

BIOTECHNOLOGY, MASTER OF SCIENCE

MS in Biotechnology

advanced.jhu.edu/msbiotech (<http://biotechnology.jhu.edu>)

The MS in Biotechnology program offers a comprehensive exploration of basic science, applied science, and lab science, with a biotechnology focus. The program gives students a solid grounding in biochemistry, molecular biology, cell biology, genomics, and proteomics, and the flexibility for students to tailor elective coursework to meet their individual career goals. In addition to the general degree, the program offers six different concentrations:

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

Thus, students can choose to solely focus on strengthening their science knowledge and research skills, or to also develop the skills to lead lab teams, make development and planning decisions, create and apply research modalities to large projects, and take the reins of management and marketing decisions.

This 10-course degree program is thesis-optional, part-time or full-time, and can be completed fully on-site, online, or through a combination of on-site 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 requires:

An undergraduate degree in the natural sciences or engineering with at least a 3.0 on a 4.0 scale in undergraduate studies (relevant work experiences are also considered); applicants with degrees in other disciplines may be able to enroll if their undergraduate work included the prerequisite courses that follow:

- Two semesters of biology.
- Two semesters of college chemistry, preferably with laboratories.
- Two semesters of organic chemistry, preferably with laboratories. Students without adequate organic chemistry may be admitted provisionally to take AS.410.302 Bio-Organic Chemistry.

The Admissions Committee reserves the right to request additional information, such as a GRE score or letters of recommendation, to assess the applicant's candidacy for admission.

Program Requirements

Code	Title	Credits
Core Courses - Required:		
AS.410.601	Biochemistry	4
AS.410.602	Molecular Biology	4
AS.410.603	Advanced Cell Biology ("Advanced Cell Biology" starting Fall 2022)	4
AS.410.604	Cellular Signal Transduction ("Cellular Signal Transduction" starting Fall 2022)	4
Electives		
Select six elective courses ¹		24
Total Credits		40

¹ See course listings page (https://e-catalogue.jhu.edu/course-descriptions/_biotechnology/); at least two must be science electives.

Course requirements differ for the certificate and concentration programs.

Please note: Many of the elective courses require prior completion of core courses. The core courses introduce the foundational information required for these courses.

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 advisor.

MS in Biotechnology Concentrations (Optional)

Students wishing to focus on a specialized discipline within the MS in Biotechnology program may enroll in one of seven concentrations:

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

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 bio threats.

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.410.601	Biochemistry	4
AS.410.602	Molecular Biology	4
AS.410.603	Advanced Cell Biology	4
AS.410.633	Introduction to Bioinformatics	4
AS.410.692	Biological & Chemical Threat Response & Forensics	4
AS.410.693	Science, Medicine & Policy in Biodefense	4
Core Courses - Customizable:		
Select one of the following:		4
Must be completed onsite		
AS.410.652	Cell Culture Techniques	
AS.410.656	Recombinant DNA Laboratory	
AS.410.658	Biodefense & Infectious Disease Laboratory Methods	
AS.410.659	Advanced Recombinant DNA Lab	
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.410.614	Pathogenic Bacteriology	
AS.410.615	Microbiology	
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	Cell Culture Techniques	
AS.410.655	Radiation Biology	
AS.410.656	Recombinant DNA Laboratory	
AS.410.658	Biodefense & Infectious Disease Laboratory Methods	
AS.410.659	Advanced Recombinant DNA Lab	
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		40

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 (Biochemistry, Molecular Biology, Advanced Cell Biology I, and Advanced Cell Biology II) and the two science electives, degree candidates must complete any four of these courses to satisfy the bioinformatics concentration requirements:

Code	Title	Credits
Bioinformatics Courses		
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	

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. Students in this concentration must complete four core science courses, four core enterprise courses, and two science electives.

Code	Title	Credits
Biotechnology Enterprise Concentration Courses		
Select four of the following:		16
AS.410.607	Proseminar in Biotechnology	
AS.410.627	Translational Biotechnology: From Intellectual Property to Licensing ¹	
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 ¹	
AS.410.646	Creating a Biotechnology Enterprise	
AS.410.647	Research Ethics	

AS.410.649	Introduction to Regulatory Affairs
AS.410.650	Legal Aspects of Biotechnology
AS.410.651	Clinical Development of Drugs and Biologics ¹
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 ("Problem Solving and Innovation" starting Fall 2022)
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)
Total Credits	16

¹ These courses count toward science elective requirement.

Concentration in Molecular Targets and Drug Discovery

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	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	
Total Credits		24

¹ The following is a list of recommended electives for the MTDDT concentration.

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 in the Master of Science in Biotechnology 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.

Students in this concentration must complete four core science courses, four core regulatory affairs courses, and two science electives.

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	
AS.410.803	Regulatory Science Thesis	
Total Credits		16

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, who 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 which are using cell therapies for treatment of diseases.

In addition to the four core courses (Biochemistry, Molecular Biology, Advanced Cell Biology I and Advanced Cell Biology II), students must complete the four concentration courses and any 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