

BIOTECHNOLOGY, MASTER OF SCIENCE

MS in Biotechnology (<https://advanced.jhu.edu/academics/graduate/ms-biotechnology/>)

The MS in Biotechnology program prepares students for a career in the field and allows biotechnology professionals to further hone their skills toward career advancement. The program provides a solid grounding in theory and delivers real-world skills and practice. Students can meet their individual career goals through the selection of a concentration or get a more customized experience by choosing their own set of six elective classes.

This 10-course degree program is thesis-optional and can be pursued part time or full time, onsite, online, or through a combination of onsite and online courses.

Admissions Criteria for all Advanced Academic Programs (<https://e-catalogue.jhu.edu/arts-sciences/advanced-academic-programs/enrollment-services/admission/>)

PROGRAM-SPECIFIC REQUIREMENTS

In addition to the materials and credentials required for all programs, the Master of Science in Biotechnology program requires an undergraduate degree in the natural sciences or engineering with a grade point average of at least 3.0 on a 4.0 scale. Meeting the minimum GPA requirement does not guarantee admission.

- **Resume**
- **Statement of purpose:** Discuss why you wish to pursue the MS in Biotechnology degree. Focus on your long-term goals and how this academic program will complement these goals. Discuss the strengths of your academic and professional background, as well as any additional comments that will assist in evaluating your application materials.
- **Program-specific prerequisite courses:**
 - Two semesters of biology
 - Two semesters of chemistry
 - One semester of organic chemistry
 - One semester of biochemistry

Program Requirements

Students take 10 courses to complete the degree.

Code	Title	Credits
Core Courses - Required:		
AS.410.602	Molecular Biology	4
AS.410.603	Advanced Cell Biology	4
AS.410.604	Cellular Signal Transduction	4
AS.410.607	The Biotechnology Enterprise (starting in Fall 2023)	4

Electives	
Select six elective courses ^{1, 2}	24
Total Credits	40

¹ See course listings page (https://e-catalogue.jhu.edu/course-descriptions/_biotechnology/).

² Many electives have the core courses as a prerequisite

Course requirements differ for the certificate and concentration programs.

MS in Biotechnology with Thesis Option

Students interested in pursuing the MS in Biotechnology with the thesis are required to take 11 courses. The thesis requires a two-semester research project. Students complete AS.410.800 Independent Research in Biotechnology, and then AS.410.801 Biotechnology Thesis the following semester. Students interested in this option should consult with the program adviser.

MS in Biotechnology Concentrations (Optional)

Students wishing to focus on a specialized discipline within the MS in Biotechnology program may enroll in one of six optional concentrations after being accepted into the program:

- Biodefense
- Bioinformatics
- Biotechnology Enterprise
- Molecular Targets and Drug Discovery
- Regulatory Affairs
- Regenerative and Stem Cell Technologies

Concentration in Biodefense

The biodefense concentration integrates basic and translational science to train the next generation of professionals for employment in academia, industry, and government. The curriculum provides students with a solid foundation in basic science, and investigates the various applications of medical science and biotechnology for detection, identification, and response to biothreats.

Specific disciplines of study include molecular biology, infectious diseases, bioinformatics, immunology, epidemiology, molecular diagnostics, and policy.

Code	Title	Credits
Core Courses Required:		
Core requirements differ for this concentration.		
AS.410.602	Molecular Biology	
AS.410.603	Advanced Cell Biology	
AS.410.607	The Biotechnology Enterprise	
AS.410.633	Introduction to Bioinformatics	
AS.410.692	Biological & Chemical Threat Response & Forensics	
AS.410.693	Science, Medicine & Policy in Biodefense	

Core Courses - Customizable:

Select one of the following: 4
Must be completed onsite

AS.410.652	Mammalian Cell Culture Techniques
AS.410.656	Recombinant DNA Laboratory
AS.410.658	Biodefense & Infectious Disease Laboratory Methods
AS.410.660	Immunological Techniques in Biotechnology
AS.410.731	Bioprocessing and Scale-up Laboratory
AS.410.752	High Throughput Screening & Automation Lab
AS.410.780	Stem Cell Culture Laboratory Methods

Electives

Select three of the following: 12

AS.410.604	Cellular Signal Transduction
AS.410.611	Vaccinology
AS.410.613	Principles of Immunology
AS.410.616	Virology
AS.410.618	Parasitology
AS.410.621	Agricultural Biotechnology
AS.410.631	Infectious Diseases
AS.410.632	Emerging Infectious Diseases
AS.410.639	Protein Bioinformatics
AS.410.640	Molecular Phylogenetic Techniques
AS.410.641	Clinical & Molecular Diagnostics
AS.410.645	Biostatistics
AS.410.652	Mammalian Cell Culture Techniques
AS.410.656	Recombinant DNA Laboratory
AS.410.658	Biodefense & Infectious Disease Laboratory Methods
AS.410.660	Immunological Techniques in Biotechnology
AS.410.662	Epidemiology: Diseases in Populations
AS.410.666	Next Generation DNA Sequencing and Analysis
AS.410.671	Gene Expression Data Analysis and Visualization
AS.410.696	Bioassay Development
AS.410.731	Bioprocessing and Scale-up Laboratory
AS.410.752	High Throughput Screening & Automation Lab
AS.410.780	Stem Cell Culture Laboratory Methods

Total Credits 16

Concentration in Bioinformatics

Given the vast amount of information generated from studies on humans and other organisms, and the need for scientists and researchers to access and manipulate these data, the biotechnology program offers courses that can either be sampled individually or taken together to complete a concentration in bioinformatics.

In addition to the four core courses, degree candidates must complete any four bioinformatics concentration courses from the list below and two electives (i.e. any AS.410.6xx course not already taken):

Code	Title	Credits
Bioinformatics Courses		
Select four of the following:		16
AS.410.633	Introduction to Bioinformatics	
AS.410.634	Practical Computer Concepts for Bioinformatics	
AS.410.635	Bioinformatics: Tools for Genome Analysis	
AS.410.639	Protein Bioinformatics	
AS.410.640	Molecular Phylogenetic Techniques	

AS.410.645	Biostatistics
AS.410.666	Next Generation DNA Sequencing and Analysis
AS.410.671	Gene Expression Data Analysis and Visualization
AS.410.698	Bioperl
AS.410.709	Cancer Genomics
AS.410.712	Advanced Practical Computer Concepts for Bioinformatics
AS.410.713	Advanced Genomics and Genetics Analyses
AS.410.736	Genomic and Personalized Medicine
AS.410.734	Practical Introduction to Metagenomics

Electives

Select two electives 8

Total Credits 24

Concentration in Biotechnology Enterprise

For research discoveries to reach the public, an understanding of the overall enterprise of biotechnology is essential. Success in this industry requires two distinct sets of skills and perspectives: understanding the science and understanding the business.

In addition to the four core courses, degree candidates must complete any four Biotechnology Enterprise concentration courses from the list below and two electives (i.e. any AS.410.6xx course not already taken).

Code	Title	Credits
Biotechnology Enterprise Concentration Courses		
Select four of the following:		16
AS.410.627	Translational Biotechnology: From Intellectual Property to Licensing	
AS.410.637	Bioethics	
AS.410.638	Cancer Biology	
AS.410.642	Economic Dynamics of Change in Biotechnology	
AS.410.643	Managing and Leading Biotechnology Professionals	
AS.410.644	Marketing Aspects of Biotechnology	
AS.410.645	Biostatistics	
AS.410.646	Creating a Biotechnology Enterprise	
AS.410.647	Research Ethics	
AS.410.649	Introduction to Regulatory Affairs	
AS.410.651	Clinical Development of Drugs and Biologics	
AS.410.665	Bioscience Communication	
AS.410.680	Finance for Biotechnology	
AS.410.684	Technology Transfer & Commercialization	
AS.410.685	Emerging Issues in Biotechnology	
AS.410.687	Ethical, Legal & Regulatory Aspects of the Biotechnology Enterprise	
AS.410.688	Project Management in Biotechnology	
AS.410.689	Leading Change in Biotechnology	
AS.410.703	Strategic Planning for the Biotechnology Enterprise	
AS.410.704	Social Entrepreneurship in BioScience	
AS.410.705	Problem Solving and Innovation	
AS.410.728	Managing Innovation in the Life Sciences	
AS.410.732	Funding a New Venture	

AS.410.756	Grants and Federal Funding for Biotechnology Enterprises
AS.410.806	Independent Studies in Biotechnology Enterprise and Entrepreneurship (Open only to students in the MBEE program)

Electives	
Select two electives	8
Total Credits	24

Concentration in Molecular Targets and Drug Discovery

Within the biotechnology industry, there is a need for highly skilled professionals who possess an in-depth understanding of the structures and activities of biological molecules and their variants formed during the production of biopharmaceutical drugs, and the laboratory skills necessary to advance this high-throughput screening and clinical development. Graduates of this concentration will fill key positions in clinical, industry, and research laboratories that are doing pharmaceutical drug discovery and development.

In addition to the four core courses, students must complete the four concentration courses and two electives.

Code	Title	Credits
Concentration Courses		
AS.410.696	Bioassay Development	4
AS.410.750	Molecular Targets & Cancer	4
AS.410.751	Drug Design and Chemical Libraries	4
AS.410.752	High Throughput Screening & Automation Lab	4
Elective Courses		
Select two of the following: ¹		8
AS.410.613	Principles of Immunology	
AS.410.620	Advanced Topics in Immunology	
AS.410.622	Molecular Basis of Pharmacology	
AS.410.633	Introduction to Bioinformatics	
AS.410.638	Cancer Biology	
AS.410.639	Protein Bioinformatics	
AS.410.645	Biostatistics	
AS.410.652	Mammalian Cell Culture Techniques	
AS.410.660	Immunological Techniques in Biotechnology	
AS.410.671	Gene Expression Data Analysis and Visualization	
AS.410.731	Bioprocessing and Scale-up Laboratory	
AS.410.659		
Total Credits		24

¹ The following is a list of recommended electives for the MTDDT concentration. You may select two electives from the course listings page (https://e-catalogue.jhu.edu/course-descriptions/_biotechnology/).

Concentration in Regulatory Affairs

Developed in consultation with representatives from the Food and Drug Administration, the Regulatory Affairs Professional Society, and the biotechnology industry, this concentration provides students with the knowledge and understanding required for companies and organizations to comply with federal and state regulatory statutes for the development,

approval, and commercialization of drugs, biologics, foods, and medical devices.

In addition to the four core courses, degree candidates must complete any four Regulatory Affairs concentration courses from the list below and two electives (i.e. any AS.410.6xx course not already taken).

Code	Title	Credits
Regulatory Affairs Concentration Courses		
Select four of the following:		16
AS.410.627	Translational Biotechnology: From Intellectual Property to Licensing	
AS.410.648	Clinical Trial Design and Conduct	
AS.410.649	Introduction to Regulatory Affairs	
AS.410.651	Clinical Development of Drugs and Biologics	
AS.410.673	Biological Processes in Regulatory Affairs	
AS.410.675	International Regulatory Affairs	
AS.410.676	Food And Drug Law	
AS.410.682	Validation in Biotechnology	
AS.410.683	Introduction to cGMP Compliance	
AS.410.686	Regulation of Good Food Production Practices	
AS.410.687	Ethical, Legal & Regulatory Aspects of the Biotechnology Enterprise	
AS.410.690	International Food Regulations	
AS.410.701	Intro to Food Safety Regulation	
AS.410.702	Biomedical Software Regulation	
AS.410.715	Medical Device Regulation	
AS.410.727	Regulatory Strategies in Biopharmaceuticals	
AS.410.802	Independent Studies in Regulatory Science	
Electives		
Select two electives		8
Total Credits		24

Students may choose any two science electives for which they have met the prerequisites.

Concentration in Regenerative and Stem Cell Technologies

Within the biotechnology industry, there is increasingly a need for highly skilled professionals in the area of regenerative technologies. The professionals must possess an in-depth understanding of stem cells, gene therapy, regenerative medicine, and the laboratory skills necessary to advance this rapidly expanding field of research and clinical development. Graduates of this concentration will fill key positions in clinical, industry, and research laboratories that use cell therapies for treatment of diseases.

In addition to the four core courses, students must complete the four concentration courses and two electives.

Code	Title	Credits
Concentration Courses		
AS.410.630	Gene Therapy	4
AS.410.653	Regenerative Medicine: from Bench to Bedside	4
AS.410.753	Stem Cell Biology	4
AS.410.780	Stem Cell Culture Laboratory Methods	4
Electives		

Select two electives 8

Total Credits 24

Program Learning Outcomes

By the end of this program, students will be able to:

- Assess diverse methods and technologies and their applications in biochemistry.
- Apply up-to-date knowledge and skills in molecular biology in real-world settings.
- Employ key concepts in cellular biology to solve real-world issues.
- Critique scientific information from various subdisciplines of biotechnology.
- Demonstrate ability to communicate scientifically both orally and in writing.
- Demonstrate the ability to collaborate in a diverse group to achieve an objective.