

# BIOENGINEERING

The Bioengineering PhD program combines existing expertise in Chemical and Biochemical Engineering with 10 allied engineering and science departments (Biological Sciences, Chemical Engineering, Chemistry, Computer Science, Civil Engineering, Electrical Engineering, Engineering Management, Materials Science and Engineering, Mechanical Engineering, and Math) spanning three colleges (the College of Engineering and Computing, the College of Arts, Sciences, and Education, and the Kummer College of Innovation, Entrepreneurship, and Economic Development) at Missouri S&T to achieve the following objectives,

1. To attract a large and diverse set of students.
2. To build a highly skilled workforce in bioengineering to meet the current and emergent needs of industries, regulatory agencies, and NGOs.
3. To serve as an integrator and catalyst for faculty members at Missouri S&T to discover new ideas, develop collaborations, and increase scholarly productivity in the critically important bioengineering research domain.
4. To build research and educational collaborations with industry and other external partners, including those within the UM system. This includes supporting existing focus areas such as precision medicine.

The PhD is open to interested students from relevant engineering and science backgrounds, but is primarily focused on those with a BS or MS degree in Chemical Engineering, Biochemical Engineering, Biomedical Engineering, Biomolecular Engineering, or Biological Engineering. The successful applicant must have minimum undergraduate grade point average of 3.0/4.0 or equivalent and strong letters of recommendations.

Students who enter the program directly with a BS degree will need to complete a minimum of 72 credit hours beyond BS degree, which should include a minimum of 30 credit hours of 4000-, 5000-, and 6000-level lecture courses. A student entering with a MS degree will receive a block of 30 credit hours toward the total 72-hour program requirement and must complete a minimum of 24 credit hours of graduate research and a minimum of 12 credit hours of 4000-, 5000-, and 6000-level lecture courses. In addition, the PhD students are required to pass a PhD qualifying exam before their 5<sup>th</sup> semester and a PhD comprehensive exam after completing at least 50% of their required coursework for the PhD degree. They must conduct research, write a PhD dissertation, and successfully defend the dissertation in their final examination (defense).

Core Courses: select a minimum of 9 credit hours from the following courses

BME 5100	Drug and Gene Delivery Systems	Drug and Gene Delivery	3
BME 6400	Biomanufacturing	Biomanufacturing	3
BME 6500	Pharmaceutical Process Engineering	Pharmaceutical Process Engineering	3
CHEM ENG 5250	Isolation and Purification of Biologicals		3
MS&E 5310	Biomaterials I		3
Ethics: required			
BME 5311	Integrity and Ethics in Bioengineering	Integrity and Ethics in Bioengineering	1
Lecture Series: enroll at least twice			
CHEM ENG 6015	Lecture Series		1

Elective Courses: select a minimum of 18 credit hours from the following courses

Biomanufacturing and Biochemical Engineering Process Design			
BME 5100	Drug and Gene Delivery Systems	Drug and Gene Delivery	3
CHEM ENG 4210	Biochemical Reactors		3

CHEM ENG 4220	Biochemical Reactor Laboratory		3
CHEM ENG 5100	Intermediate Transport Phenomena		3
CHEM ENG 5120	Interfacial Phenomena In Chemical Engineering		3
CHEM ENG 5150	Intermediate Process Computing		3
CHEM ENG 5161	Intermediate Molecular Engineering		3
CHEM ENG 5210	Intermediate Biochemical Reactors		3
CHEM ENG 5211	Intermediate Bioreactor Laboratory	Intermediate Bioreactor Laboratory	3
CHEM ENG 5220	Intermediate Engineering Thermodynamics		3
CHEM ENG 5250	Isolation and Purification of Biologicals		3
CHEM ENG 5251	Intermediate Bioseparations Laboratory	Intermediate Bioseparations Laboratory	3
MS&E 5310	Biomaterials I		3
Biomaterials and Tissue Engineering			
CHEM ENG 5300	Principles Of Engineering Materials		3
CHEM ENG 5320	Introduction to Nanomaterials		3
CHEM ENG 6150	Molecular Modeling and Simulation		3
CHEM ENG 6300	Biomaterials II		3
ELEC ENG 5810	Computational Intelligence		3
ELEC ENG 6260	Integrated Microsystems Engineering		3
MECH ENG 5229	Smart Materials and Sensors		3
MS&E 5210	Tissue Engineering		3
MS&E 5460	Molecular Engineering of Materials		3
MS&E 6210	Advanced Tissue Engineering		3
MS&E 6460	Advanced Molecular Engineering of Materials		3
ENV ENG 6601	Biological Principles In Environmental Engineering Systems		3
ENV ENG 6612	Biological Operations In Environmental Engineering Systems		3
Data Analysis and Computational Modeling			
STAT 5346	Regression Analysis		3
STAT 6344	Design And Analysis Of Experiments		3
COMP SCI 5401	Evolutionary Computing		3
COMP SCI 5700	Bioinformatics		3
Biochemical Interactions and Applications in Medicine and Nanotechnology			
CHEM 5001	Special Topics	Medicinal Chemistry	3
CHEM 5610	Biochemistry		3
CHEM 5620	Biochemical Metabolism		3
CHEM 5630	Biochemical Nanotechnology		3
BIO SCI 5533	Pharmacology		3
BIO SCI 6413	Molecular Cell Biology		3
BIO SCI 6523	Advanced Biomolecules		3
BIO SCI 6666	Advanced Nanotechnology in Biomedicine		3

## BME 5001 Special Topics (LAB 0.0 and LEC 0.0)

This course is designed to give the department an opportunity to test a new course. Variable titles.

## BME 5100 Drug and Gene Delivery Systems (LEC 3.0)

Overview of drug and gene delivery systems, rational design for their applications with an emphasis on structure-property-function relationships. Three major parts: polymers and nanoparticles as drug and gene carriers; strategies to deliver drugs and genes; in vitro and in vivo techniques of assessment and validation. Prerequisites: Chem 2210 and Bio Sci 2213.

***BME 5200 Materials as Hard Tissue Devices*** (LEC 3.0)

The structure-property relationships of materials employed as medical devices, as well as the bone, cartilage, and ligament that they are designed to replace. The behavior of materials in the physiological environment, the tailoring of that behavior as a response to both bulk and surface properties, and the future of hard tissue medical devices. Prerequisites: BME 4100 or MS&E 5210.

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***BME 5300 Vaccine Manufacturing*** (LEC 3.0)

The development, manufacturing, and approval process of vaccines are covered. Vaccines that use attenuated or inactivated viruses, viral components and mRNA as the active ingredient are discussed. The manufacturing process includes the making of the active ingredient, vaccine formulation and delivery. The class includes three remote lab experiments. Prerequisites: Senior standing in an engineering discipline, physics, chemistry, or biology.

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***BME 5311 Integrity and Ethics in Bioengineering*** (LEC 1.0)

Study of ethical, social, and legal issues that arise in biotechnology and pharmaceutical industries and in biomedical research. Emphasis on professional attitudes and standard practices. Prerequisites: Senior or graduate standing.

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***BME 6400 Biomanufacturing*** (LEC 3.0)

The development, production, recovery, and analysis of biorelated products. Specific topics include biomaterial synthesis and characterization, cell culture, bioreactor design and operation, production and purification process development, and regulatory expectations. Prerequisites: graduate standing.

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***BME 6500 Pharmaceutical Process Engineering*** (LEC 3.0)

The manufacture, extraction, processing, purification, formulation/filling, and packaging of pharmaceutical materials to be used as medications for humans or animals. The major manufactured products and their principal manufacturing steps will be covered. The principles of engineering operations and scale-up process in pharmaceutical industry will be discussed together with quality control, pollution prevention, and Good Manufacturing Practices (GMP). Prerequisites: Chem Eng 5250.

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