

BIOENGINEERING

GEORGE R. BROWN SCHOOL OF ENGINEERING

CHAIR

David Hellums

PROFESSORS

Kyriacos Athanasiou

John W. Clark

Michael W. Deem

Lydia Kavradi

Antonios G. Mikos

Ka-Yiu San

Jennifer L. West

Kyriacos Zygourakis

ASSOCIATE PROFESSORS

Bahman Anvari

Michael A. Barry

Fathi Ghorbel

Jianpeng Ma

ASSISTANT PROFESSORS

Rebekah Drezek

K. Jane Grande-Allen

Michael Liebschner

Nikolaos Mantzaris

Robert Raphael

LECTURER/DIRECTOR OF LABORATORY INSTRUCTION

Ann Saterbak

ADJUNCT PROFESSORS

William Brownell

Gregory R. D. Evans

Craig J. Hartley

José A. López

Joel L. Moake

Jacqueline Shanks

C. Wayne Smith

Kenneth Wu

ADJUNCT ASSOCIATE PROFESSORS

David W. Chang

Michael H. Kroll

Michael Miller

Charles W. Patrick

Peter Saggau

Mark M. Udden

Mark E. K. Wong

Alan W. Yasko

Michael Yaszemski

George Zouridakis

ADJUNCT ASSISTANT PROFESSORS

Daniel E. Epner

Karen K. Hirschi

Rex A. Marco

Doreen Rosenstraach

Rolando E. Rumbaut

DEGREES OFFERED: BSB, MS, PHD

Graduate programs in bioengineering offer concentrations in areas that include cellular and molecular engineering; bioinstrumentation, imaging, and optics; biomaterials and biomechanics; and computation bioengineering. Undergraduate programs in bioengineering offer concentrations in areas that include cellular and molecular engineering; bioinstrumentation, imaging, and optics; biomaterials and biomechanics; and computation bioengineering. Research areas include biomechanical engineering, biological systems modeling, bioinformatics, biomaterials, biomedical lasers, cellular and molecular engineering, controlled release technologies, metabolic engineering, spectroscopy, statistical mechanics, 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 BS degree in bioengineering will:

- Provide students with a fundamental understanding of mathematics and the natural, life, and medical sciences
- Teach students bioengineering principles and their applications 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 BSB 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 BS IN BIOENGINEERING

For general university requirements, see Graduation Requirements (pages 14–15). The curriculum for a BS 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. 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 BSB program will choose courses from one of the four specialization tracks:

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

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* *Tissue Engineering Laboratory Module*

BIOE 443* *Bioprocessing Laboratory Module*

BIOE 444* *Biomechanical Testing 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 *Introduction to Engineering Computation*

ChemistryCHEM 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 or 444 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).

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 ME, MS, AND PHD IN BIOENGINEERING

For general university requirements, see Graduate Degrees (pages 57–61).

ME Program—To obtain a Masters of Engineering from the Bioengineering department you must complete the following course work:

- Curriculum has to be approved by the Academic Affairs Committee (This will be done on a case by case basis)
- Total of 30 credit hours are required (Course must be above and beyond the requirement for the undergraduate degree)
- At least 18 credit hours of the 30 must be taken as BIOE courses including the foundation courses
 - Foundation courses include:
 - Biosystems Transport and Reaction Processes (BIOE 520)
 - Fundamentals of Systems Physiology (BIOE 572)
 - Introduction to Partial Differential Equations (MATH 381)
- One additional Engineering Course (3 hours).
- Three Additional courses approved by the Academic Affairs Committee (9 hours)

18 hours in BIOE courses

3 hours of additional Engineering

9 hours of additional approved by Academic Affairs Committee

30 Total credit hours

MS Program—Candidates for the MS 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

PhD Program—Candidates for the PhD 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 MS 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. PhD 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
- Computational bioengineering

See BIOE in the Courses of Instruction section.