

MASTER OF SCIENCE IN BIOTECHNOLOGY

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The Master of Science in Biotechnology is designed to broaden student understanding of the biological sciences and to prepare students for a professional career in Biotechnology or for doctoral study. Classes are usually held in the evenings and include lectures, laboratory experiences, research methodology, and seminars in current topics. Research, analytical, and communication skills are developed through original research, culminating in a written thesis and defense. In addition to the matriculated program, courses are open to students who hold a Bachelor's degree in a biological subject, biotechnology, or chemistry.

A combined B.S./M.S. program is available for Worcester State University students majoring in Biotechnology. Please see the Undergraduate Catalog for further information on this program.

Prerequisites for Admission to the Program

To be admitted to the program, a candidate must meet the Worcester State University general admission requirements for the degree of Master of Science. To view these requirements please go to: <http://worcester.edu/Graduate>

The program is open to graduates of accredited institutions of higher education who have been awarded a baccalaureate degree in Biology, Biotechnology, Chemistry, or a similar science major. Graduate study in Biotechnology at Worcester State University assumes sound undergraduate training and evidence of academic capability. Applicants are expected to have completed courses in Chemistry I and II, Organic Chemistry I, Physics I and II, Microbiology, Cell and/or Molecular Biology (all with a laboratory component), Organic Chemistry II lecture course (no lab requirement), and math coursework up to the level of Pre-calculus. The applicant should have achieved a minimum grade point average of 2.75 in all undergraduate work and an average of 3.00 in all course work within his/her major and in the ancillary courses.

Items Needed to Apply:

- Online application found at www.worcester.edu/apply
- Essay explaining reason for pursuing this degree program
- Application fee
- General GRE test scores
- Two letters of recommendation from professional or academic sources
- Official transcripts from ALL colleges and universities attended showing a bachelor's degree from a regionally accredited institution in Biology, Biotechnology, Chemistry, or a similar science major
- Official transcript evaluation for any transcript from outside the United States
- An English language proficiency test if the student's academic background is not in English
- Prerequisite courses: Chemistry I and II, Organic Chemistry I, Physics I and II, Microbiology, Cell and/or Molecular Biology (all with a laboratory component), and math coursework up to the level of Pre-Calculus

Program of Study for the Degree

The program of study includes 36 graduate credits in required and elective courses, including research in biology/biotechnology culminating in an acceptable written thesis and thesis defense.

Of the 36 credits required for the degree, at least 24 credits must be earned as a matriculated graduate student at Worcester State University. Credits for which students have earned a "B-" or higher within a two year period immediately prior to the date of their acceptance into the program are transferable from an accredited institution, including credits earned at Worcester State University. A maximum of 12 such transfer credits may be accepted. Matriculated students who do not maintain a GPA 3.0 or higher or have two grades below a "B-" will be terminated from the program. All work for the degree must be completed within a period of six years from the date of admission to the program.

Degree Requirements required of all students

Required Courses

Code	Title	Credits
BI-921	Biotechnology and DNA	4
BI-927	Tissue Culture Techniques	4
BI-930	Biological Chemistry	3
BI-942	Biostatistical Analysis and Experimental Design	4
BI-996	Thesis Research I	3
BI-997	Thesis Research II	3
BI-998	Thesis Writing	3
BI/CH 900-Level Biology or Chemistry electives. One elective may include a Business course from the list below.		12
Total Credits		36

Elective Courses are from this list or others when approved by the faculty:

Code	Title	Credits
BI-923	Fermentation Technology	3
BI-936	Immunology	3
BI-937	Molecular Virology	3
BI-938	Toxicology	3
BI-980	Selected Topics: Advanced Biology	1-4
BI-981	Independent Study in Biology/Biotechnology	1-6
BI-985	Graduate Internship in Biology/Biotechnology	3-4
CH-990	Special Problems in Chemistry	3
CH-991	Independent Study	1-4
CH-996	Internship: Chemistry	3
BA-914	Organizational Behavior	3
BA-961	Organizational Development and Change	3
BA-960	Leadership Theory and Skills	3
BA-962	Ethics and Social Responsibility of Leadership	3

To fulfill requirements for the Program the candidate must complete 9 credits of Thesis Research and Writing coursework (BI 996, BI 997 and BI 998). Laboratory investigations are supervised by faculty in the laboratories at Worcester State University or by arrangement at another

institution. The candidate must adhere to the form specified for the thesis by the Biology Department graduate faculty. The thesis will be defended in an oral examination conducted by the faculty.

During the semester in which the candidate anticipates receiving the degree, the following timetable for the thesis completion and defense shall apply:

A minimum of four weeks prior to the defense, the completed written thesis must be presented to the candidate's graduate research advisor. The comprehensive exam/thesis defense will be scheduled with the candidate's thesis committee, comprised of the thesis advisor, the program coordinator and another member of the program graduate faculty.

A minimum of two weeks prior to the defense, the final copy of the thesis, with approval by the candidate's graduate research advisor, will be submitted to the members of the candidate's thesis committee.

Comprehensive Examination/Thesis defense

The Master of Science in Biotechnology candidate is required to pass a comprehensive examination/thesis defense in the candidate's area of specialization. At least twenty-four approved graduate credits must be earned before the candidate can submit a request for the scheduling of a comprehensive exam/thesis defense. If the candidate fails the examination, he/she will be granted one additional opportunity to fulfill this requirement. All work for the degree must be completed within a period of six years from the date of admission to the program.

Graduate Biotechnology Courses

BI-917 Topics in Cell and Molecular Biology

Each topic is a lecture and/or laboratory course in a selected area of cell and molecular biology presented by a departmental instructor and/or guest lecturer when appropriate. Topic to be announced in advance. May be repeated as long as cell and molecular biology topics differ. Prerequisite: Matriculation in the Biology or Biotechnology MS program, or permission of graduate coordinator and/or instructor. Other or on demand and every 2-3 years. 3-4 Credits

BI-918 Topics in Genetics and Genomics

Each topic is a lecture and/or laboratory course in a selected area of genetics or genomics presented by a departmental instructor and/or guest lecturer when appropriate. Topic to be announced in advance. May be repeated as long as genetics and genomics topics differ. Prerequisite: Matriculation in the Biology or Biotechnology MS program, or permission of graduate coordinator and/or instructor. Other or on demand and every 2-3 years. 3-4 Credits

BI-921 Biotechnology and DNA

Applications of recombinant DNA technology, together with business and industry information and government regulations. Includes a three hour laboratory. Every year. 4 Credits

BI-923 Fermentation Technology

The growth of microorganisms in bioreactors under sterile conditions and the production of useful products. Other or on demand and other or on demand. 3 Credits

BI-927 Tissue Culture Techniques

Presents the most important techniques used for mammalian tissue culture by lecture and laboratory demonstration and practice. The course also includes topics in plant tissue culture. (Prereq: BS in biological science) Spring only and every year. 4 Credits

BI-930 Biological Chemistry

Concerns the physical, chemical, and biological properties and metabolism of carbohydrates, proteins, lipids, DNA and RNA. 3 Credits

BI-936 Immunology

Recent advances in understanding the immune system will be covered. B.S. in a biological science is required. This course integrates both lecture and lab activities. 3 Credits

BI-937 Molecular Virology

A study of virus families with emphasis on replication and regulation of gene expression. B.S. in biology science required. This course integrates both lecture and lab activities. 3 Credits

BI-938 Toxicology

A theoretical course presenting the principles and mechanisms of toxic damage to cells, organs and organisms. 3 Credits

BI-941 Topics in Physiology

Each topic is a lecture and/or laboratory course in a selected area of physiology presented by a departmental instructor and/or guest lecturer when appropriate. Topic to be announced in advance. May be repeated as long as physiology topics differ. Prerequisite: Matriculation in the Biology or Biotechnology MS program, or permission of graduate coordinator and/or instructor. Other or on demand and every 2-3 years. 3-4 Credits

BI-942 Biostatistical Analysis and Experimental Design

Provides a foundation in biological data analysis and interpretation as well as experimental design, discussing the underlying principles of how scientific investigations are conducted to maximize the validity of the results. This course will guide students through the process of developing a scientific question and a hypothesis, designing appropriate experimental methods, selecting and using relevant statistical tools, interpreting results, and conveying results to a scientific audience in multiple formats. Fall only and every year. 4 Credits

BI-943 Experimental Design

Prerequisites: Undergraduate degree in Biology, Chemistry or related field completion of a college course in statistics and completion of math which includes pre-calculus or higher level courses. The underlying principles of how scientific investigations are conducted in order to maximize the validity of the results will be discussed. This course will cover the philosophy of science as it pertains to experiments, methods of experimental design, statistical inference, analysis and presentation of data, and clear communication of scientific results. Fall only and every 2-3 years. 3 Credits

BI-950 Physiological Ecology

Considers the physiological adjustments which animals make in response to environmental factors; emphasizes the physiological basis of animal evolution and distribution. 3 Credits

BI-951 Topics in Ecology and Evolution

Each topic is a lecture and/or laboratory course in a selected area of ecology or evolution presented by a departmental instructor and/or guest lecturer when appropriate. Topic to be announced in advance. [3 credits for lecture only course and 4 credits w/ lab]. May be repeated as long as ecology and evolution topics differ. Prerequisite: Matriculation in the Biology or Biotechnology MS program, or permission of graduate coordinator and/or instructor
Other or on demand and every 2-3 years. 3-4 Credits

BI-952 Topics in Zoology

Each topic is a lecture and/or laboratory course in a selected area of animal biology presented by a departmental instructor and/or guest lecturer when appropriate. Topic to be announced in advance. May be repeated as long as zoology topic differs. Prerequisite: Matriculation in the Biology or Biotechnology MS program, or permission of graduate coordinator and/or instructor
Other or on demand and every 2-3 years. 3-4 Credits

BI-968 Cancer Biology

Cancer results from genomic mutations that compromise the mechanisms that normally regulate cell growth and proliferation, cell death, and cell-cell interactions. This course will examine how cancer cells differ from normal cells (morphologically, behaviorally, and in the functioning of molecular pathways), the genetic basis of cancer, how cells progress from a normal to a cancerous state, factors that promote cancer development, and strategies for cancer therapy. It will also include examination of the historical evolution of our understanding of cancer and societal issues related to cancer. Prerequisite: Undergraduate courses in Genetics and Biochemistry or permission of instructor.
Other or on demand and every 2-3 years. 3 Credits

BI-980 Selected Topics: Advanced Biology

Each topic is a timely and exciting new lecture and/or laboratory course. Topics will be announced in advance and will service needs in growth areas; e.g., biotechnology.
1-4 Credits

BI-981 Independent Study in Biology/ Biotechnology

Independent study or directed study on a topic of interest to both the student(s) and the instructor.
Other or on demand. 1-6 Credits

BI-983 Techniques in Laboratory and Field Resea**LASC Categories: LAB**

Students will carry out an experimental research project in a topic area defined by the instructor. Projects may involve laboratory- or field-based research, or a combination of the two. Research topic areas will be announced in advance. Prerequisite: Matriculation in the Biology or Biotechnology MS program, or permission of graduate coordinator and/or instructor
Other or on demand and every year. 4 Credits

BI-985 Graduate Internship in Biology/ Biotechnology

Requires successful completion of a minimum of twelve graduate credits toward the degree and approval of the Biology faculty. Provides Master of Science candidates the chance to gain practical experience at off-campus agencies where technical and analytical skills can be gained.
3-4 Credits

BI-990 Seminar in Biology/Biotechnology

Study and discussion of current researches, books, and periodicals in the field of biology; includes reports of research in progress.
3 Credits

BI-995 Research in Biology/Biotechnology

Original research in biology under faculty supervision. Requires an acceptable written thesis or paper in publishable format.
1-6 Credits

BI-996 Thesis Research I

Prerequisites: Completion of at least four Biology/Biotechnology master's courses, with BI-942 Biostatistical Analysis and Experimental Design being one of these courses (or taken concurrently), and permission of the Program Coordinator. Matriculated students only.

Original, experimental research in biology or biotechnology under faculty supervision, working toward production of a written thesis in an approved format. A research problem will be identified and a literature search conducted. For students choosing the experimental track of the MS in Biology program (designated Track II) and all students in the MS in Biotechnology program, experiments will be designed and planned, and preliminary research work may be performed. This course is the first course in a series of research coursework (BI 996, BI 997, BI 998) leading to completion of a thesis research project.

Fall and Spring and every year. 3 Credits

BI-997 Thesis Research II

Prerequisites: BI-996 Thesis Research I, permission of Program Coordinator. Matriculated students only.

Original research in biology or biotechnology under faculty supervision, working toward production of a written thesis, in a approved format. Experimental laboratory work will be performed and results evaluated. This course is a continuation of BI 996: Thesis Research I.

Fall and Spring and every year. 3 Credits

BI-998 Thesis Writing

Prerequisites: BI 996 Thesis Research I and BI 997 Thesis Research II (for the M.S. in Biotechnology, or the experimental track of the M.S. in Biology, Track II) and permission of Program Coordinator. Matriculated students only.

Preparation of a thesis, written in an approved format, describing original, experimental research or literature-based research in biology or biotechnology under faculty supervision, and presentation of an oral thesis defense. This course will follow BI 996: Thesis Research I and BI 997: Thesis Research II for all students in the MS in Biotechnology program and for those students choosing the experimental track for the MS in Biology program, Track II .

Fall and Spring and every year. 3 Credits

BI-999 Biology Research Review

Prerequisites: Completion of BI-942: Biostatistical Analysis Experimental Design and BI-983: Techniques in Laboratory and Field Research, at least 3 elective courses in the MS in Biology program, and permission of Program Coordinator. Matriculated students only.

Preparation of a written, comprehensive literature review on an approved topic in the biological sciences under the supervision of an Biology or Biotechnology graduate faculty member, leading to an oral defense. Students can complete this 4-credit class in one semester, or over a maximum of 2 semesters totaling 4 credits. Course may be repeated.
Other or on demand and other or on demand. 1-4 Credits

BT-901 Directed Study: Biotechnology

Directed study offers graduate students, who because of unusual circumstances may be unable to register for a course when offered, the opportunity to complete an existing course with an established syllabus under the direction and with agreement from a faculty member. Variable credits.

Fall and Spring and every year. 1-12 Credits

- Demonstrate the advanced body of scientific knowledge as applied to biotechnology, including the following core content areas:
 - Cellular & molecular biology and biochemistry
 - Biostatistics and experimental design
 - Applications of cells and organisms for industrial and research purposes
- Demonstrate knowledge by critically applying analytical skills to biotechnological problems
 - Identify and formulate appropriate experiments to test a hypothesis
 - Gather, organize, interpret and evaluate data
 - Employ reason and logic, analyze pros and cons, and evaluate the validity of conclusions in experiments and scientific literature
- Perform laboratory techniques and practices used in the biotechnology industry
 - Proper use of tools, equipment/instrumentation, and materials
 - Demonstration of safety procedures and proper techniques
 - Conduct experiments independently and work effectively in a group or team environment
- Effectively communicate scientific results and information to appropriate target audiences using well-structured written and oral forms of communication, including:
 - Written material (laboratory reports, standard operating procedures, posters)
 - Oral presentations provided in a professional format
- Exhibit awareness of the social implications and impacts of biotechnology on society, including the ethical considerations for biotechnology, by addressing
 - The effect of biotechnology on the environment, business, and human health
 - The ethical issues that influence decisions related to biotechnology and society