



The Master of Science in Biotechnology

Biotechnology is a rapidly expanding cutting-edge scientific discipline with new discoveries and often life-saving products at a breathtaking pace. This industry, a merger of science and business, demands a multi-disciplinary workforce skilled in basic-research, product development, regulatory affairs and commercialization.

The Biotechnology industry harnesses advances in molecular biology, genomics, and proteomics to move discoveries and ideas out of the laboratory and into the product development pipeline. Students in the Master of Science in Biotechnology program learn to advance their careers by broadening their skill base and understanding of this dynamic field

The Master of Science in Biotechnology is grounded in Biochemistry and Cell Biology. With this foundation in science, students continue with studies in the areas of pure science, applied science, lab science, regulatory affairs and biotechnology business. The curriculum is designed so that graduates can participate fully in research; lead lab teams, help to make development and planning decisions, create and apply research modalities to larger schemes set in large research projects. Also, managers and marketers, lawyers and liaisons, all are able to bridge the worlds between their roles and the scientists in their organization, allowing for effective communications and decision making.

The Master of Science in Biotechnology courses and curriculum, presented here, has been developed in consultation with the present courses and curriculum of similar programs at Harvard University, Johns Hopkins University and Vanderbilt University, USA.

Master of Science in Biotechnology requires:

Credentials and Prerequisite Courses

- An undergraduate degree in the natural sciences or in engineering with at least a 3.0 on a 4.0 scale (professional interests and relevant work experience are also considered); applicants with degrees in other disciplines may be able



to enroll if their undergraduate work included the prerequisite courses which follow.

- Two semesters (at least 8 credits) of college chemistry, preferably with laboratories.
- Two semesters (at least 8 credits of organic chemistry, preferably with laboratories; students without adequate organic chemistry may be admitted provisionally to take *Biotech 300 Bio-Organic Chemistry*)
- The admissions committee reserves the right to request additional information from applicants, if needed, to assess their candidacy for admission.

Course Requirements

- | | |
|-----------------------------------|------------|
| • Foundation courses: | 12 credits |
| • Biotechnology core courses: | 12 credits |
| • Biotechnology elective courses: | 12 credits |

Total	36 credits
--------------	-------------------

Thesis and Non-thesis

Students taking course Biotech 701 Research in Biotechnology will be on thesis group; others not taking Biotech 701 will be on non-thesis group.

Course Description:

Students whose background in organic chemistry is found to be less than satisfactory for admission may be admitted to take *Biotech 300 Bio-Organic Chemistry* to prepare for graduate level courses.

Biotech 300: BioOrganic Chemistry

This course provides a foundation in structural organic chemistry, acid base chemistry, chemical thermodynamics, and reaction mechanisms. Subjects include Lewis structures, atomic and hybridized orbitals, stereochemistry, inter- and intramolecular forces of attraction, nucleophilic reaction mechanisms, functional groups, and the organic chemistry of biological molecules. Please note that this



course does not count toward requirements for the master's degree in biotechnology.

Biotechnology Foundation Courses:

Students must complete four foundation courses before they are allowed to enroll in Biotechnology electives. A student who has mastered some or all of the material covered in the foundation courses in previous academic work may request that one or more of these courses be waived. After reviewing the student's request, the program committee may approve a waiver. The student then is required to replace the waived core course(s) with Biotechnology electives. Electives should be chosen in consultation with the student's advisor and should accommodate individual career goals.

Biotech 601: Biochemistry

This course explores the roles of essential biological molecules including proteins, lipids, and carbohydrates, with an introduction to nucleic acids. Students examine the structure of proteins, their function, the methodologies for the purification and characterization of proteins, and the alteration of protein function through protein engineering. Enzymes and their kinetics and mechanisms are covered in detail. This course provides the linkage between the inanimate world of chemistry and the living world of biology.

Biotech 608: Advanced Biochemistry and Molecular Biology

This course focuses on intermediary metabolism and the role carbohydrates and lipids play in cell function. In addition, students examine nucleic acid structure and function and investigate the tools used in recombinant DNA technology. Specific topics include glycolysis, Krebs's cycle, oxidative phosphorylation; and DNA replication, transcription, translation, gene regulation, targeted expression of desired genes in plants and animals and post-transcriptional gene silencing like RNA interference (RNAi).

Prerequisite: Biotech 601 Biochemistry



Biotech 615: Advanced Cell Biology I

This course covers cell organization and subcellular structure. Students examine the evolution of the cell, chromosome and plasma membrane structures and behaviors, mechanics of cell division, sites of macromolecular synthesis and processing, transport across cell membranes, cell dynamics, organelle biogenesis, and cell specialization. Students also are introduced to the experimental techniques used in cell biology to study cell growth, manipulation, and evaluation. *Prerequisite: Biotech 601 Biochemistry*

Biotech 622: Microbiology

This course is an overview of microorganisms important in clinical diseases and biotechnology. Students are introduced to the general concepts concerning the morphology, genetics, and reproduction of these microbial agents. Lectures focus on individual organisms with emphasis on infectious diseases, biotechnology applications, molecular and biochemical characteristics, and molecular and serological identification methods. Students will also discuss the impact biotechnology, and particularly genomics, will have on the development of antibiotics and vaccines as treatment and preventative measures.

Biotechnology Core Courses:

Biotech 630: Principles of Immunology

This course covers molecular and cellular immunology, including antigen and antibody structure and function, effector mechanisms, complement, major histocompatibility complexes, B- and T-cell receptors, antibody formation and immunity, cytotoxic responses, and regulation of the immune response. Students are also introduced to the applied aspects of immunology, which include immunoassay design, various formats and detection methods, and flow cytometry. Special topics include immunomodulation, immunosuppression, immunotherapy, autoimmunity, and vaccination. *Prerequisites: Biotech.601 Biochemistry; Biotech 608 Advanced Biochemistry and Molecular Biology; Biotech 615 Cell Biology I*

Biotech 638: Virology

This course covers the advanced study of viruses with regard to the basic, biochemical, molecular, epidemiological, clinical, and biotechnological aspects of



animal viruses primarily and bacteriophage, plant viruses, viroids, prions, and unconventional agents secondarily. Specific areas of virology, including viral structure and assembly, viral replication, viral recombination and evolution, virus-host interactions, viral transformation, gene therapy, antiviral drugs, and vaccines, are presented. The major animal virus families are discussed individually with respect to classification, genomic structure, virion structure, virus cycle, pathogenesis, clinical features, epidemiology, immunity, and control. The viral vectors and their applications in biotechnology are discussed. *Prerequisite: Biotech.601 Biochemistry; Biotech 608 Advanced Biochemistry and Molecular Biology Biotech .615 Advanced Cell Biology I*

Biotech 645: Plant Biotechnology

In this course, students are introduced to the application of recombinant DNA technology to agriculture. Studied are methods for the introduction of foreign DNA into plant and animal cells and generation of stably transformed plants and animals. Students consider specific examples of the use of transgenic plants and animals in biotechnology, which can provide protection against insects, diseases, and tolerance to specific herbicides. They also investigate how recombinant growth hormones can result in leaner meat, greater milk yield, better feed utilization, how transgenic plants and animals can serve as bioreactors for the production of medicinals or protein pharmaceuticals, methods of introducing foreign genes to plants, inducible control of gene expression, and use of different/suitable promoters for tissue specific expression. Because recombinant agricultural products are released into the environment or consumed as foods, students also need to become familiar with environmental safety issues.

Prerequisites: Biotech 601 Biochemistry; Biotech 608 Advanced Biochemistry and Molecular Biology; Biotech 615 Advanced Cell Biology I

Biotech 652: Industrial Microbiology

This course covers the principles of various processes associated with the production and recovery of different bioproducts derived from prokaryotes and eukaryotes. Topics include the classification of microorganisms, media development, instrumentation, fermentation principles, mammalian and insect cell propagation, product recovery, protein purification, and the principles of current good manufacturing practices (cGMP). Emphasis is on large-scale production



methods and production of recombinant proteins for diagnostic and clinical applications. *Prerequisites: Biotech 601 Biochemistry; Biotech 608 Advanced Biochemistry and Molecular Biology; Biotech.615 Advanced Cell Biology I*

Biotech 659: Genes and Disease

Because of recent advances, powerful diagnostic tests now detect genetic diseases, and there is promise of gene replacement therapy. In this course students cover general genetic principles, DNA tools for genetic analysis, cytogenetics, gene mapping, the molecular basis of genetic diseases, animal models, immunogenetics, genetics of development, genetics of cancer, and treatment of genetic diseases. Molecular methods of analysis are emphasized. *Prerequisites: All four-core courses*

Biotech 671: Bioinformatics

Retrieval and analysis of electronic information are essential in today's research environment. This course explores the theory and practice of biological database searching and analysis. In particular, students are introduced to integrated systems where a variety of data sources are connected through worldwide web access. Information retrieval as well as interpretation are discussed and many practical examples in a computer laboratory setting enable students to improve their data mining skills. Methods included in the course are searching the biomedical literature, sequence homology searching and multiple alignment, protein sequence motif analysis, and several genome analytical methods. Classes are held in a computer laboratory. Acquaintance with computers is required. *Prerequisites: Biotech 601 Biochemistry; Biotech 608 Advanced Biochemistry and Molecular Biology*

Biotech 678: Practical Computer Concepts for Bio-informatics

This course introduces students with a background in the life sciences to the basic computing concepts of the UNIX operating system, relational databases, structured programming, object-oriented programming, and the Internet. Included is an introduction to SQL and the Perl scripting language. The course emphasizes relevance to molecular biology and bio-informatics. It is intended for students with no computer programming background, but with a solid knowledge of molecular biology. *Prerequisites: Biotech 601 Biochemistry. Biotech 608 Advanced Biochemistry and Molecular Biology*



Biotech 685: Biostatistics

This course introduces statistical concepts and analytical methods as applied to data encountered in biotechnology and biomedical sciences. It emphasizes the basic concepts of experimental design, quantitative analysis of data, and statistical inferences. Topics include probability theory and distributions; population parameters and their sample estimates; descriptive statistics for central tendency and dispersion; hypothesis testing and confidence intervals for means, variances, and proportions; the chi-square statistic; categorical data analysis; linear correlation and regression model; analysis of variance; and nonparametric methods. The course provides students a foundation to evaluate information critically to support research objectives and product claims and a better understanding of statistical design of experimental trials for biological products/devices. *Prerequisites: Basic mathematics (algebra); scientific calculator*

Biotech 695: Pharmaceutical Biotechnology

This course include – Pharmaceutical applications of recombinant technology, biophysical and biochemical analysis of recombinant proteins, production of biotech compounds, additional biotechnology related techniques, gene therapy vaccines, monoclonal antibody based pharmaceuticals, recombinant human deoxyribonuclease and dispensing of biotechnology products

Biotech 701: Research in Biotechnology (For thesis student)

Students in the biotechnology program have the opportunity to enroll in an independent research course. This elective course is an option after a student has completed at least eight graduate-level courses and has compiled a strong academic record. Prior to proposing a project, interested students must have identified a research topic and a mentor who is familiar with their prospective inquiry and who is willing to provide guidance and oversee the project. The research project must be independent of current work related responsibilities as determined by the project mentor. The mentor may be a faculty member teaching in the biotechnology program, a supervisor from the student's place of work, or any expert with appropriate credentials. *Prerequisites: All foundation courses and two core courses.*



Biotechnology Elective Courses

The following electives build skill and understanding in the management, marketing, and legal areas of biotechnology. At most, four of these courses can count toward the master's degree in biotechnology. All these courses can be taken concurrently with the core courses.

Biotech 708: Economic Aspects of Biotechnology

This course examines the economic, business, and financial forces that define and shape the biotechnology industry, with special focus on early stage and growing companies. A major focus is on decision making under uncertainty, which includes how to interpret and screen various input types in the decision process and how to balance the empirical and intuitive approaches to analyzing problems arising from the nature of the biotechnology business. The course will permit the student to prepare an analytic approach to complex problems, identify and assess risks and payoffs, evaluate risks and payoffs in monetary and non-monetary terms, develop a structure for strategy and tactics, and understand how and why people make the decisions they make. Topics include defining and distinguishing the biotechnology industry, competitive forces and impact on strategy, regulation of genetic products, planning under uncertainty, system thinking and system failure, the economic environment, estimating costs and benefits, strategic components, marketing and sales, research and development, and valuing a company.

Biotech 713: Managing Biotechnology Professionals

The roles of managers and leaders within biotechnology companies undergo constant change. Biotechnology managers must engage in new and innovative problem-solving strategies; lead a diverse and global workforce; develop partnerships with other businesses, customers, and competitors; manage horizontally and across teams; and utilize technology as a competitive advantage. The student is able to address current challenges in his/her own organization and learn methods of implementing change, such as negotiation techniques and motivation. The course includes in-depth discussions of leadership skills, communication, conflict resolution, and goal integration. Students research a biotechnology organization and analyze what is working and not working within the management systems and suggest alternatives.



Biotech 721: Marketing Aspects of Biotechnology

This course introduces students to the strategic and tactical approaches used in the marketing of biotechnological products and services. Students gain a thorough understanding of the research and planning necessary to develop a marketing plan, the relationship between the marketing and sales functions, the difference between marketing a scientific product and a scientific service, pricing strategies, distribution alternatives, communications, promotion, and the importance of perception. Knowledge of marketing terminology and techniques prove helpful to anyone in the industry.

Biotech 731: Managerial Finance for Biotechnology

This course integrates the tools of financial analysis with real-world problems in the technology industries. Topics include modeling, costs and benefits, and ratio and break-even analysis. Students will read, prepare, and analyze financial statements. The difference between management financial and tax financial statements will also be covered.

Biotech 741: Introduction to cGMP Compliance

This course will introduce students to the cGMP model for quality systems. Compliance to current Good Manufacturing Practices is required in the production of biotechnology as well as drug products. After an introduction to the history of cGMP and the current regulations as they exist today, participants in this course will learn to develop quality systems that will ensure compliance. Topics will include cGMP history, to the applicable regulations. comparison of other regulatory models, Quality Assurance/Quality Control, Document Management and Systems Implementation

Biotech 751: QA/QC for the Pharmaceutical and Biotechnology Industries

There are many new quality initiatives for drugs, biotech products and medical devices that have been recently introduced. These include risk based, science based and systems based assessments. Students will be presented with a comprehensive overview of the current best practices in quality assurance and quality control. Students will also be exposed to the most recent theories and expectations from the Food and Drug Administration.



Biotech 760: Ethical, Legal, and Regulatory Aspects of the Biotechnology Enterprise

This course provides an overview of the important ethical, legal, and regulatory issues that are critical to the biotechnology industry. The course is divided into the three sections of ethics, legal issues, and regulations, each section taught by a faculty member who specializes in the area. The three sections are organized to provide basic material in a way that allows for an appreciation of how each influences the others. The section on ethics introduces students to core ethical values that guide the practice of science in the biotechnology industry. The section on legal issues focuses on key legal concepts, such as protecting inventions and intellectual property, and licensing. The section on regulation addresses the range of regulatory oversight mechanisms with which the biotech industry must comply and strategies for doing so.

Biotech 773: Biology of HIV and AIDS

This course includes an overview of the biology and life cycle of the immunodeficiency virus, including the simian viruses (SIVs). Specific areas of HIV immunopathogenesis are emphasized, to include HIV diagnosis, HIV-induced immune dysfunction, and therapeutic breakthroughs in the treatment of HIV-1 disease. Students become familiarized with current methods in biotechnology that have advanced our understanding of the biology of retroviruses. Special topics include international genetic variation (subtypes and clades). HIV vaccine development, and global economic impact. *Prerequisites: Biotech 601 Biochemistry; .Biotech 602 Advanced Biochemistry and Molecular Biology; Biotech 603 Advanced Cell BiologyI*

Biotech 781: Protein Bioinformatics

Because the gap between the number of protein sequences and the number of protein crystal structures continues to expand, protein structural predictions are increasingly more important. This course provides a working knowledge of various computer-based tools available for predicting the structure and function of proteins. Topics include protein database searching, protein physicochemical properties, secondary structure prediction, and statistical verification. Also covered are graphic visualization of the different types of three-dimensional folds and predicting 3-D structures by homology. Computer laboratories complement material presented in lectures. *Prerequisites: Biotech 601 Biochemistry; Biotech 602 Advanced Biochemistry and Molecular Biology; Biotech 610 Bio-informatics*



Biotech 785: Methods in Proteomics

This course covers the analytical methods used to separate and characterize pharmaceutical compounds (predominantly proteins) derived through biotechnology. While emphasis is placed on the general principles and applicability of the methods, current protocols are discussed, and problem sets representing realistic developmental challenges are assigned. Topics include chromatography (HPLC, SEC, IEC), electrophoretic techniques (2-D gel electrophoresis), spectroscopic methods (UV/Vis, fluorescence, CD), analytical ultracentrifugation, microarrays, mass spectroscopy, amino acid analysis, sequencing, and methods to measure protein-protein interactions. *Prerequisites: Biotech 601 Biochemistry; Biotech 608 Advanced Biochemistry and Molecular Biology*

Biotech 791: Genomic Sequencing and Analysis

The completion of the human genome sequence is just the latest achievement in genome sequencing. Armed with the complete genome sequence, scientists need to identify the genes encoded within, to assign functions to the genes, and to put these into functional and metabolic pathways. This course will provide an overview of the laboratory and computational techniques beginning with genome sequencing and annotation, extending to bioinformatics analysis and comparative genomics and including functional genomics. *Prerequisites: Biotech 601 Biochemistry; Biotech 602 Advanced Biochemistry and Molecular Biology; Biotech 671 Bio-informatics*



Reading Materials

1. Biochemistry – Lehlinger
2. Molecular Biology of the gene: Watson
3. Bio-informatics computing: Bryan Bergeron, MD. (Harvard Medical School)
4. Introduction to Bio-informatics: TK Attwood & DJ Parry Smith
5. Current Communication in Molecular Biology: Robert Flettrick Mark Zoller
6. Physical Biochemistry: application to biochemistry and molecular biology. David Freifelder
7. Biochemistry of Nucleic Acid: Roger L. P. Adams
8. Annual Review of Biochemistry (Annual Review 2000-2004)
9. Annual Review of Immunology (Annual Review 2000-2004)
10. Annual Review of Genomics & Human Genetics
11. Bioinformatics (Oxford University Press)
12. Biotechnology Advances (Elsevier Science)
13. Biotechnology and Applied Biochemistry (Portland Press)
14. Biotechnology and Bioengineering (Wiley Inter science)