.

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 and graduate work. Applicants must submit, along with the application, three letters of recommendation, a Statement of Future Plans, and scores from the Graduate Record Examination (GRE). 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 requires appointment to a teaching assistantship, research assistantship, or research fellowship. 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 Cell and Molecular Biology. 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 appropriate Doctoral Studies Committee.

A. Core curriculum (18 semester credit hours required): 18
   BIO 5123 Principles of Molecular Biology
   BIO 5133 Principles of Cell Biology
   BIO 5213 Principles of Chemical Biology
   BIO 7113 Supervised Teaching in Biology
   BIO 7143 Principles of Biological Scientific Writing
   BIO 7571 & BIO 7572 Experimental Techniques in Biology

B. Colloquia (10 semester credit hours minimum—a minimum of 1 credit hour each semester throughout tenure in the program): 10
   BIO 7041 Biology Colloquium

C. Doctoral research (42 semester credit hours minimum): 42
   BIO 7211 Doctoral Research (before admission to candidacy)
   BIO 7212 Doctoral Research (before admission to candidacy)
cells or other tissue-specific stem cells, as well as stem cells from non-
and will be based on studies of embryonic stem cells, induced pluripotent
integrity in stem cells, and the use of stem cells to study disease etiology,
cells, epigenetic programming in stem cells, maintenance of genetic
but is not limited to, molecular biology of stem cells, cell biology of stem
to tissue engineering or other therapeutic approaches. This will include,
to translational research involving potential contributions of stem cells
basic biology of stem cells (from any species) as well as those related
opportunity to focus on Stem Cell Biology, including topics related to the
Stem Cell Biology is a rapidly emerging field rooted in basic principles
Molecular Microbiology and Immunology Track
The primary objective of the track in Molecular Microbiology and
Immunology is to provide graduates with advanced academic and
research training in all aspects of Microbiology and Immunology,
especially in those areas that pertain to infectious diseases. This track
will provide expertise in bacteriology, virology, parasitology, mycology,
immunology, vaccinology, biodefense, and molecular genetics. The
information derived from research in this area has an enormous impact
on biology and medicine.

Students in this track follow the regular core curriculum for the
concentration in Cell and Molecular Biology. However, their Doctoral
Dissertation topic, proposal and research need to be in an area related to
Microbiology and Immunology. Likewise, students are also encouraged
to select the majority of their elective courses and colloquia from
those offered that are broadly related to the field of Microbiology and Immunology. The overall program of study for this track may differ
by no more than 12 semester credit hours from the program of study
for the regular concentration in Cell and Molecular Biology and must
be approved by the student’s Dissertation Advisor and the Cell and
Molecular Biology Doctoral Studies Committee.

STEM CELL BIOLOGY TRACK
Stem Cell Biology is a rapidly emerging field rooted in basic principles
of Cell and Molecular Biology that has provided new avenues to
investigate normal cellular and developmental processes as well as novel
approaches to learning more about and/or treating complex diseases
and other debilitating conditions. The Stem Cell Biology Track will allow
students pursuing their doctoral degree in Cell and Molecular Biology the
opportunity to focus on Stem Cell Biology, including topics related to the
basic biology of stem cells (from any species) as well as those related to
translational research involving potential contributions of stem cells to
tissue engineering or other therapeutic approaches. This will include,
but is not limited to, molecular biology of stem cells, cell biology of stem
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 may differ by no more than 12 semester credit hours from
the standard program of study for the concentration in Cell and Molecular
Biology and 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 administered by a five-member Oral Qualifying Exam
Committee made up of tenured or tenure-track faculty. Each qualifying
exam 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.

DOCTOR OF PHILOSOPHY DEGREE IN NEUROBIOLOGY
The Department of Biology offers opportunities for advanced study and
research leading to the Doctor of Philosophy degree in Neurobiology. The
Ph.D. in Neurobiology is awarded to candidates who have displayed an in-
depth understanding of the subject matter and demonstrated the ability

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<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>
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<tr>
<td>BIO 7313</td>
<td>Doctoral Dissertation (for Ph.D. candidates)</td>
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<td></td>
<td>D. Electives (9 semester credit hours minimum):</td>
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<tr>
<td></td>
<td>These can be selected from any 5000--7000 level courses offered in Biology or from any 5000--7000 level courses offered in other departments with the approval of the Cell and Molecular Biology Doctoral Studies Committee.</td>
</tr>
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<td>Total Credit Hours 79</td>
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</tbody>
</table>
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, a Statement of Future Plans, and scores from the Graduate Record Examination (GRE). 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 requires appointment to a teaching assistantship, research assistantship, or research fellowship. 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 Neurobiology. 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 (14 semester credit hours required):

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>BIO 5433</td>
<td>Neurophysiology</td>
</tr>
<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>Supervised Teaching in Biology</td>
</tr>
</tbody>
</table>

Select 2 semester credit hours of the following:

- BIO 7571 Experimental Techniques in Biology

### B. Colloquia (8 semester hours minimum – a minimum of 1 credit hour each Fall and Spring semester):

- BIO 7041 Biology Colloquium

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

- BIO 7211 Doctoral Research (before admission to candidacy)
- BIO 7212 Doctoral Research (before admission to candidacy)
- BIO 7213 Doctoral Research (before admission to candidacy)
- BIO 7311 Doctoral Dissertation (for Ph.D. candidates)
- BIO 7312 Doctoral Dissertation (for Ph.D. candidates)
- BIO 7313 Doctoral Dissertation (for Ph.D. candidates)

D. Electives (12 semester credit hours minimum):

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

<table>
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<tr>
<th>Total Credit Hours</th>
<th>79</th>
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<tbody>
<tr>
<td>1</td>
<td>Enrollment in BIO 7041 Biology Colloquium is required every semester through the fifth year.</td>
</tr>
<tr>
<td>2</td>
<td>Enrollment in BIO 7571 Experimental Techniques in Biology is required in the Fall and Spring semesters of the first year.</td>
</tr>
</tbody>
</table>

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.) Course Fees: GS01 $30; LRS1 $5; STSI $5.
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. Course Fees: GS01 $90; IUB1 $10; L001 $30; LRS1 $15; STSI $15.

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.) Course Fees: GS01 $90; LRS1 $15; STSI $15.

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 genetics of control of development will also be covered. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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.") Course Fees: GS01 $90; IUB1 $10; L001 $30; LRS1 $15; STSI $15.

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.) Course Fees: GS01 $90; IUB1 $10; L001 $30; LRS1 $15; STSI $15.

BIO 5193. Hands-On Scientific Learning. (0-6) 3 Credit Hours.
An introduction to the practical application of a variety of cell and molecular biology techniques. This course is intended to provide laboratory experience in selective aspects of modern biotechnology and their applications appropriate for Science Educators. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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.) Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 5273. Global Change Biology. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. Historical, present-day and future predictions of global changes in biological communities and species will be examined. Gas exchange, mating systems, phenological changes, pollination and pollinators as well as other species interactions, species diversity and species distribution will be examined. Both intrinsic and extrinsic factors influencing the changes will be scrutinized. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 5363. Microbial Genetics and Recombinant DNA. (3-0) 3 Credit Hours.
Prerequisites: BIO 2313, BIO 3513, and BIO 3713, or consent of instructor. This course covers recombinant DNA and various technologies that it has spawned. It also covers those aspects of microbial genetics that directly relate to recombinant DNA. (Formerly BIO 5373. Credit cannot be earned for both BIO 5363 and BIO 5373.) Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 5423. Neuroanatomy. (3-0) 3 Credit Hours.
Prerequisite: Consent of instructor. The anatomy of the vertebrate nervous system. Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 5433. Neurophysiology. (3-0) 3 Credit Hours.
Prerequisite: BIO 3433 or an equivalent. The fundamentals of neurophysiology are presented from the cellular to the systems level. Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 5443. Molecular Neurobiology. (3-0) 3 Credit Hours.
Prerequisite: BIO 3433 or an equivalent. Biochemical pathways, protein synthesis, and function of neuronal communication. Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 5453. Neuroendocrinology. (3-0) 3 Credit Hours.
Prerequisites: BIO 3433 and BIO 3813. An anatomical and molecular neurobiology of the endocrine hypothalamus and associated organs. Morphological, cell biological, and feedback mechanisms of endocrine regulation are emphasized. Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 5463. Reproductive Biology. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing in Biology. Mammalian reproduction including mechanisms involved in sexual differentiation, fertilization, and fetal development. Endocrine regulation and environmental influences with a focus on human reproduction. Course Fees: GS01 $90; LRS1 $15; STSI $15.
BIO 5473. Developmental Neurobiology. (3-0) 3 Credit Hours.  
Prerequisite: BIO 3433 or consent of instructor. A study of the development of the nervous system, with an emphasis on neurogenesis, neuronal migration, growth factors, axonal guidance, and the role of neuronal activity in synapse stabilization. Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 5483. Computational Neuroscience. (3-0) 3 Credit Hours.  
Prerequisite: BIO 3433 or an equivalent. A non-mathematical approach to the computational functions of the brain, including sensory coding, neural control of movement, and the computational properties of neurons and neuronal networks. Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 5493. Cognitive Neuroscience. (3-0) 3 Credit Hours.  
Prerequisite: BIO 3433 or consent of instructor. The biological foundations of mental phenomena, including perception, attention, learning, memory, language, motor control, and executive function, as well as functional specialization, development and plasticity, through various methodologies. Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 5503. Sensory Physiology. (3-0) 3 Credit Hours.  
Prerequisite: BIO 5433 or consent of instructor. Principles of sensory physiology, including sensory transduction and central processing of sensory information in vertebrate and invertebrate species. Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 5523. Enzymes. (3-0) 3 Credit Hours.  
Prerequisite: BIO 3513 or an equivalent. A study of enzyme structure and mechanism, inhibitors, cofactor, kinetics, and regulation. Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 5533. Human Electrophysiology. (3-0) 3 Credit Hours.  
Prerequisite: BIO 3433 (or PSY 3103) recommended, or consent of instructor. The electrophysiological basis of human behavior, with an emphasis on event-related brain potentials associated with cognitive function, perception and action. Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 5543. Pharmacology and Toxicology. (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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 5553. Toxicology. (3-0) 3 Credit Hours.  
Prerequisite: Graduate standing or consent of instructor. The molecular mechanisms by which varied environmental toxins impact human physiological systems will be presented, including the metabolic aspects involved in chemical biotransformation. Processes by which chemical exposures induce cancers and genetic and/or developmental anomalies will be addressed. Risk assessment, food production safety issues and biological aspects of regulatory toxicology will also be discussed. Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 5643. Bioinformatics and Computational Biology. (3-0) 3 Credit Hours.  
Prerequisites: BIO 2313 or an equivalent; enrollment in Biology Ph.D. program required, or permission of the Biology Department or instructor. Computational analysis of sequences, protein structures, and gene expression network on a large scale. Comparative genomics, functional genomics, and proteomics will also be covered. (Credit cannot be earned for both BIO 5643 and BIO 5623.) Course Fees: GS01 $90; LRS1 $15; STSI $15.

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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 5673. Analysis of Next Generation Sequence Data. (3-0) 3 Credit Hours.  
The course has two major goals: 1) A general understanding of next-generation sequencing technologies; 2) An understanding of the benefits in applying next generation sequencing technology for life sciences research. The emphasis will be on applications for microbial infectious diseases research. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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.) Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 5723. 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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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"). Course Fees: GS01 $90; LRS1 $15; STSI $15.

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.) Course Fees: GS01 $90; LRS1 $15; STSI $15.

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. Course Fees: GS01 $60; LRS1 $10; STSI $10.

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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 5793. Wildlife Management. (3-0) 3 Credit Hours.  
An introduction to wildlife management including ecological principles dealing with ecosystems, natural communities, and populations. The importance of animal behavior, the availability of food, cover, wildlife diseases, predators, hunting, and trapping will be included. Field trips may be included. (Same as ES 5773. Credit cannot be earned for BIO 5793 and ES 5773.) Course Fees: GS01 $90; LRS1 $15; STSI $15.
BIO 5833. Membrane Structure and Function. (3-0) 3 Credit Hours.
Prerequisite: BIO 3513 or an equivalent. A study of the composition, organization, transport functions, and permeability of natural and model membranes. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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. Course Fees: GS01 $30; LRS1 $5; STSI $5.

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. Course Fees: GS01 $60; LRS1 $10; STSI $10.

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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 6073. Medical Physiology. (3-0) 3 Credit Hours.
Prerequisites: Graduate standing or consent of the instructor. Key concepts of medical physiology will be described, to include ethnic health disparities, endocrinology, neurophysiology, autonomic function, muscle mechanics, cardiovascular, respiratory and renal physiology. Students will be expected to master the clinical pathophysiology of each key concept. In addition, the students will be expected to gain sufficient knowledge such that they can integrate multiple physiological systems and answer critical thinking questions on exams. Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 6084. MCAT Preparation. (4-0) 4 Credit Hours.
Prerequisites: Graduate standing or consent of the instructor. This course will incorporate a comprehensive review of the biology and biochemistry of living systems, the chemistry and physics of biological systems, the psychology, sociology, and biology of behavior, and critical analysis and reasoning. The course will also contain student self-assessments and effective test-taking strategies. Multiple practice MCAT’s will be administered during the course. Course Fees: GS01 $120; LRS1 $20; STSI $20.

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.) Course Fees: GS01 $90; LRS1 $15; STSI $15.

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.) Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 6233. Quantitative Biology. (3-0) 3 Credit Hours.
Prerequisites: BIO 5443 and BIO 5444, 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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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. Course Fees: GS01 $90; LRS1 $15; STSI $15.
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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 6951. Independent Study. (0-0) 1 Credit Hour.
Prerequisites: 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. Course Fees: GS01 $30; LRS1 $5; STSI $5.

BIO 6952. Independent Study. (0-0) 2 Credit Hours.
Prerequisites: 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. Course Fees: GS01 $60; LRS1 $10; STSI $10.

BIO 6953. Independent Study. (0-0) 3 Credit Hours.
Prerequisites: 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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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). Course Fees: GS01 $30; LRS1 $5; STSI $5.

BIO 6963. Critical Thinking & Writing for the Biological Sciences. (3-0) 3 Credit Hours.
Prerequisites: Consent of the instructor and of the Graduate Advisor of Record. This course introduces students to writing and critiquing research proposals, manuscripts, abstracts, and scientific presentations. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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 is required each term in which the thesis is in progress. Course Fees: GS01 $90; LRS1 $15; STSI $15.

BIO 7041. Biology Colloquium. (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 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.) Course Fees: GS01 $30; LRS1 $5; STSI $5.

BIO 7051. Seminar in Life Sciences. (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 seminar) or "NC" (unsatisfactory participation in the seminar). Course Fees: GS01 $30; LRS1 $5; STSI $5.

BIO 7113. Supervised Teaching in Biology. (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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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. Course Fees: GS01 $90; LRS1 $15; STSI $15.
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. Course Fees: GS01 $30; LRS1 $5; STSI $5.

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. Course Fees: GS01 $60; LRS1 $10; STSI $10.

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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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. Course Fees: GS01 $30; LRS1 $5; STSI $5.

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. Course Fees: GS01 $60; LRS1 $10; STSI $10.

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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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. Course Fees: GS01 $90; LRS1 $15; STSI $15.

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.) Course Fees: GS01 $30; LRS1 $5; STSI $5.

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.) Course Fees: GS01 $60; LRS1 $10; STSI $10.