phosphorylation events in regulation of metabolism and growth; calcium and other ion channels as signal transduction mechanisms, steriod hormones receptor super family; immune system signal transduction events.

BCH 230 (E-Z). Advanced Topics in Biochemistry (2) Lecture, 1 hour; discussion, 1 hour. Prerequisite(s): BCH 100 or both BCH 110A and BCH 110B or consent of instructor. Addresses advances in a particular field of biochemistry by analysis of the recent literature. E. Structure of Biological Molecules; F. Enzyme Catalysis; G. Glycobiochemistry; H. Membrane Biochemistry; I. Cytoskeleton and Extracellular Matrix; J. Metabolism; K. Regulation of Chromatin Structure and Transcription; M. Genome Stability; N. Regulation of Protein Synthesis; O. Signal Transduction; Q. Cell Cycle Regulation; R. Biochemistry of Stress Responses; S. Biochemistry of Development and Aging; T. Molecular Basis of Genetic Diseases; U. Genomics and Proteomics; V. Emerging Topics in Biochemistry and Molecular Biology; W. Stem Cell Biology.

BCH 231. The Plant Genome (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BCH 100, BIOL 107A; or BCH 110A, BCH 110B, BCH 110C; or consent of instructor. Gives students an appreciation for the structure of the plant nuclear, chloroplast, and mitochondrial genomes. Gene structure, regulation of gene expression, transposons, and methods of gene introduction are also emphasized. Cross-listed with BPSC 231.

BCH 240. Special Topics in Biochemistry (2) Lecture, 2 hours. Prerequisite(s): BCH 110A, BCH 110B, BCH 110C or equivalents (may be taken concurrently); graduate standing in Biochemistry or consent of instructor. Oral presentations and intensive small-group discussion of selected topics in the area of specialization of each faculty member. Course content emphasizes recent advances in the special topic area and varies accordingly. Transposable Elements and Insect Molecular Biology. **Atkinson**. Chromosome Segregation and Stability. **Bachant**. Mechanisms of Translational Control. **Bailey-Serres**. Biochemical Host—Parasite Relationships. **Beckage**. Signal Transduction in Fungi. **Borkovich**. Biochemical Pharmacology. **Byus**. Plant Stress Genomics. **Close**. Protein Expression and Plasticity of Brain Glutamate Receptors. **Curras-Collazo**. Photosynthesis: Electron Transfer and 0_2 Evolution. **Debus**. Specificity in Mitogen-Activated Kinase Cascades. **DeFea**. Enzymatic and Nonenzymatic Reactions. **Dunn**. Molecular Basis of Learning and Memory. **Ethell, I**. Plant Gene Expression. **Gallie**. Mutagenesis, Recombination, and Genomic Instability. **Grosovsky**. Steroid and Cyclic Nucleotide Metabolism. **Henry**. Molecular Farming. **Huang**. Mechanisms of Signal Transduction in Plants. **Larsen**. Tumor Suppressor and Cell Cycle Regulation. **Liu**. Research Topics in Endocrinology. **Luben**. Structure and Function of Transport Proteins. **Lytle**. Regulation of Eukaryotic Gene Transcription. **Martinez**. Chemokines in Healing and Disease. **Martins-Green**. Biosensors. **Mulchandani**. Mechanisms of Steroid Hormones. **Norman**. Insect Innate Immunity. **Raikhel, A**. Nutrient-Activated Gene Expression. **Raikhel, A**. Regulation of Primary Metabolism. **Roberts**. Stem Cell Biology. **Sato**. Chromatin. **Sauer.** Regulation of Tissue-Specific Gene Expression. **Sladek**. Regulation of Gene Expression. **Spindler**. Endothelial Cell Perturbation. **Stemerman**. Signal Transduction. **Traugh**. Plant Defense Mechanisms. **Walling**. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

BCH 241. Bioorganic Chemistry (3) Lecture, 3 hours. Prerequisite(s): BCH 100 or BCH 110A; BCH 184 or CHEM 110B; CHEM 112A, CHEM 112B, CHEM 112C; graduate standing or consent of instructor. Biochemical reactions discussed from a chemical standpoint, including reactions associated with bioenergetics, biosynthesis, and enzyme catalysis. Emphasis on reaction mechanisms. Cross-listed with CHEM 241.

BCH 250. Oral Presentations in Biochemistry (2) Seminar, 1 hour; discussion, 1 hour. Prerequisite(s): graduate standing. Training and practice in the presentation of biochemical concepts in both short and long seminar formats, using blackboard, overhead projector, and slides. Presentations are immediately and critically evaluated by both faculty and staff. Limited to 10 students.

BCH 251. Graduate Seminar in Biochemistry (2) Seminar, 1 hour; discussion, 1 hour. Prerequisite(s): BCH 250. Oral reports by graduate students on current research topics in biochemistry.

BCH 252. General Seminar in Biochemistry (1) Seminar, 1 hour. Prerequisite(s): graduate standing. Oral reports by faculty, graduate students, and visiting scholars on current research topics in biochemistry. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

BCH 261. Seminar in Genetics, Genomics, and Bioinformatics (1) Seminar, 1 hour. Prerequisite(s): graduate standing or consent of instructor. Oral reports by visiting scholars, faculty, and students on current research topics in Genetics, Genomics, and Bioinformatics. Graded Satisfactory (S) or No Credit (NC). Course is repeatable. Cross-listed with BIOL 261, BPSC 261, ENTM 261, GEN 261, and PLPA 261.

BCH 289. Special Topics in Neuroscience (2) Seminar, 2 hours. Prerequisite(s): graduate standing or consent of instructor. An interdisciplinary seminar consisting of student presentations and discussion of selected topics in neuroscience. Content and instructor(s) vary each time course is offered. Students who present a seminar receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade. Course is repeatable. Cross-listed with BIOL 289, CHEM 289, ENTM 289, NRSC 289, and PSYC 289.

BCH 290. Directed Studies (1-4) Outside research, 3-12 hours. Prerequisite(s): graduate standing in Biochemistry; consent of instructor and graduate advisor. Experimental or literature studies on specifically selected topics undertaken under the direction of a staff member. With prior approval of the graduate advisor, M.S. students may be assigned a letter grade; other students are graded Satisfactory (S) or No Credit (NC). Course is repeatable.

BCH 291. Individual Study in Biochemistry (1-6) Prerequisite(s): graduate standing in Biochemistry or consent of instructor. A program of studies designed to advise and assist candidates who are preparing for examinations. Open to M.S. and Ph.D. candidates; does not count toward the unit requirement for the M.S. degree. Graded Satisfactory (S) or No Credit (NC). Repeatable up to 6 units for pre-Master's students and up to 12 units for Ph.D. students prior to successful completion of the qualifying examination.

BCH 297. Directed Research (1-6) Prerequisite(s): graduate status in Biochemistry or consent of instructor. Directed research in preparation for dissertation projects performed prior to advancement to candidacy. Graded Satisfactory (S) or No Credit (NC).

BCH 299. Research for Thesis or Dissertation (1-12) Prerequisite(s): graduate status in Biochemistry or consent of instructor. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

Professional Courses

BCH 301. Teaching of Biochemistry at the College Level (1) Seminar, 1 hour. Prerequisite(s): graduate standing and consent of instructor. A program of weekly meetings and individual formative evaluations required of new biochemistry teaching assistants. Covers instructional methods and classroom/section activities most suitable for teaching Biochemistry. Conducted by the TA Development Program. Credit not applicable to graduate unit requirements. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

BCH 302. Apprentice Teaching (1-4) variable hours. Prerequisite(s): graduate standing; limited to departmental teaching assistants. Supervised teaching in lower- and upper-division Biochemistry courses. Required for all Biochemistry teaching assistants. Fulfills portion of the teaching requirements for Ph.D. Graded Satisfactory (S) or No Credit (NC). May be repeated for credit.

Bioengineering

Subject abbreviation: BIEN
The Marlan and Rosemary Bourns College of Engineering

Jerome S. Schultz, Ph.D., Chair
Department Office, A231 Bourns Hall
(951) 827-4303; **www.bioeng.ucr.edu**

Professors
Bahman Anvari, Ph.D.
Dimitrios Morikis, Ph.D.
Victor G. J. Rodgers, D.Sc.
Jerome S. Schultz, Ph.D.

Assistant Professors
Jiayu Liao, Ph.D.
Julia Lyubovitsky, Ph.D.
Boris Hyle Park, Ph.D.
Valentine Vullev, Ph.D.
**

Adjunct Professor
Paul Citron, Ph.D.

Major

The major in Bioengineering allows students to complete a B.S. degree that provides a basic education to enter the fields of bioengineering and biotechnology.

Bioengineering is rooted in physics, mathematics, chemistry, biology, and the life sciences. It is the application of a systematic, quantitative, and integrative way of thinking about and approaching the solutions of problems important to biology, health, and clinical practice.

Bioengineers develop processes and products that are important for health and treatment of diseases, new materials, protecting environments, and food production. They are employed by the pharmaceutical, biotechnology, medical device, and environmental and food industries. For students interested in medicine, the bioengineering program provides the basic courses to prepare for application to medical schools.

The objective of the bioengineering program is to produce graduates who:

- have a strong foundation to apply science, engineering, and biological principles to meet the challenges at the interface of engineering, life sciences, and medicine
- have the capability to pursue graduate studies, careers in the medical device or biotechnology industries, or entry into medical or other health related professional schools
- are effective as professionals working individually and in teams and can communicate effectively to integrate contributions from multiple disciplines to address biological and medical problems.
- have an appreciation of and sensitivity to a broad range of ethical and social concerns related to bioengineering

All undergraduates in the College of Engineering must see an advisor at least annually. Visit **student.engr.ucr.edu** for details.

University Requirements

See Undergraduate Studies section.

College Requirements

See The Marlan and Rosemary Bourns College of Engineering, Colleges and Programs section.

The Bioengineering major uses the following major requirements to satisfy the college's Natural Sciences and Mathematics breadth requirement.

1. BIOL 005A, BIOL 05LA
2. CHEM 001A, CHEM 001B, CHEM 001C
3. MATH 008B or MATH 009A

Major Requirements

1. Lower-division requirements (72 units)
   a) BIEN 010
   b) BIOL 005A, BIOL 05LA, BIOL 005B
   c) CHEM 001A, CHEM 001B, CHEM 001C, CHEM 01LA, CHEM 01LB, CHEM 01LC
   d) CS 010
   e) EE 001A, EE 01LA
   f) MATH 009A, MATH 009B, MATH 009C, MATH 010A, MATH 010B, MATH 046
   g) PHYS 040A, PHYS 040B, PHYS 040C
2. Upper-division requirements (80 units)
   a) BCH 100
   b) BIEN 105, BIEN 110, BIEN 120, BIEN 125, BIEN 130, BIEN 130L, BIEN 135, BIEN 140A/CEE 140A, BIEN 155, BIEN 159/CEE 159, BIEN 175A, BIEN 175B
   c) BIOL 171
   d) CHEM 112A, CHEM 112B, CHEM 112C
   e) STAT 155
   f) Technical electives (16 units): BIEN 140B, BIEN 197 (4 units maximum), CEE 135, CHE 105*, CHE 122, CHE 161*, EE 100A, EE 100B, EE 105, EE 110A, EE 110B, EE 138, EE 139, EE 143, EE 144, EE 146*, EE 152*, ENVE 133, ENVE 142, ENVE 171, ME 114, ME 138, ME 153, ME 180 (*require consent of instructor prior to enrollment.)

Visit the Student Affairs Office in the College of Engineering or **student.engr.ucr.edu** for a sample program.

Lower-Division Course

BIEN 010. Overview of Bioengineering (2) Lecture, 1 hour; laboratory, 3 hours. Provides an overview of the various aspects of bioengineering. Illustrates the application of engineering principles for the design of various products and processes related to the health science industries. Covers diagnostic instruments, artificial organs, biotechnology, and cell and tissue engineering. Designed for both engineering and non-engineering majors. Graded Satisfactory (S) or No Credit (NC).

Upper-Division Courses

BIEN 105. Circulation Physiology (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIOL 005B, MATH 046, PHYS 040A. Introduces tensor and vector mathematics that describe the conservation of momentum and mass transport in biological sciences, the cardiovascular system, and pulmonary system. Includes constitutive equations such as the Navier-Stokes and Casson models, significance of fluid stress in biological vessels, and the physiological relevance of fundamental parameters. Emphasizes the relation between function and system behavior.

BIEN 110. Biomechanics of the Human Body (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): CHEM 001C or CHEM 01HC, MATH 010A, PHYS 040B. Introduces the motion, structure and function of the musculoskeletal system, the cardiovascular system, and the pulmonary system. Topics include applied statics, kinematics, and dynamics of these systems and the mechanics of various tissues (ligament, bone, heart, blood vessels, lung). Emphasis is on the relation between function and material properties of these tissues.

BIEN 115. Quantitative Physiology (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIEN 110; enrollment priority is given to Bioengineering majors; consent of instructor is required for nonmajors. Analyzes engineering aspects of physiological systems and artificial organs. Covers the nervous system, muscular system, cardiovascular system, respiratory system, and renal system. Addresses ethical and professional considerations in the development and utilization of medical devices and interventions.

BIEN 120. Biosystems and Signal Analysis (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIOL 005B, CS 010, MATH 046, PHYS 040C. Provides basic knowledge for the quantitative analysis of the dynamic behavior of biological systems. Particular applications include neural systems, control of metabolic and hormonal systems, and design of instruments for monitoring and controlling biological systems. Topics include system theory, signal properties, control theory, and transfer functions.

BIEN 125. Biotechnology and Molecular Bioengineering (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BCH 100. Provides an overview of biochemical processes in cells and their use in developing new products and processes. Presents cellular processes such as metabolism, protein synthesis, enzyme behavior, and cell signaling and control from an engineering viewpoint of modeling and control.

BIEN 130. Bioinstrumentation (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIEN 120; concurrent enrollment in BIEN 130L. Introduces basic components of instruments for biological applications. Explores sources of signals and physical principles governing the design and operation of instrumentation systems used in medicine and physiological research. Topics include data acquisition and characterization; signal-to-noise concepts and safety analysis; and interaction of instrument and environment.

BIEN 130L. Bioinstrumentation Laboratory (2) Laboratory, 3 hours; discussion, 1 hour. Prerequisite(s): concurrent enrollment in BIEN 130. Laboratory experience with instrumental methods of measuring biological systems. Introduces various sensors and transducers to measure physical, chemical, and biological properties. Covers reliability, dynamic behavior, and data analysis.

BIEN 135. Biophysics and Biothermodynamics (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BCH 100, MATH 010B, MATH 046, PHYS 040C. An introduction to the application of thermodynamic principles to understanding the behavior of biological systems. Discusses biophysical properties of biomacromolecules, such as proteins, polynucleotides, carbohydrates, and lipids, and methods of characterizing their properties and interactions.

BIEN 140A. Biomaterials (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BCH 100, CHEM 112C, MATH 010B, PHYS 040B. Covers the principles of materials science and engineering, with attention to topics in bioengineering. Explores atomic structures, hard treatment, fundamentals of corrosion, manufacturing processes, and characterization of materials. Cross-listed with CEE 140A.

BIEN 140B. Biomaterials (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIEN 140A/CEE 140A. Covers the structure-property relations of metals, ceramics, polymers, and composites, as well as hard and soft tissues such as bone, teeth, cartilage, ligament, skin, muscle, and vasculature. Focuses on behavior of materials in the physiological environment. Cross-listed with CEE 140B.

BIEN 155. Biotechnology Laboratory (2) Laboratory, 3 hours; discussion, 1 hour. Prerequisite(s): BCH 100, PHYS 040C. Laboratory experience in cell culture, bioreactors, optical techniques, array techniques, and separation and purification methods.

BIEN 159. Dynamics of Biological Systems (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BCH 100 or BCH 110A. 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. Cross-listed with CEE 159. Credit is awarded for only one of BIEN 159/CEE 159 or BIEN 264/CEE 264.

BIEN 160. Biomedical Imaging (4) F Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIEN 120. An introduction to the fundamental physics and engineering principles for medical imaging systems. Covers X-ray, ultrasound, radionuclide, magnetic resonance imaging, positron emission tomography, optical coherent tomography, and other optical methods. Includes image formation and reconstruction, image characteristics, and quality and image processing.

BIEN 165. Biomolecular Engineering (4) Lecture, 2 hours; discussion, 1 hour; term paper, 3 hours. Prerequisite(s): BIEN 125; PHYS 040B or consent of instructor. Emphasizes engineering, biochemical, and biophysical concepts and technologies intrinsic to specific topics of biomolecular engineering. Introduces the history of genetic and protein engineering. Topics include biological thermodynamics, molecular kinetics, biochemical and biophysical approaches, protein engineering, high-throughput screening technologies, and protein engineering with unnatural amino acids.

BIEN 175A. Senior Design (4) Lecture, 2 hours; practicum, 3 hours; discussion, 1 hour. Prerequisite(s): BIEN 130; BIEN 130L; BIEN 135; senior standing in Bioengineering. Preparation of formal engineering reports and statistical analysis on a series of problems illustrating methodology from various branches of applied bioengineering. Covers the entire design process: design problem definition, generation of a design specification, documentation, design review process, prototype fabrication, testing and calibration, cost estimation, and federal guidelines. Requires a term project and oral presentation. Graded In Progress (IP) until BIEN 175A and BIEN 175B are completed, at which time a final, letter grade is assigned.

BIEN 175B. Senior Design (4) Lecture, 1 hour; practicum, 6 hours; discussion, 1 hour. Prerequisite(s): BIEN 175A; senior standing in Bioengineering. Preparation of formal engineering reports and statistical analysis on a series of problems illustrating methodology from various branches of applied bioengineering. Covers the entire design process: design problem definition, generation of a design specification, documentation, design review process, prototype fabrication, testing and calibration, cost estimation, and federal guidelines. Requires a term project and oral presentation. Satisfactory (S) or No Credit (NC) grading is not available.

BIEN 190. Special Studies (1-5) Individual study, 3-15 hours. Prerequisite(s): upper-division standing; consent of instructor and department chair. Provides individual study to meet special curricular needs. Course is repeatable to a maximum of 9 units.

BIEN 197. Research for Undergraduates (1-4) Laboratory, 3-12 hours. Prerequisite(s): consent of instructor and Bioengineering undergraduate program advisor. Directed research on a topic relevant to bioengineering. Requires a final written report. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

Graduate Courses

BIEN 220. Chemical Genomics Design Studio (2) Lecture, 1 hour; practicum, 4 hours. Prerequisite(s): Course work in cell biology, genetics, combinatorial chemistry; or consent of instructor; graduate standing. Explores chemical genomic research approaches. Emphasizes critical thinking; advanced planning of time-consuming tests of hypotheses and experimental caveats, trade-offs, and options. Taught in a case-study approach, teams consist of students with engineering, biology, computational sciences, and chemical backgrounds. Teams generate an interdisciplinary chemical genomic research project. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with CMDB 220.

BIEN 223. Engineering Analysis of Physiological Systems (3) Lecture, 3 hours. Prerequisite(s): course work in basic biology, calculus, chemistry, and physics; graduate standing or consent of instructor. Provides a bioengineering approach to the physiological properties and interactions of various mammalian organ systems. Covers the nervous, muscular, cardiovascular, respiratory, and renal systems. Emphasizes the physical and engineering principles governing these systems by applying quantitative and analytical approaches. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor.

BIEN 224. Cellular and Molecular Engineering (4) Lecture, 2 hours; discussion, 1 hour; practicum, 3 hours. Prerequisite(s): graduate standing in Bioengineering or consent of instructor. Emphasizes biophysical and engineering concepts intrinsic to specific topics at the cellular and molecular level. Includes receptor-ligand dynamics in cell signaling and function; DNA replication and RNA processing; cellular and protein sorting; control of gene expression; membrane structure, transport and traffic; biological signal transduction; and mechanics of cell division. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor.

BIEN 227. Biophotonics: Laser-Tissue Interactions and Therapeutic Applications (3) Lecture, 2 hours; term paper, .5 hours; extra reading, 1 hour; written work, 1.5 hours. Prerequisite(s): BIOL 005C, CHEM 001C, CS 005, MATH 046, PHYS 002C, or equivalents. Provides an overview of various types of interactions between lasers and biological tissues. Addresses methods of optical properties measurements, mathematical modeling of light propagation, and selected therapeutic applications of lasers. Includes one or two field trips to medical laser centers to observe laser treatment procedures.

BIEN 228. Biophotonics: Optical Diagnosis and Measurements (3) Lecture, 2 hours; outside research, .5 hours; extra reading, 1 hour; written work, 1.5 hours. Prerequisite(s): BIEN 227. Covers the fundamentals underlying optical diagnostic procedures, including absorption and scattering-based techniques. Also addresses physics of optical tweezers and their applications in biological sciences.

BIEN 233. Computational Modeling of Biomolecules (4) Lecture, 2 hours; workshop, 2 hours. Prerequisite(s): BIOL 005B; CHEM 112B; MATH 009C or MATH 09HC; PHYS 040B; basic computer programming experience. Introduces computational methods for the quantitative analysis of biomolecular structures at atomic resolution. Aids in understanding the physicochemical properties of biomolecular function, the prediction of biological properties, and the design of new experiments. Forms the basis for structure-based design of proteins with tailored properties and inhibitors of protein function. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor.

BIEN 245. Fluorescence Methods in Biology and Chemistry (3) Lecture, 3 hours. Prerequisite(s): CHEM 109 or equivalent, graduate standing, consent of instructor. Topics include the origin of fluorescence and other emission processes that modulate the characteristics of molecular emissions. Presents emission-based analytical and bioanalytical methods and techniques. Reviews state-of-the-art instrumentation, including their applicability, limitations, and source, as well as interpretation and meaning of the measured signals, with applications to biological systems. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Course is repeatable as content changes.

BIEN 249. Integration of Computational and Experimental Biology (4) Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): BIOL 005B; MATH 009B or MATH 09HB; graduate standing. Multidisciplinary introduction to the mathematical concepts of design of experiments, information content, causation versus correlation, and statistical analysis with respect to hypothesis testing, model development, and parameter estimation. Covers state-of-the-art experimental techniques in proteomics, transcriptomics, metabolomics, and genetics. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with CEE 249.

BIEN 251. Biophotonics: Optical Microscopy and Its Biological Applications (3) S, F, W Lecture, 2 hours; discussion, 1 hour. Prerequisite(s): graduate standing or consent of instructor. Examines the fundamentals of optical system design and system integration in light microscopy. Covers design components, including light sources, lenses, mirrors, dispersion elements, optical fibers, and detectors. Also covers optical system analysis, transfer functions, magnification, resolution, contrast, and molecular, cellular, organ, and organism applications.

BIEN 260. Special Topics in Bioinstrumentation (1 or 2) Seminar, 1 hour; term paper, 0-3 hours. Prerequisite(s): graduate standing or consent of instructor. Focuses on advanced technologies in bioengineering studies, such as spectroscopy, microscopy, magnetic resonance imaging, computed tomography, ultrasonography, and biosensors. Students who submit a term paper receive credit for 2 units; other students receive credit for 1 unit. 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 261. Special Topics in Biotransport (1 or 2) Seminar, 1 hour; term paper, 0-3 hours. Prerequisite(s): graduate standing or consent of instructor. Focuses on advanced methods of analysis of biological transport phenomena such as drug distribution, microcirculation, membrane transport, and transport in organs and tissues. Students who submit a term paper receive credit for 2 units; other students receive credit for 1 unit. 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 262. Special Topics in Biosignaling (1 or 2) Seminar, 1 hour; term paper, 0-3 hours. Prerequisite(s): graduate standing or consent of instructor. Focuses on current research in cell signaling and control, including G protein-coupled receptors, signal transduction and cytoskeletal dynamics, and cell adhesion and cell metabolism. Students who submit a term paper receive credit for 2 units; other students receive credit for 1 unit. 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 263. Special Topics in Biocomputation (1 or 2) Seminar, 1 hour; term paper, 0-3 hours. Prerequisite(s): graduate standing; consent of instructor. Focuses on various advanced methods for computational studies of biomolecules and simulations. Includes Brownian dynamics simulations; Monte Carlo methods; normal mode analysis; electrostatic calculations; and free energy calculations. 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 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.