

Biomedical Engineering

Director of undergraduate studies: Lawrence H. Staib (lawrence.staib@yale.edu), N309 B TAC, 785-5958; seas.yale.edu/departments/biomedical-engineering

Engineering methods and strategies are used to address biomedical problems ranging from studies of physiological function using images to the development of novel drug delivery methods and new biomaterials. The B.S. degree in Biomedical Engineering is designed to provide students with an understanding of common fundamental methodologies in biomedical engineering and the ability to develop quantitative approaches to one of four biomedical engineering concentrations: Bioimaging, Biomechanics and Mechanobiology, Biomolecular Engineering, and Systems Biology. The course structure of the major permits students to bridge basic concepts in the life sciences and traditional areas of engineering, while gaining a comprehensive understanding of biomedical engineering as a field of study. The program provides graduates with an excellent background for graduate study in biomedical engineering and related areas, or in medicine and other health professions as well as for a diverse range of careers in industry, consulting, or government.

PREREQUISITES

The following prerequisites are common to all concentrations in the major: BIOL 1010 and 1020 or a higher-level course in MCDB or MB&B, with the permission of the director of undergraduate studies (DUS); a lecture course in chemistry numbered CHEM 1610 or higher; MATH 1150 or MATH 1160 (not necessary if placed into MATH 1200 or ENAS 1510); MATH 1200 or ENAS 1510; ENAS 1940; PHYS 1800, 1810 and PHYS 2050L, 2060L or PHYS 1650L, 1660L. Advanced high school preparation does not bypass these prerequisites; instead, students move ahead to more advanced courses with DUS permission.

REQUIREMENTS OF THE MAJOR

See Links to the attributes indicating courses approved for the Biomedical Engineering major requirements.

Students must complete thirteen term courses, totaling at least eleven course credits, beyond the prerequisites, including at least three required courses in the chosen concentration and the senior requirement (see below). During the first two years, students study basic biology, chemistry, mathematics, and physics (see prerequisites). By the end of the sophomore year, students should have taken BENG 2080, 2800, and 3200. In the junior year, students gain a comprehensive grounding in the field through BENG 3600, 3400, 3500, 3100, and 3110. During the junior and senior years, students acquire depth by taking electives in one of the four concentrations. One relevant course (e.g. MB&B 3000) may be substituted with DUS permission. A senior seminar (BENG 4080) provides information about the field and a senior project (BENG 4974 or BENG 4973, 4974) allows students to explore an area in depth.

Students in all concentrations are required to take the following courses: BENG 2800, 2080, 3200, 3600, 3400, 3500, 3100, 3110, and 4080.

Students in the *Bioimaging concentration* (YC BENG Bioimaging) must also take three courses chosen from, e.g., BENG 4104, 4106, 4410, 4440, 4450, 4849, 4475, 4476, or 4485.

Students in the *Biomechanics and Mechanobiology concentration* (YC BENG Biomchnics&Mchnbiology) must also take three courses chosen from, e.g., MENG 1105, 3422, BENG 4104, 4106, 4410, 4622, 4560, or 4580.

Students in either the *Biomolecular Engineering concentration* (YC BENG Biomolecular Engrng) or the ***Systems Biology concentration*** (YC BENG Systems Biology) must also take three courses chosen from, e.g., BENG 4104, 4106, 4410, 4611, 4622, 4350, 4630, 4261, 4767, 4680, 4690, MENG 3422.

Research courses Students are permitted and encouraged to engage in research before the senior year by enrolling in BENG 4971 and/or BENG 4972. These courses, offered Pass/Fail, may be taken more than once for credit.

Credit/D/Fail No course taken Credit/D/Fail may be applied toward the requirements of the major, including prerequisites.

Outside credit Courses taken at another institution or during an approved summer or term-time study abroad program may count toward the major requirements with DUS approval.

SENIOR REQUIREMENT

In their sophomore year, all students must enroll in BENG 2080 and in their senior year, all students must enroll in BENG 4080; both are half-credit courses. They must also complete a one-term senior project in their final term of enrollment (BENG 4974) or a two-term, yearlong project (BENG 4973, 4974).

ADVISING

Preparation for graduate study The Biomedical Engineering curriculum is excellent preparation for graduate study in engineering, science, and medicine.

Combined B.S./M.S. degree program Exceptionally able and well-prepared students may apply to complete a course of study leading to the simultaneous award of the B.S. and M.S. degrees after eight terms of enrollment. See Academic Regulations, section L, Special Academic Arrangements, "Simultaneous Award of the Bachelor's and Master's Degrees." Interested students should consult the DUS prior to the sixth term of enrollment for specific requirements in Biomedical Engineering.

SUMMARY OF MAJOR REQUIREMENTS

Prerequisites BIOL 1010 and BIOL 1020, or higher-level course in MCDB or MB&B with DUS permission; 1 lecture course in chemistry numbered CHEM 1610 or higher; ENAS 1940; MATH 1150 or MATH 1160 (not necessary if placed into MATH 1200 or ENAS 1510); MATH 1200 or ENAS 1510; PHYS 1800, 1810 and PHYS 2050L, 2060L or PHYS 1650L, 1660L.

Number of courses 13 term courses, totaling at least 11 course credits, beyond prerequisites (incl senior req)

Specific courses required *All concentrations*—BENG 2800, 2080, 3200, 3600, 3400, 3500, 3100, 3110, 4080

Distribution of courses *All concentrations*—3 courses from one of four concentrations; see above for suggested courses for each concentration

Substitution permitted Relevant course with DUS permission

Senior requirement BENG 2080, a half-credit course taken sophomore year; BENG 4080, a half-credit course taken senior year; a one-term senior project in final term of enrollment (BENG 4974) or two-term, yearlong senior project (BENG 4973 and 4974)

FACULTY OF THE DEPARTMENT OF BIOMEDICAL ENGINEERING

Professors †Helene Beneviste, †Joerg Bewersdorf, Richard Carson, †Nicholas Christakis, †Todd Constable, †Robin de Graaf, James Duncan, Rong Fan, †Henry Hsia, Jay Humphrey, Fahmeed Hyder, Themis Kyriakides, †Francis Lee, Andre Levchenko, †Graeme Mason, †Evan Morris, †Xenophon Papademetris, Douglas Rothman, Mark Saltzman, †Martin Schwartz, †Frederick Sigworth, †Albert Sinusas, †Brian Smith, Lawrence Staib, †Hemant Tagare, †Paul Van Tassel, Steven Zucker

Associate Professors Stuart Campbell, Tarek Famy, †Gigi Galiana, Anjelica Gonzalez, †Michelle Hampson, Farren Isaacs, †Chi Liu, Kathryn Miller-Jensen, Michael Murrell, †Dana Peters, †Dustin Scheinost, †Jiangbing Zhou

Assistant Professors †Daniel Coman, †Nicha Dvornek, †Ansel Hillmer, Michael Mak, Christina Rodriguez, Gregory Tietjen, †Daniel Wiznia

Research Scientist †Steven Tommasini

Lecturers †Liqiong Gui, †Jing Zhou

†A joint appointment with primary affiliation in another department or school.