

# Bioengineering

## George R. Brown School of Engineering

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

Graduate and undergraduate programs in bioengineering offer concentrations in areas that include cellular and molecular engineering; bioinstrumentation, imaging, and optics; or biomaterials and biomechanics. Research areas include biochemical engineering, biological systems modeling, biomaterials, biomedical lasers, cellular and molecular engineering, controlled release technologies, metabolic engineering, 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:

- Provide students with a fundamental understanding of the life and medical sciences
- Teach students to apply engineering principles in the life and medical sciences
- Develop their critical problem solving skills in bioengineering

- Develop their ability to communicate effectively and participate in interdisciplinary teams
- Expose students to a broad education that prepares them for diverse careers

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

The B.S.B. 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; bioinstrumentation, imaging, and optics; 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 B.S. in Bioengineering

For general university requirements, see Graduation Requirements (pages 20–23). 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.** As freshmen, students considering a major in bioengineering should take MATH 101 and 102, CHEM 121 and 122, PHYS 101 or PHYS 125, PHYS 102 or PHYS 126, and CAAM 210 or CAAM 211. Sophomore students should take MATH 211 and 212, CHEM 211, 212, 215, BIOS 201, and MECH 211. BIOE 252 should be taken in the first semester of the sophomore year. BIOE 320 and BIOE 322 should be taken the second semester of the sophomore year.

**Specialization Areas.** Students in the B.S.B. program will choose courses from one of the three specialization tracks:

- Cellular and molecular engineering
- Bioinstrumentation, imaging, and optics
- Biomaterials and biomechanics

Students majoring in bioengineering must complete the following courses.

#### Core Courses

##### **Bioengineering**

BIOE 252 *Bioengineering Fundamentals*

BIOE 320 *Systems Physiology Lab*

##### *Module*

BIOE 322 *Systems Physiology*

BIOE 332 *Thermodynamics*

BIOE 342 *Tissue Culture Laboratory*

BIOE 372 *Introductory Biomechanics/*

##### *Biomaterials*

BIOE 383 *Biomedical Instrumentation*

BIOE 391 *Numerical Methods and*

##### *Statistics*

BIOE 420 *Biosystems Transport and*

##### *Reaction Processes*

BIOE 442\* *Biomechanical Testing*

##### *Laboratory Module*

BIOE 443\* *Bioprocessing Laboratory*

##### *Module*

BIOE 444\* *Tissue Engineering Laboratory Module*

BIOE 445\* *Advanced Bioinstrumentation Laboratory Module*

BIOE 451 *Bioengineering Design I*

BIOE 452 *Bioengineering Design II*

##### **Biosciences**

BIOS 201 *Introductory Biology*

BIOS 301 *Biochemistry*

BIOS 311 or 312 *Biosciences Laboratory Module*

BIOS 341 *Cell Biology*

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

CAAM 210 or CAAM 211 *Introduction to Engineering Computation*

**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*

**Mechanical Engineering**

MECH 211 *Engineering Mechanics*

**Physics**

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

\*Students must take the senior laboratory module in their specialization area: BIOE 443 for Cellular and Molecular Engineering, BIOE 442 for Biomaterials and Biomechanics, and BIOE 445 for Bioinstrumentation, Imaging and Optics. Students must take one other senior laboratory module for a total of two of the four listed modules (BIOE 442, 443, 444, and 445).

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

**Specialization Areas**

Four specialization-area elective courses, at least 2 of which must be at the senior level, will be required in one of the three areas:

- Cellular and molecular engineering
- Bioinstrumentation, imaging, and optics
- 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 M.S. and Ph.D. in Bioengineering**

For general university requirements, see Graduate Degrees (pages 65–70).

**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 semester 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.
- Submit a thesis proposal. Ph.D. students must submit and successfully defend their thesis proposals by the end of their fourth 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
- Bioinstrumentation, imaging, and optics
- Biomaterials and biomechanics

**See BIOE in the Courses of Instruction section.**