School of Natural Sciences and Mathematics

Department of Biological Sciences

Department Objectives

The Graduate Program offers training in those aspects of molecular and cell biology that underpin modern biological and biomedical sciences.

The Master of Science degree in Molecular and Cell Biology is designed for students who wish to learn the methodology of research in molecular and cell biology and the fundamentals of problem solving in these areas.

The Master of Science degree in Molecular and Cell Biology (without thesis) is intended for students who seek to gain knowledge of modern biology without the intent to seek positions as technical laboratory personnel, and for those students who are seeking additional preparation for admission to professional schools.

The Master of Science degree in Biotechnology is intended to prepare students for careers in biotechnology and biomedicine, and to assist currently employed professionals in enhancing their career opportunities.

The Master of Arts in Teaching degree in Science Education with a specialization in Biology is designed to strengthen the knowledge of high school teachers in fundamental aspects of biology and to bring them up to date on advances in this rapidly developing field. For further information on this program and for course descriptions, see the Science/Mathematics Education section of this catalog.

The Doctor of Philosophy degree in Molecular and Cell Biology is appropriate for students who show a potential for originality in research, and is designed to develop a critical and analytical understanding of current developments, which will enable them to keep abreast of the rapid advances that are likely to occur in the biological and biomedical fields.

The MS and PhD degree plans offer students the opportunity to prepare for academic careers in colleges and universities including medical and dental schools, and for careers in industrial, hospital, public health, and environmental and governmental laboratories and organizations.

Specializations

First-year MS and PhD students in Molecular and Cell Biology will complete a body of core courses that emphasize fundamental aspects of biochemistry, quantitative biology, molecular biology, and cell biology. MS Biotechnology students take core courses in genomics, proteomics and bioinformatics, and a laboratory-based course. All students may then proceed to advanced
coursework in any of these general areas. Elective courses are open to all qualified students as recommended by their supervising committees. First-year PhD students are required to participate in rotations through research laboratories.

In the second year, MS and PhD students in Molecular and Cell Biology initiate research under the supervision of one or more of the Biological Sciences faculty. The faculty and their research interests are listed below. Prospective students should recognize that it is possible to do research in closely related areas not mentioned in this list, provided a faculty member is prepared to supervise the work.

- Gail A. M. Breen: Isolation and characterization of the genes that code for proteins of the mammalian mitochondrion; mitochondrial biogenesis; eukaryotic gene regulation.
- Lee A. Bulla: Molecular basis of biopesticides.
- John G. Burr: Eukaryotic growth regulation; mechanism of viral oncogenic transformation.
- Jeff L. DeJong: Eukaryotic transcription; initiation and activation of RNA polymerase II.
- Nikki Delk: The role and regulation of autophagy and autophagy-related proteins in bone metastatic prostate cancer cell survival.
- Rockford K. Draper: Membrane traffic; protein toxins; bio-nanotechnology.
- Juan E. González: Cell-cell interactions, role of exopolysaccharides in nodulation of legumes by rhizobia; molecular genetics of plant-microbe interactions.
- Jung-whan (Jay) Kim: Cancer cell metabolism and the tumor microenvironment.
- Tae Hoon Kim: Genome expression mechanisms involving transcription elongation and insulation; functional genomics tools for understanding and targeting cancer genomes and epigenomes.
- Dennis L. Miller: Structure and organization of mitochondrial DNA; mitochondrial gene expression; RNA editing; mitochondrial biogenesis.
- Lawrence J. Reitzer: Regulation of gene expression and metabolism in prokaryotes.
- Stephen Spiro: Regulation of bacterial gene expression by environmental signals; genetic and physiological adaptation to stress.
- Duane D. Winkler: Structural, biophysical, and thermodynamic analysis of trans-acting factors responsible for the dynamic nature of nucleosomes with regard to normal DNA metabolism and disease.
- Zhenyu Xuan: Computational biology and bioinformatics.
- Li Zhang: Molecular mechanisms of cell signaling, heme signaling and oxygen sensing, genomics, and systems biology.
- Michael Qiwei Zhang: Computational biology; gene regulation and epigenomics.

Facilities

Major items of equipment used by the faculty are available for graduate student research. This equipment includes fluorescence and confocal microscope systems, two high throughput sequencing platforms, fluorescence activated cell sorter, isothermal titration calorimeter, protein crystallization robot, Veeco MultiMode SPM atomic force microscope, Molecular Dynamics PhosphorImagers, BioRad real-time polymerase chain reaction instruments, Beckman scintillation counters and Optima ultracentrifuges, a Jasco J-715 spectropolarimeter, and mass spectrometers for proteomics and metabolomics. Individual laboratories are well-equipped with instrumentation needed for research in molecular and cell biology, including thermal cyclers, spectrophotometers, chromatography and electrophoresis systems, chemical hoods, and mammalian cell culture facilities.

Other shared biology facilities include environmental chambers, two staffed media kitchens with autoclaves and washing machines, a darkroom with an x-ray film developer, and an electronics workshop. There is a modern research animal housing facility on campus, as well as a GE 500 MHz FT multinuclear magnetic resonance spectrometer.

Admission Requirements

The University's general admission requirements are discussed on the [Graduate Admission](https://catalog.utdallas.edu/2018/graduate/programs/nsm/biological-sciences) page.

For full participation in the Graduate Program in Molecular and Cell Biology, the student should have a good background in calculus, general physics, organic chemistry, biochemistry, and general biology, including genetics and cell biology. Entering students not having this background may be required to take some additional coursework in their first year or in the summer immediately preceding entry. Students intending to do research in computational biology should have some background in mathematics and in programming. Admission is competitive. A minimum GRE score of 295 (verbal plus quantitative) with a minimum of 147 for the verbal component is required. Average test scores for admitted students vary from year to year. The actual scores required for admission are higher, especially for PhD applicants.

Degree Requirements

The University's general degree requirements are discussed on the [Graduate Policies and Procedures](https://catalog.utdallas.edu/2018/graduate/programs/nsm/biological-sciences) page.

Upon satisfactory completion of the core courses (and, for PhD candidates, a favorable evaluation following the spring semester as described below), a supervising committee is appointed for each student (except non-thesis MS students) based upon mutual agreement between student, research mentor and faculty. The supervising professor, possibly with the advice of the supervising committee will help plan an elective course curriculum. The supervising committee will oversee the
student's research and thesis or dissertation.

Master of Science in Biotechnology

36 semester credit hours minimum

Department Faculty

**Professors:** Lee A. Bulla, Rockford K. Draper, Juan E. González, Lawrence J. Reitzer, Stephen Spiro, Li Zhang, Michael Qiwei Zhang

**Professors Emeritus:** Hans Bremer, Donald M. Gray

**Clinical Professor:** David Murchison

**Associate Professors:** Gail A. M. Breen, John G. Burr, Jeff L. DeJong, Ernest M. Hannig, Tae Hoon Kim, Dennis L. Miller, Zhenyu Xuan

**Assistant Professors:** Zachary Campbell, Nikki Delk, Heng Du, Jung-whan (Jay) Kim, Faruck Morcos, Kelli Palmer, Duane D. Winkler, Hyuntae Yoo

**Research Assistant Professors:** Lan Guo, Li Liu

**Senior Lecturers:** Irina Borovkov, Mehmet Candas, Brenna Hill, Wen-Ju Lin, Meenakshi Maitra, Robert C. Marsh, Jing Pan, Elizabeth Pickett, Ruben D. Ramirez, Scott A. Rippel, Ilya Sapozhnikov, Uma Srikanth, Michelle Wilson, Wen-Ho Yu

Degree Objectives

The MS degree in biotechnology is intended to prepare students for careers in biotechnology and biomedicine and to assist currently employed professionals in enhancing their career opportunities.

Biotechnology captures the exciting possibilities provided by the decoding of the human genome and by advances in bioanalytical instrumentation, and the field is projected for continued rapid growth. The MS in Biotechnology is designed so that students may enter the program with a wide range of prior disciplinary backgrounds, prepare for and take the four core courses, and, by choice from a wide range of approved electives, tailor the remainder of the degree program to their career aspirations. In this manner, students may develop areas of additional depth in fields such as:

- molecular and cell biology
- chemistry
- engineering and computer science
- health care policy
- management and business administration
The MS in Biotechnology requires 36 semester credit hours of courses, typically twelve courses of three semester credit hours each. Students may also elect to prepare and defend a thesis; more than 36 semester credit hours may be required for such a program.

The MS in Biotechnology is administered by the Department of Biological Sciences. Students seeking further information or advisement should contact the Biological Sciences Department office.

Core Courses

The core consists of four courses: **BIOL 5375** Genes to Genomes, **BIOL 5381** Genomics, **BIOL 6373** Proteomics, and **BIOL 6384** Biotechnology Laboratory. **BIOL 6384** Biotechnology Laboratory is a skills based course. Students must show that they have adequate laboratory skills in order to enroll in **BIOL 6384**. Students enrolled in the MS in Biotechnology program will have priority for enrollment in **BIOL 6384**.

The four core courses should be taken in the following order: **BIOL 5375** Genes to Genomes, **BIOL 5381** Genomics, **BIOL 6373** Proteomics, **BIOL 6384** Biotechnology Laboratory. Instructor consent is required for core courses taken out of this sequence.

Program Policies

The program is open to all students who hold a bachelor's degree, although those with laboratory science, mathematics, computer science, or engineering degrees are particularly encouraged to apply. In general, students will not be admitted to the MS in Biotechnology program if they require more than two courses in order to be ready to take the core courses.

Every student admitted to the MS in Biotechnology program shall consult with the program advisor(s) and develop a mutually agreed degree plan. All requests for deviations from the degree program described in this catalog shall be discussed first with a program advisor, who will forward the request to the Committee on Biotechnology for decision.

There are no formal prerequisites for most of the core courses, and a student, after obtaining consent from the program advisor, may attempt one or more core courses. However, the level of the BIOL core courses is such that most students will want to have mastered the material in the following courses:

- General Chemistry (two semesters, with lab), Organic Chemistry (two semesters, with lab)
- **BIOL 2311** Introduction to Modern Biology I (with workshop)
- **BIOL 3361** Biochemistry I or **BIOL 6352** Modern Biochemistry I
- **BIOL 3301** Classical and Molecular Genetics or **BIOL 6331** Molecular Genetics
- **BIOL 3302** Eukaryotic Molecular and Cell Biology or **BIOL 6356** Eukaryotic Molecular and Cell Biology

Students who elect to prepare and defend a thesis must satisfy the MS thesis procedures specified by the department of their thesis supervisor.
Elective Courses

As a general rule, any UT Dallas graduate course that is approved by the advisor as being relevant to the student's tailored degree plan may be taken as an elective for the Biotechnology MS program. Students should consult the program advisor for the current list of recommended electives.

Master of Science in Molecular and Cell Biology

36 semester credit hours minimum

Department Faculty

Professors: Lee A. Bulla, Rockford K. Draper, Juan E. González, Lawrence J. Reitzer, Stephen Spiro, Li Zhang, Michael Qiwei Zhang

Professor Emeritus: Hans Bremer, Donald M. Gray

Clinical Professor: David Murchison

Associate Professors: Gail A. M. Breen, John G. Burr, Jeff L. DeJong, Ernest M. Hannig, Tae Hoon Kim, Dennis L. Miller, Zhenyu Xuan

Assistant Professors: Zachary Campbell, Nikki Delk, Heng Du, Jung-whan (Jay) Kim, Faruck Morcos, Kelli Palmer, Duane D. Winkler, Hyuntae Yoo

Research Assistant Professors: Lan Guo, Li Liu

Senior Lecturers: Irina Borovkov, Mehmet Candas, Brenna Hill, Wen-Ju Lin, Meenakshi Maitra, Robert C. Marsh, Jing Pan, Elizabeth Pickett, Ruben D. Ramirez, Scott A. Rippel, Ilya Sapozhnikov, Uma Srikanth, Michelle Wilson, Wen-Ho Yu

UT Dallas Affiliated Faculty: Leonidas Bleris, Sheena D'Arcy, Stephen D. Levene, Jonathan E. Ploski, Lucien (Tres) Thompson

Degree Objectives

All students seeking the Master of Science degree in Molecular and Cell Biology must satisfactorily complete a total of at least 36 graduate semester credit hours, which must include the following core courses:

Core Courses

- **BIOL 5410** Biochemistry
- **BIOL 5420** Molecular Biology
- **BIOL 5460** Quantitative Biology
**BIOL 5440** Cell Biology

MS students intending to submit a thesis must, in addition to the core courses specified above, satisfactorily complete a further 20 semester credit hours of Biology courses which includes **BIOL 6193** Colloquium in Molecular and Cell Biology, **BIOL 8V01** Research in Molecular and Cell Biology, **BIOL 6V98** Thesis, and a minimum of 6 semester credit hours of general electives for which a letter grade is assigned. The remainder of the semester credit hours usually reflects experimental research but may also be based on literature research as determined by mutual agreement of the student and Supervising Committee. For MS (thesis) students, the maximum number of Pass/Fail credits allowed within the 36 semester credit hour minimum is 13 semester credit hours.

MS (non-thesis) students must, in addition to the core courses specified, satisfactorily complete a minimum of four general elective courses in Biology (for which a letter grade is assigned) for a minimum of 9 semester credit hours, up to 11 semester credit hours of special electives, and/or, with approval of the graduate advisor, other graduate courses. For non-thesis MS students, the maximum number of Pass/Fail credits allowed within the 36 semester credit hour minimum is 11 semester credit hours.

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**Master of Science in Bioinformatics and Computational Biology**

*36 semester credit hours minimum*

**Mathematics Faculty**

**Professors:** Larry P. Ammann, Zalman I. Balanov, Pankaj K. Choudhary, Mieczyslaw K. Dabkowski, Vladimir Dragovic, Sam Efromovich, Yulia Gel, M. Ali Hooshyar, Wieslaw Krawcewicz, Susan E. Minkoff, L. Felipe Pereira, Dmitriy Rachinskiy, Viswanath Ramakrishna, Janos Turi, John Zweck

**Professors Emeritus:** Patrick Odell, John W. Van Ness

**Clinical Professors:** Natalia Humphreys, Wenyi (Roy) Lu

**Associate Professors:** Swati Biswas, Yan Cao, Min Chen

**Assistant Professors:** Mohammad Akbar, Maxim Arnold, Carlos Arreche, Bhargab Chattopadhyay, Sy Han (Steven) Chiou, Qingwen Hu, Frank Konietzschke, Yifei Lou, Oleg Makarenkov, Tomoki Oshawa, Sunyoung Shin, Anh Tran, Nathan Williams

**Senior Lecturers:** Mohammad Ahsan, Kelly Aman, Malgorzata Dabkowska, Rabin Dahal, Anatoly Eydelzon, Manjula Foley, Bentley T. Garrett, Farid Khafizov, Yuly Koshevnik, David L. Lewis, Changsong Li, Brady McCary, Derege Mussa, My Linh Nguyen, Jigarkumar Patel, Paul Stanford, Julie Sutton, Tristan Whalen

**UT Dallas Affiliated Faculty:** Hervé Abdi, Titu Andreescu, Alain Bensoussan, Stefano Leonardi, Faruck Morcos, John J. Wiorowski, Zhenyu Xuan, Hyuntae Yoo, Michael Qiwei Zhang
Mathematics Faculty With Research Interests in Bioinformatics and Computational Biology:
Swati Biswas, Yan Cao, and Min Chen

Biology Faculty

Professors: Lee A. Bulla, Rockford K. Draper, Juan E. González, Lawrence J. Reitzer, Stephen Spiro, Li Zhang, Michael Qiwei Zhang

Professors Emeritus: Hans Bremer, Donald M. Gray

Clinical Professor: David Murchison

Associate Professors: Gail A. M. Breen, John G. Burr, Jeff L. DeJong, Ernest M. Hannig, Tae Hoon Kim, Dennis L. Miller, Zhenyu Xuan

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UT Dallas Affiliated Faculty: Leonidas Bleris, Sheena D'Arcy, Stephen D. Levene, Jonathan E. Ploski, Lucien (Tres) Thompson

Biological Sciences Faculty With Research Interests in Bioinformatics and Computational Biology: Faruck Morcos, Zhenyu Xuan, Hyuntae Yoo, and Michael Q. Zhang

Program Objective

The Master of Science program in Bioinformatics and Computational Biology is an interdisciplinary program offered jointly by the Departments of Mathematical Sciences and Biological Sciences, with the former serving as the administrative unit. By combining coursework from the disciplines of Biology, Computer Science, Mathematics, and Statistics, it caters to the growing demand of a new breed of scientists who have expertise in all these disciplines. In addition to coursework, the program also provides opportunities to gain practical experience by getting involved in research with faculty members.

A successful applicant to the program is expected to have a Bachelor's degree in Biology, Mathematics, Statistics, or in another science/engineering discipline, and must have completed Differential and Integral Calculus courses. Additional coursework in one or more of the disciplines of Biology, Computer Science, Mathematics, and Statistics is desirable but is not required.

Degree Requirements

The University's general degree requirements are discussed on the Graduate Policies and Procedures page.
The MS program in Bioinformatics and Computational Biology requires completion of at least 36 semester credit hours. The program offers a choice between two tracks. Track 1 is designed for students with a general background in science/engineering, whereas Track 2 is designed for students with a strong background in biology. To build further expertise, both tracks offer a choice of three elective groups, namely, Computer Science oriented, Statistics oriented, and Biology oriented elective groups. Both also offer opportunities for research. Students are expected to choose a track and an elective group based on their backgrounds and interests in consultation with the Graduate Advisor for the program.

**Track 1 (MS)**

I. Core: 15 semester credit hours

- **BMEN 6374** Genes, Proteins and Cell Biology for Engineers
- **BIOL 6V00** Topics in Biological Sciences (Computational Molecular Evolution)
- **CS 5303** Computer Science I
- **MATH 5303** Advanced Calculus and Linear Algebra
- **STAT 5351** Probability and Statistics I (for Elective Group 2)
  - or **STAT 5353** Probability and Statistics for Data Science and Bioinformatics (for Elective Groups 1 and 3)

II. Elective Groups (Choose one elective group)

**Elective Group 1 (Computer Science Oriented): 15 semester credit hours**

- **CS 5343** Algorithm Analysis and Data Structures
- **MATH 6312** Combinatorics and Graph Theory
- **MATH 6341** Bioinformatics
  - or **BIOL 5376** Applied Bioinformatics
- **MATH 6346** Medical Image Analysis

AND one of the following:

- **CS 6307** Introduction to Big Data Management and Analytics for non-CS Majors
- **CS 6314** Web Programming Languages
- **CS 6360** Database Design
- **CS 6375** Machine Learning

**Elective Group 2 (Statistics Oriented): 18 semester credit hours**

- **STAT 5352** Probability and Statistics II
STAT 6337 Advanced Statistical Methods I
STAT 6338 Advanced Statistical Methods II
STAT 6340 Statistical and Machine Learning
MATH 6341 Bioinformatics
   or BIOL 5376 Applied Bioinformatics
MATH 6346 Medical Image Analysis
Elective Group 3 (Biology oriented): 15 semester credit hours
   MATH 6341 Bioinformatics
      or BIOL 5376 Applied Bioinformatics
   MATH 6345 Mathematical Methods in Medicine and Biology
   MATH 6346 Medical Image Analysis
AND two of the following:
   BIOL 5375 Genes to Genomes
   BIOL 5381 Genomics
   BIOL 6315 Epigenetics
   BIOL 6373 Proteomics
   BIOL 6385 Computational Biology
      or BMEN 6389 Computational Biology
      or MATH 6343 Computational Biology

III. Research or Elective(s) or a Combination Thereof
   • Elective Group 1: 6 semester credit hours
   • Elective Group 2: 3 semester credit hours
   • Elective Group 3: 6 semester credit hours

Track 2 (MS)

I. Core: 14 semester credit hours
   BIOL 5410 Biochemistry
   BIOL 5420 Molecular Biology
   STAT 5351 Probability and Statistics I (for Elective Group 2)
or STAT 5353 Probability and Statistics for Data Science and Bioinformatics (for Elective Groups 1 and 3)

MATH 5303 Advanced Calculus and Linear Algebra

II. Elective Groups (Choose one elective group)

Elective Group 1 (Computer Science oriented): 18 semester credit hours

CS 5303 Computer Science I
CS 5343 Algorithm Analysis and Data Structures
MATH 6312 Combinatorics and Graph Theory
MATH 6341 Bioinformatics
or BIOL 5376 Applied Bioinformatics
MATH 6346 Medical Image Analysis

AND one of the following:

CS 6307 Introduction to Big Data Management and Analytics for non-CS Majors
CS 6314 Web Programming Languages
CS 6360 Database Design
CS 6375 Machine Learning

Elective Group 2 (Statistics oriented): 18 semester credit hours

STAT 5352 Probability and Statistics II
STAT 6337 Advanced Statistical Methods I
STAT 6338 Advanced Statistical Methods II
STAT 6340 Statistical and Machine Learning
MATH 6341 Bioinformatics
or BIOL 5376 Applied Bioinformatics
MATH 6346 Medical Image Analysis

Elective Group 3 (Biology oriented): At least 18 semester credit hours

MATH 6341 Bioinformatics
or BIOL 5376 Applied Bioinformatics
MATH 6346 Medical Image Analysis
MATH 6345 Mathematical Methods in Medicine and Biology
AND two of the following:

- **BIOL 5375** Genes to Genomes
- **BIOL 5381** Genomics
- **BIOL 6315** Epigenetics
- **BIOL 6373** Proteomics
- **BIOL 6385** Computational Biology
  
  or **BMEN 6389** Computational Biology
  
  or **MATH 6343** Computational Biology
- **BIOL 6V00** Topics in Biological Sciences (Computational Molecular Evolution)
- **BIOL 6V00** Topics in Biological Sciences (Introduction to Programming for Biological Sciences)

III. Research or Elective(s) or a Combination Thereof

All Elective Groups: 4 semester credit hours

Other Requirements

- For a PhD bound student in the Department of Biological Sciences, **BIOL 5440** Cell Biology and **BIOL 5460** Quantitative Biology (or an equivalent) are required. This requirement can be fulfilled by taking these courses as 'electives' in the Bioinformatics and Computational Biology program.

- Electives must be approved by the Graduate Advisor of the program.

- Substitutions for required courses may be made if approved by the Graduate Advisor of the program and the Head of the Mathematical Sciences Department.

- A student may choose to write an MS thesis under the supervision of a faculty member. The thesis project can count for 3 to 6 semester credit hours of electives towards the required 36 hours, in accordance with University policies. The thesis must be approved by the Head of the Mathematical Sciences Department. Once the thesis project is completed, the student must successfully defend it before his/her thesis committee.

1. Students who have not taken the CS 5333 Discrete Structures prerequisite for CS 5343 Algorithm Analysis and Data Structures should consult with their Graduate Advisor from the Mathematical Sciences Department to determine eligibility.

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

*75 semester credit hours minimum beyond the baccalaureate degree*
Department Faculty

Professors: Lee A. Bulla, Rockford K. Draper, Juan E. González, Lawrence J. Reitzer, Stephen Spiro, Li Zhang, Michael Qiwei Zhang

Professors Emeritus: Hans Bremer, Donald M. Gray

Clinical Professor: David Murchison

Associate Professors: Gail A. M. Breen, John G. Burr, Jeff L. DeJong, Ernest M. Hannig, Tae Hoon Kim, Dennis L. Miller, Zhenyu Xuan

Assistant Professors: Zachary Campbell, Nikki Delk, Heng Du, Jung-whan (Jay) Kim, Faruck Morcos, Kelli Palmer, Duane D. Winkler, Hyuntae Yoo

Research Assistant Professors: Lan Guo, Li Liu

UT Dallas Affiliated Faculty: Leonidas Bleris, Sheena D'Arcy, Stephen D. Levene, Jonathan E. Ploski, Lucien (Tres) Thompson

Degree Objectives

All PhD students must satisfactorily complete a total of at least 75 semester credit hours beyond the bachelor's degree and four core courses: BIOL 5410 Biochemistry, BIOL 5420 Molecular Biology, BIOL 5460 Quantitative Biology, and BIOL 5440 Cell Biology.

In the first year, PhD candidates must perform two laboratory rotations, and take BIOL 6V02 The Art of Scientific Presentation, and BIOL 6193 Colloquium in Molecular and Cell Biology. At the end of the first year, students are evaluated based upon performance in the core classes, laboratory rotations, and performance as teaching assistants (if applicable). Students who pass this evaluation must then pass an oral qualifying examination within three semesters to determine the student's aptitude for continuation of dissertation research.

PhD students will earn an MS degree in Molecular and Cell Biology after satisfactory completion of the four core courses, 36 total hours, two graded electives, and passing the qualifying examination (usually at the end of the second year).

After the first year, students must also complete a minimum of four general elective courses in Biology (for which a letter grade is assigned). A dissertation defense will be conducted after the dissertation has been written. All students are required to submit (and have accepted for publication) a minimum of one manuscript for publication in an internationally recognized, peer-reviewed scientific journal. There is no foreign language requirement.

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