BIEN 264. Dynamics of Biological Systems (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing or consent of instructor. Covers engineering principles for the analysis and modeling of biological phenomena. Topics include molecular diffusion and transport, membranes, ligand-bioreceptor interactions, enzyme kinetics, and dynamics of metabolic pathways and the application of these principles to the design of bioreactors, bioassays, drug delivery systems, and artificial organs. Normally graded Satisfactory (S) or No Credit (NC), but students may petition the instructor for a letter grade on the basis of assigned extra work or examination. Cross-listed with CEE 264. Credit is awarded for only one of BIEN 159/CEE 159 or BIEN 264/CEE 264.

BIEN 265. Special Topics in Biomedical Optical Imaging (1 or 2) S Seminar, 1 hour; term paper, 0-3 hours. Prerequisite(s): graduate standing or consent of instructor. Focuses on advanced theory, technology, and applications of biomedical optical imaging. Addresses novel sources of optical contrast, current developments in optical imaging instrumentation, and recent advances in their application to bioengineering. Students who submit a term paper receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable.

BIEN 266. Special Topics in Biological Nuclear Magnetic Resonance (NMR) Spectroscopy (1 or 2) Seminar, 1 hour; term paper, 0-3 hours. Prerequisite(s): graduate standing or consent of instructor. Focuses on various advanced methods for the determination of structure, dynamics, and interactions of biomolecules, using multidimensional and multinuclear NMR spectroscopy. Students who submit a term paper receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable.

BIEN 267. Special Topics in Biophotonics (1 or 2) Seminar, 1 hour; term paper, 0-3 hours. Prerequisite(s): graduate standing or consent of instructor. Focuses on advanced science and technology methods that use electromagnetic radiation for medical and biological applications. Covers photonic devices, detection, microscopy and spectroscopy techniques, and diagnostics and mechanistic ideas on photodynamic therapy. Students who submit a term paper receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable.

BIEN 268. Bioengineering Experimentation and Analysis (2) Laboratory, 3 hours; discussion, 1 hour; written work, 2 hours. Prerequisite(s): BIOL 005C, CHEM 001C, CS 005, MATH 046, PHYS 002C or equivalents or consent of instructor. Introduces measurement principles and data acquisition methods related to biomechanics and biochemical and bioelectrical signals from living systems. Addresses the fundamental mechanisms underlying the operation of various sensor types and the modern instruments illustrating noise analysis, filtering, signal processing, and conditioning. Includes experiments aimed at investigating physical responses of cells and tissues to a variety of stimuli.

BIEN 269. Special Topics in Optical Measurements and Photomedicine (2) Discussion, 1 hour; extra reading, 3 hours. Prerequisite(s): graduate standing or consent of instructor. Focuses on the applications of optical trapping methods to characterize the mechanical and electromechanical properties of biological cells and membranes, as well as to quantify molecular interactions. Also covers the use of optical probes for cellular and tissue imaging, as well as optical therapy. Graded Satisfactory (S) or No Credit (NC). Course is repeatable as content changes.

BIEN 286. Colloquium in Bioengineering (1) Colloquium, 1 hour. Prerequisite(s): graduate standing or consent of instructor. Colloquia on current research topics in bioengineering and other related fields. Presented by faculty members and visiting scientists. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

BIEN 290. Directed Studies (1-6) Individual study, 3-18 hours. Prerequisite(s): graduate standing; consent of instructor and graduate advisor. Faculty-directed individual study of selected topics in Bioengineering. Graded Satisfactory (S) or No Credit (NC). Course is repeatable to a maximum of 9 units.

BIEN 297. Directed Research (1-6) Outside research, 3-18 hours. Prerequisite(s): graduate standing; consent of instructor. Provides research opportunities for selected problems in bioengineering. Conducted under faculty supervision. Graded Satisfactory (S) or No Credit (NC). Course is repeatable to a maximum of 15 units.

BIEN 298-I. Individual Internship (1-12) Internship, 2-24 hours; written work, 1-12 hours. Prerequisite(s): graduate standing; consent of instructor. An individual apprenticeship in bioengineering with an approved professional individual or organization and academic work under the direction of a faculty member. Requires a written report. Graded Satisfactory (S) or No Credit (NC). Course is repeatable to a maximum of 16 units.

BIEN 299. Research for the Thesis or Dissertation (1-12) Outside research, 3-36 hours. Prerequisite(s): graduate standing; consent of instructor. Designated for research in bioengineering for the M.S. thesis or Ph.D. dissertation. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

Professional Course

BIEN 302. Teaching Practicum (1-4) Practicum, 3-12 hours. Prerequisite(s): graduate standing; appointment as a teaching assistant or associate in Bioengineering. Provides supervised teaching in undergraduate courses. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

Bioengineering Interdepartmental Graduate Program

Jerome S. Schultz, Ph.D., Director
Department Office, A231 Bourns Hall
(951) 827-2111; jssbio@engr.ucr.edu

Participating Faculty

Distinguished Professors
- Robert C. Haddon, Ph.D. (Chemistry)
- Dallas Rabenstein, Ph.D. (Chemistry)
- Natasha Raikhel, Ph.D. (Botany & Plant Sciences)
- Jerome Schultz, Ph.D. (Bioengineering)

Professors
- Michael E. Adams, Ph.D. (Cell Biology & Neuroscience/ Entomology)
- Bahman Anvari, Ph.D. (Bioengineering)
- G. John Andersen, Ph.D. (Psychology)
- Bir Bhanu, Ph.D. (Electrical Engineering)
- David Bocian, Ph.D. (Chemistry)
- Wilfred Chen, Ph.D. (Chemical & Environmental Engineering)
- Sarjeet Gill, Ph.D. (Cell Biology & Neuroscience)
- Tao Jiang, Ph.D. (Computer Science)
- David Johnson, Ph.D. (Biomedical Sciences)
- Cynthia K. Larive, Ph.D. (Chemistry)
- Elizabeth Lord, Ph.D. (Botany & Plant Sciences)
- Manuela Martins-Green, Ph.D. (Cell Biology & Neuroscience)
- Umar Mohideen, Ph.D. (Physics & Astronomy)
- Dimitrios Morikis, Ph.D. (Bioengineering)
- Thomas H. Morton, Ph.D. (Chemistry)
- Ashok Mulchandani, Ph.D. (Chemical & Environmental Engineering)
- Eugene Nothnagel, Ph.D. (Botany & Plant Sciences)
- Victor G. J. Rodgers, D.Sc. (Bioengineering)
- John Shyy, Ph.D. (Biomedical Sciences)
- Harry W. K. Tom, Ph.D. (Physics & Astronomy)
- Kambiz Vafai, Ph.D. (Mechanical Engineering)
- Yushan Yan, Ph.D. (Chemical & Environmental Engineering)

Professor Emeritus
- Richard A. Luben, Ph.D. (Biochemistry & Biomedical Sciences)

Associate Professors
- Guillermo Aguilar, Ph.D. (Mechanical Engineering)
- Stefano Lonardi, Ph.D. (Computer Science)
- Michael Marsella, Ph.D. (Chemistry)
- Cengiz S. Ozkan, Ph.D. (Mechanical Engineering)
- Mihri Ozkan, Ph.D. (Electrical Engineering)
- Thomas F. Stahovich, Ph.D. (Mechanical Engineering)
- Jianzhong Wu, Ph.D. (Chemical & Environmental Engineering)

Assistant Professors
- Christopher J. Bardeen, Ph.D. (Chemistry)
- Quan Cheng, Ph.D. (Chemistry)
- Jiayu Liao, Ph.D. (Bioengineering)
- Julia Lyubovitsky, Ph.D. (Bioengineering)
- Nosang Myung, Ph.D. (Chemical & Environmental Engineering)
- Vladimir Parpura, Ph.D. (Cell Biology & Neuroscience)
- Valentine Vullev, Ph.D. (Bioengineering)
- Sharon Walker, Ph.D. (Chemical & Environmental Engineering)

Program Overview

The interdepartmental graduate program is the umbrella for graduate level research effort associated with the faculty in the Department of Bioengineering as well as other faculty at UCR who have an interest in training graduate students in bioengineering. The program offers graduate instruction leading to M.S. and Ph.D. degrees in Bioengineering.

Our interdisciplinary program combines a solid fundamental foundation in biological science and engineering, and aims to equip the students with diverse communication skills and training in the most advanced quantitative bioengineering research so that they can become leaders in their respective fields. The result is a rigorous, but exceptionally interactive and welcoming educational training for Bioengineering graduate students.

The interdepartmental aspect of the program allows students to develop skills related to bioengineering with faculty in a broad range of disciplines. The research vision is to build strength from experts in biochemistry, biophysics, biology and engineering to focus on critical themes that impact bioengineering.

Contributing departments include: Bioengineering, Biochemistry, Biomedical Sciences, Botany & Plant Sciences, Cell Biology & Neuroscience, Chemistry, Chemical & Environmental Engineering, Computer Science, Electrical Engineering, Entomology, Mechanical Engineering, Physics & Astronomy, and Psychology.

The dominant research theme of the interdepartmental graduate program is BioCellular Engineering. BioCellular Engineering envisions the design and implementation of processes that incorporate biomolecular assemblies and cellular structures for the development of advanced technologies. Specifically, these efforts include: cellular control and regulation (signal transduction pathways, regulation of immune system, metabolic controls, intracellular biosensors); mathematical and in-silico computational modeling (transport and kinetics of reactive species in organelles, biomolecules and biomolecular interactions, analysis of neural systems); and macromolecular, supramolecular, and membrane biophysics.

Other research areas of the interdepartmental graduate program faculty include: structural bioinformatics, rational protein, peptide, and drug design, drug delivery and pharmacokinetics, bioreactor design and analysis, microfluidics, charge transfer in biological and biomimetic systems, thermodynamics of proteins, electrophysiology and non-linear neural modeling, site specific, diagnostic-guided optical therapy, immunophysics, auditory bioengineering, molecular mechanisms of platelets activation, high-throughput screening systems, fatty acid contributions to obesity and diabetes, brain imaging, and bioseparations.

Please visit the UCR website to determine the research emphasis of the various participating faculty. The research efforts of faculty in the Department of Bioengineering can be found at www.bioeng.ucr.edu.

Combined B.S. + M.S. Five-Year Program The college offers a combined B.S. + M.S. program in Bioengineering designed to lead to a Bachelor of Science degree as well as a Master of Science degree in five years. Applicants for this program must have a high school GPA above 3.6, a combined SAT Reasoning score above 1950 (or ACT plus Writing equivalent), complete the Entry Level Writing Requirement before matriculation, and have sufficient mathematics preparation to enroll in calculus in their first quarter as freshmen.

Interested students who are entering their junior year should check with their academic advisor for information on eligibility and other details.

Admission In addition to the following requirements, all applicants must meet the general requirements as set forth in this catalog under the Graduate Studies section.

Applicants will need to have completed coursework in chemistry, physics, math, biochemistry and biology, and engineering. Students without an undergraduate engineering degree should have excellent training in mathematics and the physical sciences.

Specific recommendations for students without an undergraduate engineering degree are:

- Two years of mathematics (equivalent UCR course = Math 9A-C, Math 10A,B)
- One year of physics (equivalent UCR course = Phys 2 A-C with lab)
- One year of inorganic chemistry including lab (equivalent UCR course = Chem 1A-C)
- One year of organic chemistry including lab (equivalent UCR course = Chem 112 A-C).
- One course in biochemistry (equivalent UCR course = BCH 100 or BCH 110A or B or C).
- One course in molecular biology (equivalent UCR course = BCH 110C or Biol 107).

Students with strong academic records may be admitted with limited coursework deficiencies, provided that these are satisfied by appropriate coursework taken during the first two years of graduate study.

Language Requirement All International students whose first language is not English must satisfactorily complete the SPEAK test.

Students may be admitted to either the Master's or the Ph.D. program.

Students in the Master's program may petition for admission into the Ph.D. program.

Masters Program

The M.S. program is ideal for professionals seeking greater depth in several areas of bioengineering. The degree requires a minimum of 36 quarter credits and may be completed in three to four academic quarters of full-time study. Both thesis and non-thesis options are offered for the degree program (Plan I, Thesis and Plan II, Comprehensive Examination).

Student must request permission to pursue an M.S. in Bioengineering while simultaneously pursing a Ph.D. in a program other than Bioengineering.

Normative Time to Degree
Two years.

Plan I (Thesis)

In addition to the following requirements, all applicants must meet the requirements for Plan I as set forth in this catalog under the Graduate Studies section Master's Degree Plan I (Thesis).

Course Requirements Students must satisfy the core course requirements (see Core Courses). Students enroll in the interdepartmental colloquium series in Bioengineering each quarter it is offered.

Plan II (Comprehensive Examination)

This plan is designed primarily for students who do not intend to pursue a Ph.D. in Bioengineering.

In addition to the following requirements, all applicants must meet the requirements for Plan I as set forth in this catalog under the Graduate Studies section Master's Degree Plan II (Comprehensive Examination).

Course Requirements Students must satisfy the core course requirements (see Core Courses). Students enroll in the interdepartmental colloquium series in Bioengineering each quarter it is offered.

The comprehensive examination is prepared and administered by the Graduate Examination Committee. The student is allowed to choose between an oral and a written examination. The examination covers a broad range of topics chosen from upper division undergraduate courses and graduate courses taken by M.S. students.

Subsequent to the examination, the Graduate Examination Committee issues a passing or failing grade. Students who fail in the first attempt may retake the examination at the next scheduled comprehensive examination period. No more than two attempts to pass the exam are allowed.

The M.S. Comprehensive Examination may be held at the end of any quarters throughout the year. The committee to administer the M.S. Comprehensive Examination is selected by the Graduate Advisor and approved by the Graduate Program Committee.

Doctoral Program

The Ph.D. program is heavily integrated with research activities and is intended for well-qualified individuals who wish to pursue leadership careers in academic or industrial research. The Ph.D. program requires approximately three years of full-time study beyond the master's degree. In consultation with a faculty advisor, Ph.D. students plan their program of study. The doctoral dissertation is based on original research in the field of specialization. An M.S. degree is not a prerequisite for entering the Ph.D. program.

The doctoral program includes a teaching requirement, an oral and written qualifying examination, and a dissertation.

Normative Time to Degree Five years.

Course Requirements Students must satisfy the core course requirements (see Core Courses). Students will enroll in the interdepartmental colloquium series in Bioengineering each quarter it is offered.

Written Qualifying Examination Students in the Ph.D. program must pass a written qualifying examination that covers the fields of engineering and biology that relate to the student's dissertation project.

Oral Qualifying Examination Following successful completion of the written examination, candidates for the doctoral degree must pass an oral examination, normally within three quarters of the date of their written exam. The oral examination is scheduled only after the candidate has written a proposal detailing the rationale, specific aims and approaches to be undertaken for her/his dissertation research.

Dissertation A written dissertation is completed by each student.

Candidates for the degree of Ph.D. may be required to defend the dissertation in a public, oral presentation at a time announced to members of the University community.

Core Courses All Bioengineering graduate students are required to take at least three courses from the following six Bioengineering courses. Other courses may be substituted but must be approved by the bioengineering graduate advisor. Students from non-engineering backgrounds are also required to take BIEN 268 in addition to the courses stipulated here.

Bioengineering Core

1. BIEN 220 - Chemical Genomics Design Studio
2. BIEN 223 - Engineering Analysis of Physiological Systems
3. BIEN 224 - Cellular and Molecular Engineering
4. BIEN 249 - Integration of Computational and Experimental Biology
5. BIEN 264 - Dynamics of Biological Systems
6. BIEN 268 - Bioengineering Experimentation and Analysis

Other required courses:

1. One bioscience class chosen from: BCH 210, BCH 211, BCH 212, BIOL/CMDB 200, BIOL/CMDB 201,BIOL 203, BIOL 221/MCBL 221/PLPA 226, or, with consent of instructor, BMSC 229, BMSC 230, BMSC 231, BMSC 232, BMSC 234, and BMSC 235.
2. Other courses may be substituted but must be approved by the Bioengineering Graduate Advisor.
3. BIEN 286 - Colloquium in Bioengineering This course is required every quarter in which it is offered.

Additional courses may be required by the Advisory Committee depending on the student's background and fields of interest.

M.S. and Ph.D. students must complete the course requirements for the programs within their first year of residence.

Course Descriptions All Bioengineering courses are listed and described under Bioengineering.

Biological Sciences

Subject abbreviation: BLSC
College of Natural and Agricultural Sciences

_____, Director
Raphael Zidovetzki, Lead Advisor
Program Office, 1223 Pierce Hall
(951) 827-3579

Committee in Charge

Edith Allen, Ph.D. *Conservation Biology, Evolution and Ecology, Plant Biology*
Katherine Borkovich, Ph.D. *Microbiology*
Xuemei Chen, Ph.D. *Bioinformatics and Genomics*
David A. Johnson, Ph.D. *Medical Biology*
Howard Judelson, Ph.D. *Cell, Molecular, and Developmental Biology*
Morris Maduro, Ph.D. *Biology*
Frances Sladek, Ph.D. *Environmental Toxicology*
Linda L. Walling, Ph.D.
Divisional Dean Life Sciences, College of Natural and Agricultural Sciences, ex officio

Faculty, see listings for
Department of Biology
Department of Botany and Plant Sciences
Department of Cell Biology and Neuroscience
Department of Entomology
Department of Environmental Sciences
Department of Nematology
Department of Plant Pathology and Microbiology

Major

Biological Sciences is an interdepartmental major that includes faculty (more than 150) from seven departments in the College of Natural and Agricultural Sciences. The major offers the B.S. degree and is unified by the Life Sciences core curriculum (see below, Major Requirements), which students complete during their initial years at UCR or at another college or university (transfer students).

For advanced study in the junior and senior years, students select an area of specialization (track) from the nine that are now available: Bioinformatics and Genomics; Biology; Cell, Molecular and Developmental Biology; Conservation Biology; Evolution and Ecology; Environmental Toxicology; Medical Biology; Microbiology; and Plant Biology. Each track provides the opportunity to combine broad basic training in biological sciences with an emphasis in an area of particular interest to the student. Both the name of the major (Biological Sciences) and the track are included on the official transcript.

The organization of the major into tracks and the participation of a large number of faculty allows a diversity of student choices that could not be provided by a single department. The track structure allows flexibility to incorporate new faculty and research areas so students can prepare for graduate study and careers in emerging fields of biology. As their interests change and develop during the initial years at UCR, students can easily change their track selection for the junior and senior years.

As can be seen from the track descriptions and other items below, the Biological Sciences major provides preparation for a broad diversity of professional schools, graduate schools and careers. Students in this major and all others at UCR are eligible to complete admission requirements and apply to medical schools throughout the United States, including the 24 positions reserved for UCR students in the joint UCR/UCLA medical school (Thomas Haider Program in Biomedical Sciences). For additional information, see below, Admission Requirements for Medical and Health Professional Schools.

University Requirements

See Undergraduate Studies section.

College Requirements

See College of Natural and Agricultural Sciences, Colleges and Programs section.

Major Requirements

Some of the following requirements for the major may also fulfill the college's breadth requirements. Consult with a department advisor for program planning.

The major requirements for the B.S. in Biological Sciences are as follows:

1. Life Sciences core requirements (68-72 units) Students must complete all required courses with a grade of "C-" or better and with a cumulative GPA in the core courses of at least 2.0. Grades of "D" or "F" in two core courses, either separate courses or repetitions of the same course, are grounds for discontinuation from the major.

a) BIOL 005A, BIOL 05LA, BIOL 005B, BIOL 005C

b) CHEM 001A, CHEM 001B, CHEM 001C, CHEM 01LA, CHEM 01LB, CHEM 01LC, CHEM 112A, CHEM 112B, CHEM 112C

c) MATH 008B or MATH 009A, MATH 009B

d) PHYS 002A, PHYS 002B, PHYS 002C, PHYS 02LA, PHYS 02LB, PHYS 02LC

e) STAT 100A

f) BCH 100 or BCH 110A

2. As specified in the individual tracks, at least 36 upper-division units for the major and 16 units of substantive course work related to the major. Courses in Statistics and Biochemistry taken as part of the core may be included.

A student is subject to discontinuation from the major whenever the GPA in upper-division course work is below 2.0. Students finding themselves in this circumstance must meet with an advisor.

Bioinformatics and Genomics Track

Bioinformatics and Genomics are popular new fields whose emergence is catalyzed by the explosion of data made available through automated DNA sequencing. They meld in a seamless fashion genetics, molecular and