

# Bioengineering

## George R. Brown School of Engineering

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*Degrees offered: B.S., M.S., Ph.D.*

Graduate and undergraduate programs in bioengineering offer concentrations in areas that include cellular and molecular engineering, systems engineering and instrumentation, or biomaterials and biomechanics. Research areas include biochemical engineering, biological systems modeling, biomaterials, biomedical lasers, cellular and molecular engineering, controlled release technologies, metabolic engineering, phytoremediation, spectroscopy, systems engineering and instrumentation, thrombosis, tissue engineering, and transport processes.

**Undergraduate Program.** The bioengineering undergraduate program will prepare students for careers in rapidly developing areas of biomedical engineering and bioprocessing. Our unified and comprehensive program leading to the B.S. degree in bioengineering will:

- Build a solid engineering background for our students and equip them with advanced analytical, computational, and experimental skills
- Provide them with a fundamental understanding of the life and medical sciences
- Develop their ability to participate in interdisciplinary teams with molecular and cell biologists, or medical scientists

Undergraduates in bioengineering will then have the training to pursue further education in graduate school or medical school or will have strong preparation for a career in the biotechnology industry.

The B.S. degree is organized around a core of required courses and a selection of elective courses from three specialization areas. The specialization electives provide a flexibility that can be used to create a focus in cellular and molecular engineering, systems engineering and instrumentation, or biomaterials and biomechanics. Because of the number of options, students should consult early with departmental advisers to plan a program that meets their needs.

### **Degree Requirements for the B.S. Degree in Bioengineering**

For general university requirements, see Graduation Requirements (pages 16–18). The curriculum for a B.S. degree in bioengineering requires 94 credit hours, which count toward the total of 134 hours required to graduate.

**Preparation.** Students considering a major in bioengineering should take as freshmen MATH 101 and 102 Single Variable Calculus I and II, CHEM 121 and 122 General Chemistry, PHYS 101 (or PHYS 111) or PHYS 125 Mechanics, PHYS 102 (or PHYS 112) or PHYS 126 Electricity and Magnetism, and CAAM 210 or CAAM 211 Introduction to Engineering Computation. Sophomore students should take MATH 211 and 212, CHEM 211, 212, 215, BIOS 201, and either MECH 211 or ELEC 243. BIOE 252 Bioengineering Fundamentals should be taken in the first semester of the sophomore year.

**Concentration Areas.** Students in the B.S. program will choose courses from three specialization areas:

- Cellular and molecular engineering
- Systems engineering and instrumentation
- Biomaterials and biomechanics

Students majoring in bioengineering must complete the following courses.

#### **Core Courses**

##### ***Bioengineering***

BIOE 252 *Bioengineering Fundamentals*

BIOE 322 *Systems Physiology*

BIOE 342 *Tissue Culture Laboratory*

BIOE 372 *Introductory Biomechanics/  
Biomaterials*

BIOE 420 *Biosystems Transport and  
Reaction Processes*

BIOE 441 *Senior Bioengineering  
Laboratory*

BIOE 452 *Bioengineering Design*

##### ***Biosciences***

BIOS 201 *Introductory Biology*

BIOS 301 *Biochemistry*

BIOS 311 or 312 (1 hour) *Laboratory  
Module*

BIOS 341 *Cell Biology*

##### ***Computational and Applied Mathematics***

CAAM 210 or CAAM 211 *Introduction  
to Engineering Computation*

CAAM 335 or CAAM 336 *Foundations  
of Applied Math*

##### ***Chemical Engineering***

CENG 411 *Thermodynamics*

##### ***Chemistry***

CHEM 121 *General Chemistry*

CHEM 122 *General Chemistry*

CHEM 211 *Organic Chemistry*

CHEM 212 *Organic Chemistry*

CHEM 215 *Organic Chemistry  
Laboratory*

**Math**

MATH 101 *Single Variable Calculus I*  
 MATH 102 *Single Variable Calculus II*  
 MATH 211 *ODEs and Linear Algebra*  
 MATH 212 *Multivariable Calculus*

**Physics**

PHYS 101 or PHYS 111 or PHYS 125  
*Mechanics*  
 PHYS 102 or PHYS 112 or PHYS 126  
*Electricity and Magnetism*

**Other Engineering**

ELEC 243 or MECH 211 *Circuits  
 and Electronics or Engineering  
 Mechanics*

Please note that some of these courses may not be listed in the course listings section of this publication. As these courses become available, they will be listed in the schedule of courses.

**Specialization Areas**

Five bioengineering-area elective courses, at least 3 of which must be at the senior level, will be required in one of the three areas:

- Cellular and molecular engineering
- Systems engineering and biomedical instrumentation
- Biomaterials and biomechanics

The elective courses in these concentration areas will be announced in future course listings.

**Graduate Program.** The bioengineering graduate program at Rice educates its students so that they can directly interact with physicians and cell and molecular biologists, while still excelling in the quantitative capabilities so important for engineering applications.

**Degree Requirements for the M.S. and Ph.D. Degrees in Bioengineering**

For general university requirements, see Graduate Degrees (pages 60-65).

**M.S. Program.** Candidates for the M.S. degree must:

- Complete at least 18 semester hours of foundation, supporting, and advanced courses with high standing
- Fulfill a teaching requirement
- Submit an original research thesis
- Defend the thesis in a public oral examination

**Ph.D. Program.** Candidates for the Ph.D. degree must:

- Complete at least 36 approved semester hours of foundation, supporting, and advanced courses, with high standing. With departmental approval, the course requirements may be reduced to not less than 22 hours for students already holding an M.S. degree.
- Fulfill a teaching requirement. After their first two semesters in residence, students may be asked to spend the equivalent of 6 to 10 hours per week for a total of three semesters on teaching assignments.

- Pass the Ph.D. qualifying examinations. All Ph.D. students must pass the Ph.D. qualifying examinations usually given during the first year of study. The qualifying examinations are comprehensive tests on the knowledge acquired in the bioengineering foundation courses.
- Submit a thesis proposal. Ph.D. students must submit and successfully defend their thesis proposals by the end of their fifth semester in residence.
- Complete a three to six month industrial internship. This requirement may be waived for those with adequate previous industrial experience.
- Submit a thesis that provides evidence of their ability to carry out original research in a specialized area of bioengineering.
- Defend the thesis in a public oral examination.

Graduate students take required courses and electives in the following areas:

- Cellular and molecular engineering
- Systems engineering and instrumentation
- Biomaterials and biomechanics

**See BIOE (pages 267–271) in the Courses of Instruction section.**