BIOE (BIOE)

Courses

BIOE 10N. Form and Function of Animal Skeletons. 3 Units.
Preference to freshmen. The biomechanics and mechanobiology of the musculoskeletal system in human beings and other vertebrates on the level of the whole organism, organ systems, tissues, and cell biology. Field trips to labs.
Same as: ME 10N

BIOE 32Q. Bon Appétit, Marie Curie! The Science Behind Haute Cuisine. 3 Units.
This seminar is for anyone who loves food, cooking or science! We will focus on the science and biology behind the techniques and the taste buds. Not a single lecture will pass by without a delicious opportunity - each weekly meeting will include not only lecture, but also a lab demonstration and a chance to prepare classic dishes that illustrate that day's scientific concepts.

BIOE 36Q. The Biophysics of Innate Immunity. 3 Units.
The innate immune system provides our first line of defense against disease--bothninfections, and cancer. Innate immune effectors such as host defense peptides arendeployed by numerous cell types (for instance neutrophils, macrophages, NK cells,nepithelial cells and keratinocytes) and work by biophysical mechanisms of action. The ourse draws from the primary literature and covers the evolution, structures, mechanisms,and physiological functions of important "innate immune effectors" (components of the innate immune system that can attack pathogens, and infected or host cells, and kill or incapacitate them directly). The course is aimed at students who have an interest in biochemistry, molecular/cellular biology, biophysics, and/or bioengineering.

BIOE 41. Physical Biology of Macromolecules. 4 Units.
Principles of statistical physics, thermodynamics, and kinetics with applications to molecular biology. Topics include entropy, temperature, chemical forces, enzyme kinetics, free energy and its uses, self assembly, cooperative transitions in macromolecules, molecular machines, feedback, and accurate replication. Prerequisites: MATH 41, 42; CHEM 31A, B (or 31X); strongly recommended: PHYSICS 41, CME 100 or MATH 51, and CME 106; or instructor approval.

BIOE 42. Physical Biology of Cells. 4 Units.
Principles of transport, continuum mechanics, and fluids, with applications to cell biology. Topics include random walks, diffusion, Langevin dynamics, transport theory, low Reynolds number flow, and beam theory, with applications including quantitative models of protein trafficking in the cell, mechanics of the cell cytoskeleton, the effects of molecular noise in development, the electromagnetics of nerve impulses, and an introduction to cardiovascular fluid flow. Prerequisites: MATH 41, 42; CHEM 31A, B (or 31X); strongly recommended: CS 106A, PHYSICS 41, CME 100 or MATH 51, and CME 106; or instructor approval. 4 units, Spr (Huang, K).

BIOE 44. Fundamentals for Engineering Biology Lab. 4 Units.
Introduction to next-generation techniques in genetic, molecular, biochemical, and cellular engineering. Lab modules build upon current research including: gene and genome engineering via decoupled design and construction of genetic material; component engineering focusing on molecular design and quantitative analysis of experiments; device and system engineering using abstracted genetically encoded objects; and product development based on useful applications of biological technologies. Concurrent or previous enrollment in BIO 41.

BIOE 51. Anatomy for Bioengineers. 4 Units.
Fundamental human anatomy, spanning major body systems and tissues including nerve, muscle, bone, cardiovascular, respiratory, gastrointestinal, and renal systems. Explore intricacies of structure and function, and how various body parts come together to form a coherent and adaptable living being. Correlate clinical conditions and therapeutic interventions. Participate in lab sessions with predissected cadaveric material and hands-on learning to gain understanding of the bioengineering human application domain. Encourage anatomical thinking, defining challenges and opportunities for bioengineers.

BIOE 70Q. Medical Device Innovation. 3 Units.
BIOE 70Q invites students to apply design thinking to the creation of healthcare technologies. Students will learn about the variety of factors that shape healthcare innovation, and through hands-on design projects, invent their own solutions to clinical needs. Guest instructors will include engineers, doctors, entrepreneurs, and others who have helped bring ideas from concept to clinical use.

BIOE 80. Introduction to Bioengineering (Engineering Living Matter). 4 Units.
Students completing BIOE.80 should have a working understanding for how to approach the systematic engineering of living systems to benefit all people and the planet. Our main goals are (1) to help students learn ways of thinking about engineering living matter and (2) to empower students to explore the broader ramifications of engineering life. Specific concepts and skills covered include but are not limited to: capacities of natural life on Earth; scope of the existing human-directed bioeconomy; deconstructing complicated problems; reaction & diffusion systems; microbial human anatomy; conceptualizing the engineering of biology; how atoms can be organized to make molecules; how to print DNA from scratch; programming genetic sensors, logic, & actuators; biology beyond molecules (photons, electrons, etc.); what constraints limit what life can do?; what will be the major health challenges in 2030?; how does what we want shape bioengineering?; who should choose and realize various competing bioengineering futures?.
Same as: ENGR 80

BIOE 101. Systems Biology. 3 Units.
Complex biological behaviors through the integration of computational modeling and molecular biology. Topics: reconstructing biological networks from high-throughput data and knowledge bases. Network properties. Computational modeling of network behaviors at the small and large scale. Using model predictions to guide an experimental program. Robustness, noise, and cellular variation. Prerequisites: CME 102; BIO 41, BIO 42; or consent of instructor.
Same as: BIOE 210

BIOE 103. Systems Physiology and Design. 4 Units.
Physiology of intact human tissues, organs, and organ systems in health and disease, and bioengineering tools used (or needed) to probe and model these physiological systems. Topics: Clinical physiology, network physiology and system design/plasticity, diseases and interventions (major syndromes, simulation, and treatment, instrumentation for intervention, stimulation, diagnosis, and prevention), and new technologies including tissue engineering and optogenetics. nbsp;Discussions of pathology of these systems in a clinical-case based format, with a view towards identifying unmet clinical needs. nbsp;Learning computational skills that not only enable simulation of these systems but also apply more broadly to biomedical data analysis. Prerequisites: CME 102; PHYSICS 41; BIO 41, 42.

BIOE 103B. Systems Physiology and Design. 4 Units.
ONLINE Offering of BIOE103. This pilot class, BIOE103B, is an entirely online offering with the same content, learning goals, and prerequisites as BIOE103. Students attend class by watching videos and completing assignments remotely. Students may attend recitation and office hours in person, but cannot attend the BIOE103 in-person lecture due to room capacity restraints. Physiology of intact human tissues, organs, and organ systems in health and disease, and bioengineering tools used (or needed) to probe and model these physiological systems. Topics: Clinical physiology, network physiology and system design/plasticity, diseases and interventions (major syndromes, simulation, and treatment, instrumentation for intervention, stimulation, diagnosis, and prevention), and new technologies including tissue engineering and optogenetics. Discussions of pathology of these systems in a clinical-case based format, with a view towards identifying unmet clinical needs. Learning computational skills that not only enable simulation of these systems but also apply more broadly to biomedical data analysis. Prerequisites: MATH 41, 42; CME 102; PHY 41; BIO 41, 42; strongly recommended PHY 43; or instructor approval.

BIOE 115. Computational Modeling of Microbial Communities. 4 Units.
Provides biologists with basic computational tools and knowledge to confront large datasets in a quantitative manner. Students learn basic programming skills focused on Matlab, but also are introduced to Perl and Python. Topics include: image analysis, bioinformatics algorithms, reaction diffusion modeling, Monte Carlo algorithms, and population dynamics. Students apply computational skills to a miniature research project studying the human gut microbiota.
Same as: MI 245

BIOE 122. Biosecurity and Bioterrorism Response. 4-5 Units.
Overview of the most pressing biosecurity issues facing the world today. Guest lecturers have included former Secretary of State Condoleezza Rice, former Special Assistant on BioSecurity to Presidents Clinton and Bush Jr. Dr. Ken Bernard, Chief Medical Officer of the Homeland Security Department Dr. Alex Garza, eminent scientists, innovators and physicians in the field, and leaders of relevant technology companies. How well the US and global healthcare systems are prepared to withstand a pandemic or a bioterrorism attack, how the medical/healthcare field, government, and the technology sectors are involved in biosecurity and pandemic or bioterrorism response and how they interface, the rise of synthetic biology with its promises and threats, global bio-surveillance, making the medical diagnosis, isolation, containment, hospital surge capacity, stockpiling and distribution of countermeasures, food and agriculture biosecurity, new promising technologies for detection of bio-threats and countermeasures. Open to medical, graduate, and undergraduate students. No prior background in biology necessary. This course satisfies the TiS requirement for Engineering students; please check with your major advisor to verify this. 4 units for twice weekly attendance (Mon. and Wed.); additional 1 unit for writing a research paper for 5 units total maximum. PLEASE NOTE: This class will meet for the first time on Wednesday, April 1.
Same as: PUBLPOL 122, SURG 122

BIOE 123. Optics and Devices Lab. 4 Units.
This course provides a hands-on introduction to designing, and building devices for controlling experiments in the field of bioengineering. This course focuses on the tools and concepts related to optics and electronics, but also touches on other valuable techniques such as rapid prototyping and micro-fluidics. The first part of the course consists of guided modules, while the second half of the course is project based where students design and develop their own biotic game. Prerequisites: BIOE 41 and Matlab recommended.

BIOE 131. Ethics in Bioengineering. 3 Units.
Bioengineering focuses on the development and application of new technologies in the biology and medicine. These technologies often have powerful effects on living systems at the microscopic and macroscopic level. They can provide great benefit to society, but they also can be used in dangerous or damaging ways. These effects may be positive or negative, and so it is critical that bioengineers understand the basic principles of ethics when thinking about how the technologies they develop can and should be applied. On a personal level, every bioengineer should understand the basic principles of ethical behavior in the professional setting. This course will involve substantial writing, and will use case-study methodology to introduce both societal and personal ethical principles, with a focus on practical applications.

BIOE 141A. Senior Capstone Design I. 4 Units.
Lecture/Lab. First course of two-quarter capstone sequence. Team based project introduces students to the process of designing new biological technologies to address societal needs. Topics include methods for validating societal needs, brainstorming, concept selection, and the engineering design process. First quarter deliverable is a design for the top concept. Second quarter involves implementation and testing. Guest lectures and practical demonstrations are incorporated. Prerequisites: BIOE 123 and BIOE 44. This course is open only to seniors in the undergraduate Bioengineering program.

BIOE 141B. Senior Capstone Design II. 4 Units.
Lecture/Lab. Second course of two-quarter capstone sequence. Team based project introduces students to the process of designing new biological technologies to address societal needs. Emphasis is on implementing and testing the design from the first quarter with the at least one round of prototype iteration. Guest lectures and practical demonstrations are incorporated. Prerequisites: BIOE123 and BIOE44. This course is open only to seniors in the undergraduate Bioengineering program.nIMPORTANT NOTE: class meets in Shriram 112.

BIOE 191. Bioengineering Problems and Experimental Investigation. 1-5 Unit.
Directed study and research for undergraduates on a subject of mutual interest to student and instructor. Prerequisites: consent of instructor and adviser. (Staff).

BIOE 191X. Out-of-Department Advanced Research Laboratory in Bioengineering. 1-15 Unit.
Individual research by arrangement with out-of-department instructors. Credit for 191X is restricted to declared Bioengineering majors pursuing honors and requires department approval. See http://bioengineering.stanford.edu/education/undergraduate.html for additional information. May be repeated for credit.

BIOE 196. INTERACTIVE MEDIA AND GAMES. 1 Unit.
Interactive media and games increasingly pervade and shape our society. In addition to their dominant roles in entertainment, video games play growing roles in education, arts, and science. This seminar series brings together a diverse set of experts to provide interdisciplinary perspectives on these media regarding their history, technologies, scholarly research, industry, artistic value, and potential future.
Same as: BIOPHYS 196

BIOE 201C. Diagnostic Devices Lab. 2 Units.
This course exposes students to the engineering principles and clinical application of medical devices through lectures and hands-on labs, performed in teams of two. Teams take measurements with these devices and fit their data to theory presented in the lecture. Devices covered include X-ray, CT, MRI, EEG, ECG, Ultrasound and BMI (Brain-machine interface). Prerequisites: BioE 103 or BioE 300B or EE 122B.
Same as: BIOE 301C

BIOE 210. Systems Biology. 3 Units.
Complex biological behaviors through the integration of computational modeling and molecular biology. Topics: reconstructing biological networks from high-throughput data and knowledge bases. Network properties. Computational modeling of network behaviors at the small and large scale. Using model predictions to guide an experimental program. Robustness, noise, and cellular variation. Prerequisites: CME 102; BIO 41, BIO 42; or consent of instructor.
Same as: BIOE 101

BIOE 211. Biophysics of Multi-cellular Systems and Amorphous Computing. 2-3 Units.
Provides an interdisciplinary perspective on the design, emergent behavior, and functionality of multi-cellular biological systems such as embryos, biofilms, and artificial tissues and their conceptual relationship to amorphous computers. Students discuss relevant literature and introduced to and apply pertinent mathematical and biophysical modeling approaches to various aspect multi-cellular systems, furthermore carry out real biology experiments over the web. Specific topics include: (Morphogen) gradients; reaction-diffusion systems (Turing patterns); visco-elastic aspects and forces in tissues; morphogenesis; coordinated gene expression, genetic oscillators and synchrony; genetic networks; self-organization, noise, robustness, and evolvability; game theory; emergent behavior; criticality; symmetries; scaling; fractals; agent based modeling. The course is geared towards a broadly interested graduate and advanced undergraduates audience such as from bio / applied physics, computer science, developmental and systems biology, and bio / tissue / mechanical / electrical engineering. Prerequisites: Previous knowledge in one programming language - ideally Matlab - is recommended; undergraduate students benefit from BIOE 41, BIOE 42, or equivalent.
Same as: BIOE 311, BIOPHYS 311, DBIO 211

BIOE 212. Introduction to Biomedical Informatics Research Methodology. 3 Units.
Hands-on software building. Student teams conceive, design, specify, implement, evaluate, and report on a software project in the domain of biomedicine. Creating written proposals, peer review, providing status reports, and preparing final reports. Guest lectures from professional biomedical informatics systems builders on issues related to the process of project management. Software engineering basics. Because the team projects start in the first week of class, attendance that week is strongly recommended. Prerequisites: BIOMEDIN 210 or 211 or 214 or 217 or consent of instructor.
Same as: BIOMEDIN 212, CS 272, GENE 212

BIOE 214. Representations and Algorithms for Computational Molecular Biology. 3-4 Units.
Topics: introduction to bioinformatics and computational biology, algorithms for alignment of biological sequences and structures, computing with strings, phylogenetic tree construction, hidden Markov models, Gibbs Sampling, basic structural computations on proteins, protein structure prediction, protein threading techniques, homology modeling, molecular dynamics and energy minimization, statistical analysis of 3D biological data, integration of data sources, knowledge representation and controlled terminologies for molecular biology, microarray analysis, machine learning (clustering and classification), and natural language text processing. Prerequisites: programming skills; consent of instructor for 3 units.
Same as: BIOMEDIN 214, CS 274, GENE 214

BIOE 215. Physics-Based Simulation of Biological Structure. 3 Units.
Modeling, simulation, analysis, and measurement of biological systems. Computational tools for determining the behavior of biological structures-from molecules to organisms. Numerical solutions of algebraic and differential equations governing biological processes. Simulation laboratory examples in biology, engineering, and computer science. Limited enrollment. Prerequisites: basic biology, mechanics (F=ma), ODEs, and proficiency in C or C++ programming.

BIOE 220. Introduction to Imaging and Image-based Human Anatomy. 3 Units.
Focus on learning the fundamentals of each imaging modality including X-ray Imaging, Ultrasound, CT, and MRI, to learn normal human anatomy and how it appears on medical images, to learn the relative strengths of the modalities, and to answer, "What am I looking at?" Course website: http://rad220.stanford.edu.
Same as: RAD 220

BIOE 221. Physics and Engineering of Radionuclide Imaging. 3 Units.
Physics, instrumentation, and algorithms for positron emission tomography (PET) and single photon emission computed tomography (SPECT). Topics include basic physics of photon emission and detection, electronics, system design, strategies for tomographic image reconstruction, data correction algorithms, methods of image quantification, and image quality assessment, and current developments in the field. Prerequisites: A year of university mathematics and physics.
Same as: RAD 221

BIOE 222. Instrumentation and Applications for Multi-modality Molecular Imaging of Living Subjects. 3-4 Units.
Focuses on instruments, algorithms and other technologies for imaging of cellular and molecular processes in living subjects. Introduces preclinical and clinical molecular imaging modalities, including strategies for molecular imaging using PET, SPECT, MRI, Ultrasound, Optics, and Photoacoustics. Covers basics of instrumentation physics, the origin and properties of the signal generation, and image data quantification.
Same as: RAD 222

BIOE 223. Physics and Engineering of X-Ray Computed Tomography. 3 Units.
CT scanning geometries, production of x-rays, interactions of x-rays with matter, 2D and 3D CT reconstruction, image presentation, image quality performance parameters, system components, image artirfacts, radiation dose. Prerequisites: differential and integral calculus. Knowledge of Fourier transforms (EE261) recommended.
Same as: RAD 223

BIOE 224. Probes and Applications for Multi-modality Molecular Imaging of Living Subjects. 4 Units.
Focuses on molecular contrast agents (a.k.a. "probes") that interrogate and target specific cellular and molecular disease mechanisms. Covers the ideal characteristics of molecular probes and how to optimize their design for use as effective imaging reagents that enables readout of specific steps in biological pathways and reveal the nature of disease through noninvasive imaging assays. Prerequisites: none.
Same as: RAD 224

BIOE 225. Ultrasound Imaging and Therapeutic Applications. 3 Units.
Covers the basic concepts of ultrasound imaging including acoustic properties of biological tissues, transducer hardware, beam formation, and clinical imaging. Also includes the therapeutic applications of ultrasound including thermal and mechanical effects, visualization of the temperature and radiation force with MRI, tissue assessment with MRI and ultrasound, and ultrasound-enhanced drug delivery. Course website: http://bioe325.stanford.edu.
Same as: RAD 225

BIOE 227. Functional MRI Methods. 3 Units.
(Same as RAD 227, BIOPHYS 227) Basics of functional magnetic resonance neuroimaging, including data acquisition, analysis, and experimental design. Journal club sections. Cognitive neuroscience and clinical applications. Prerequisites: basic physics, mathematics; neuroscience recommended.

BIOE 229. Advanced Research Topics in Multi-modality Molecular Imaging of Living Subjects. 3-4 Units.
Covers advanced topics and controversies in molecular imaging in the understanding of biology and disease. Lectures will include discussion on instrumentation, probes and bioassays. Topics will address unmet needs for visualization and quantification of molecular pathways in biology as well as for diagnosis and disease management. Areas of unmet clinical needs include those in oncology, neurology, cardiovascular medicine and musculoskeletal diseases. The aim is to identify important problems and controversies in a field and address them by providing background and relevance through review of the relevant primary literature, and then proposing and evaluating innovative imaging strategies that are designed to address the problem. The organization of lectures is similar to the thought process that is necessary for writing an NIH grant proposal in which aims are proposed and supported by background and relevance. The innovation of proposed approaches will be highlighted. An aim of the course is to inform students on how to creatively think about a problem and propose a solution focusing on the key elements of writing a successful grant proposal. Prerequisites: none.
Same as: RAD 222C

BIOE 231. Protein Engineering. 3 Units.
The design and engineering of biomolecules emphasizing proteins, antibodies, and enzymes. Combinatorial and rational methodologies, protein structure and function, and biophysical analyses of modified biomolecules. Clinically relevant examples from the literature and biotech industry. Prerequisite: basic biochemistry. Winter, Cochran.
Same as: BIOE 331

BIOE 236. Biophysical Mechanisms of Innate Immunity. 3 Units.
The innate immune system provides our first line of defense against infections of all kinds as well as cancer. Innate immune effectors, e.g. host defense peptides are deployed by numerous cell types (neutrophils, macrophages, NK cells, as well as epithelial cells, keratinocytes, and others) and attack by biophysical mechanisms of action. Disorders of innate immunity are increasingly being implicated in human autoimmune disease. Using primary literature, we will cover the evolution, structures, mechanisms, and functions of innate immune effectors.

BIOE 244. Advanced Frameworks and Approaches for Engineering Integrated Genetic Systems. 4 Units.
Concepts and techniques for the design and implementation of engineered genetic systems. Topics covered include the quantitative exploration of tools that support (a) molecular component engineering, (b) abstraction and composition of functional genetic devices, (c) use of control and dynamical systems theory in device and systems design, (d) treatment of molecular "noise", (e) integration of DNA-encoded programs within cellular chassis, (f) designing for evolution, and (g) the use of standards in measurement, genetic layout architecture, and data exchange. Prerequisites: CME104, CME106, CHEM 33, BIO41, BIO42, BIOE41, BIOE42, and BIOE44 (or equivalents), or permission of the instructors.

BIOE 253. Science and Technology Policy. 3-4 Units.
How U.S. and international political institutions and processes govern science and technology; the roles of scientists, engineers, and physicians in creating and implementing policies; introduction to analytical techniques that are common to research and policy analysis in technology and public policy; and examples from specific mission areas (e.g., economic growth, health, climate, energy and the environment, information technology, international security). Assignments: analyzing the politics of particular legislative outcomes, assessing options for trying to reach a policy objective, and preparing a mock policy memo and congressional testimony.
Same as: PUBLPOL 353

BIOE 260. Tissue Engineering. 3 Units.
Principles of tissue engineering and design strategies for practical applications for tissue repair. Topics include tissue components and dynamics, morphogenesis, stem cells, cellular fate processes, cell and tissue characterization, controlled drug and gene delivery, bioreactors, cell-materials interactions, and host integration. Present research proposal to solve a real life tissue engineering problem.
Same as: ORTHO 260

BIOE 261. Principles and Practice of Stem Cell Engineering. 3 Units.
Quantitative models used to characterize incorporation of new cells into existing tissues emphasizing pluripotent cells such as embryonic and neural stem cells. Molecular methods to control stem cell decisions to self-renew, differentiate, die, or become quiescent. Practical, industrial, and ethical aspects of stem cell technology application. Final projects: team-reviewed grants and business proposals.
Same as: NSUR 261

BIOE 273. BIODESIGN FOR MOBILE HEALTH. 1-3 Unit.
This seminar examines the emerging mobile health industry. Mobile health is the provision of health services and information via mobile technologies such as mobile phones and wearable sensors. Faculty from Stanford University and other academic institutions and guest lecturers from the mobile health industry discuss the driving needs, opportunities and challenges that characterize the emerging mobile health innovation landscape, and present an overview of the technologies, initiatives and companies that are transforming the way we access health care today.
Same as: MED 273

BIOE 280. Skeletal Development and Evolution. 3 Units.
The mechanobiology of skeletal growth, adaptation, regeneration, and aging is considered from developmental and evolutionary perspectives. Emphasis is on the interactions between mechanical and chemical factors in the regulation of connective tissue biology. Prerequisites: BIO 42, and ME 80 or BIOE 42.
Same as: ME 280

BIOE 281. Biomechanics of Movement. 3 Units.
Experimental techniques to study human and animal movement including motion capture systems, EMG, force plates, medical imaging, and animation. The mechanical properties of muscle and tendon, and quantitative analysis of musculoskeletal geometry. Projects and demonstrations emphasize applications of mechanics in sports, orthopedics, and rehabilitation.
Same as: ME 281

BIOE 282. Performance, Development, and Adaptation of Skeletal Muscle. 3 Units.
Fundamentals of skeletal muscle by study of classical and recent research articles. Emphasis on the interactions between mechanics, biology, and electrophysiology in skeletal muscle performance, development, adaptation, control, and disease. Lab activities explore research methods discussed in class. Limited Enrollment. Applications due Friday, September 16th by 5pm. Applications available at http://bioe282.stanford.edu/. Prerequisites: engineering or biology core coursework. Fall (Cromie, Liske, Steele, Delp).

BIOE 283. Mechanotransduction in Cells and Tissues. 3 Units.
Mechanical cues play a critical role in development, normal functioning of cells and tissues, and various diseases. This course will cover what is known about cellular mechanotransduction, or the processes by which living cells sense and respond to physical cues such as physiological forces or mechanical properties of the tissue microenvironment. Experimental techniques and current areas of active investigation will be highlighted.
Same as: BIOPHYS 244, ME 244

BIOE 284B. Cardiovascular Bioengineering. 3 Units.
Continuation of ME/BIOE 284A. Integrative cardiovascular physiology, blood fluid mechanics, and transport in the microcirculation. Sensing, feedback, and control of the circulation. Overview of congenital and adult cardiovascular disease, diagnostic methods, and treatment strategies. Engineering principles to evaluate the performance of cardiovascular devices and the efficacy of treatment strategies.
Same as: ME 284B

BIOE 287. Introduction to Physiology and Biomechanics of Hearing. 3 Units.
Hearing is fundamental to our ability to communicate, yet in the US alone over 30 million people suffer some form of hearing impairment. As engineers and scientists, it is important for us to understand the underlying principles of the auditory system if we are to devise better ways of helping those with hearing loss. The goal of this course is to introduce undergraduate and graduate students to the anatomy, physiology, and biomechanics of hearing. Principles from acoustics, mechanics, and hydrodynamics will be used to build a foundational understanding of one of the most complex, interdisciplinary, and fascinating areas of biology. Topics include the evolution of hearing, computational modeling approaches, fluid-structure interactions, ion-channel transduction, psychoacoustics, diagnostic tools, and micrometer to millimeter scale imaging methods. We will also study current technologies for mitigating hearing loss via passive and active prostheses, as well as future regenerative therapies.
Same as: ME 166, ME 266

BIOE 291. Principles and Practice of Optogenetics for Optical Control of Biological Tissues. 3 Units.
Principles and practice of optical control of biological processes (optogenetics), emphasizing bioengineering approaches. Theoretical, historical, and current practice of the field. Requisite molecular-genetic, optoelectronic, behavioral, clinical, and ethical concepts, and mentored analysis and presentation of relevant papers. Final projects of research proposals and a laboratory component in BioX to provide hands-on training. Contact instructor before registering.

BIOE 299B. Practical Training. 1 Unit.
For Ph.D. students. Educational opportunities in high technology research and development labs in industry. Students engage in internship work and integrate that work into their academic program. Following internship work, students complete a research report outlining work activity, problems investigated, key results, and follow-up projects they expect to perform. Meets the requirements for curricular practical training for students on F-1 visas. Student is responsible for arranging own internship/employment and faculty sponsorship. Register under faculty sponsor's section number. All paperwork must be completed by student and faculty sponsor, as the student services office does not sponsor CPT. Students are allowed only two quarters of CPT per degree program. Course may be repeated twice.

BIOE 300A. Molecular and Cellular Bioengineering. 3 Units.
The molecular and cellular bases of life from an engineering perspective. Analysis and engineering of biomolecular structure and dynamics, enzyme function, molecular interactions, metabolic pathways, signal transduction, and cellular mechanics. Quantitative primary literature. Prerequisites: CHEM 171 and BIO 41 or equivalents; MATLAB or an equivalent programming language.

BIOE 300B. Engineering Concepts Applied to Physiology. 3 Units.
This course focuses on engineering approaches to quantifying, modeling and controlling the physiology and pathophysiology of complex systems, from the level of individual cells to tissue, organ and multi-organ systems.

BIOE 300C. Medical Devices, Diagnostics, and Pharmaceuticals: Technologies, Regulation, and Applications. 3 Units.
Preference to Bioengineering graduate students. Major classes of technologies including imaging techniques, chemical diagnostics, drug design and delivery. Topics include pacemakers, fMRI, PCR, stents, and biomaterials. Principles, practical limitations, and feature trade-offs in clinical settings.

BIOE 301A. Molecular and Cellular Engineering Lab. 2 Units.
Preference to Bioengineering graduate students. Practical applications of biotechnology and molecular bioengineering including recombinant DNA techniques, molecular cloning, microbial cell growth and manipulation, and library screening. Emphasis is on experimental design and data analysis. Limited enrollment. Fall (Cochran).

BIOE 301B. Clinical Needs and Technology. 2 Units.
The goal of this course is to introduce bioengineering students to medical technology as it is used in current clinical practice, in the modern tertiary care, subspecialty hospital. Half of the course will be devoted to labs, in which small groups of students participate in hands-on experiences using advanced clinical technology in areas such as medical imaging, robotic surgery, and minimally invasive diagnosis and treatment. The second half of the course brings pairs of students and clinical faculty mentors together for a more in-depth, focused exposure to clinical care in one specific area. Final grades will be based on attendance, and presentations made by each pair of student to the class about their mentoring experience.

BIOE 301C. Diagnostic Devices Lab. 2 Units.
This course exposes students to the engineering principles and clinical application of medical devices through lectures and hands-on labs, performed in teams of two. Teams take measurements with these devices and fit their data to theory presented in the lecture. Devices covered include X-ray, CT, MRI, EEG, ECG, Ultrasound and BMI (Brain-machine interface). Prerequisites: BioE 103 or BioE 300B or EE 122B.
Same as: BIOE 201C

BIOE 311. Biophysics of Multi-cellular Systems and Amorphous Computing. 2-3 Units.
Provides an interdisciplinary perspective on the design, emergent behavior, and functionality of multi-cellular biological systems such as embryos, biofilms, and artificial tissues and their conceptual relationship to amorphous computers. Students discuss relevant literature and introduced to and apply pertinent mathematical and biophysical modeling approaches to various aspect multi-cellular systems, furthermore carry out real biology experiments over the web. Specific topics include: (Morphogen) gradients; reaction-diffusion systems (Turing patterns); visco-elastic aspects and forces in tissues; morphogenesis; coordinated gene expression, genetic oscillators and synchrony; genetic networks; self-organization, noise, robustness, and evolvability; game theory; emergent behavior; criticality; symmetries; scaling; fractals; agent based modeling. The course is geared towards a broadly interested graduate and advanced undergraduates audience such as from bio / applied physics, computer science, developmental and systems biology, and bio / tissue / mechanical / electrical engineering. Prerequisites: Previous knowledge in one programming language - ideally Matlab - is recommended; undergraduate students benefit from BIOE 41, BIOE 42, or equivalent.
Same as: BIOE 211, BIOPHYS 311, DBIO 211

BIOE 313. Neuromorphics: Brains in Silicon. 3 Units.
This course introduces neuromorphic system design, starting at the device level, going through the circuit level, and ending up at the system level. At the device level, it covers MOS transistor operation in the subthreshold region. At the circuit level, it covers silicon neuron and synapse design. And at the system level, it covers to reroutable interconnection. At the end of the course, you will understand how various neuromorphic architecturesiquest; area and energy use scale with network size. Prerequisites: EE114 & EE108A.
Same as: EE 304

BIOE 326A. In Vivo MR: SpinPhysics and Spectroscopy. 3 Units.
Collections of independent identical nuclear spins are well described by the classical vector model of magnetic resonance imaging, however, interaction among spins, as occur in many in vivo processes, require a more complete description. This course develops the basic physics and engineering principles of these interactions with emphasis on current research questions and clinical spectroscopy applications. Prerequisite: EE396b; familiarity with MRI, linear algebra recommended.
Same as: RAD 226A

BIOE 326B. In Vivo MR: Relaxation Theory and Contrast Mechanisms. 3 Units.
Principles of nuclear magnetic resonance relaxation theory as applicable to in vivo processes with an emphasis on medical imaging. Topics: physics and mathematics of relaxation, relaxation times in normal and diseased tissues, magnetization transfer contrast, chemical exchange saturation transfer, MRI contrast agents, and hyperpolarized 13C. Prerequisites: RAD 226.
Same as: RAD 226B

BIOE 331. Protein Engineering. 3 Units.
The design and engineering of biomolecules emphasizing proteins, antibodies, and enzymes. Combinatorial and rational methodologies, protein structure and function, and biophysical analyses of modified biomolecules. Clinically relevant examples from the literature and biotech industry. Prerequisite: basic biochemistry. Winter, Cochran.
Same as: BIOE 231

BIOE 332. Large-Scale Neural Modeling. 3 Units.
This course examines the dynamics of large networks of spiking neurons (several thousand), with particular focus on how these networks achieve cognitive behaviors such as working memory, selective attention, and decision making. The course will feature lectures and labs using two Python-based simulators: Brian, a software platform, and Neurogrid, a hardware platform that simulates up to a million spiking neurons in real time. Most of the course will be project-based, allowing students to explore their individual interests.

BIOE 333. Interfacial Phenomena and Bionanotechnology. 3 Units.
Control over and understanding of interfacial phenomena and colloidal science are the essential foundation of bionanotechnology. Key mathematical relationships derived by Laplace, Gibbs, Kelvin and Young are derived and explained, along with the thermodynamics of systems of large interfacial area. Forces controlling surface and interfacial phenomena and surfactant and biomacromolecule self-assembly are discussed. Protein folding/unfolding and aggregation, and nano- and microfluidics are elucidated in these terms. Students will gain insight into the interplay between physical and chemical properties of biomolecules. Spring, (Barron, A.).

BIOE 334. Engineering Principles in Molecular Biology. 3 Units.
The achievements and difficulties that exemplify the interface of theory and quantitative experiment. Topics include: bistability, cooperativity, robust adaptation, kinetic proofreading, analysis of fluctuations, sequence analysis, clustering, phylogenetics, maximum likelihood methods, and information theory. Sources include classic papers.

BIOE 335. Molecular Motors I. 3 Units.
Physical mechanisms of mechanochemical coupling in biological molecular motors, using F1 ATPase as the major model system. Applications of biochemistry, structure determination, single molecule tracking and manipulation, protein engineering, and computational techniques to the study of molecular motors.

BIOE 337. Organismic Biophysics and Living Soft-matter. 3 Units.
Integrated physical biology; from molecules to organisms. Tree of life, diversity of life forms. Multi-scale/hierarchical systems in biophysics, Hierarchical self-organization. Basic theory of squishy materials, colloidal physics. Phase transitions in living soft-matter. Experimental techniques in soft-matter physics. Active fluid models for living matter. Design of self-assembling and self-organizing, biomimetic supramolecular systems.

BIOE 355. Advanced Biochemical Engineering. 3 Units.
Combines biological knowledge and methods with quantitative engineering principles. Quantitative review of biochemistry and metabolism; recombinant DNA technology and synthetic biology (metabolic engineering). The production of protein pharaceuticals as a paradigm for the application of chemical engineering principles to advanced process development within the framework of current business and regulatory requirements. Prerequisite: CHEMENG 181 (formerly 188) or BIOSCI 41, or equivalent.
Same as: CHEMENG 355

BIOE 361. Biomaterials in Regenerative Medicine. 3 Units.
Materials design and engineering for regenerative medicine. How materials interact with cells through their micro- and nanostructure, mechanical properties, degradation characteristics, surface chemistry, and biochemistry. Examples include novel materials for drug and gene delivery, materials for stem cell proliferation and differentiation, and tissue engineering scaffolds. Prerequisites: undergraduate chemistry, and cell/molecular biology or biochemistry.
Same as: MATSCI 381

BIOE 370. Microfluidic Device Laboratory. 2 Units.
Fabrication of microfluidic devices for biological applications. Photolithography, soft lithography, and micromechanical valves and pumps. Emphasis is on device design, fabrication, and testing.

BIOE 371. Global Biodesign: Medical Technology in an International Context. 1-3 Unit.
(Same as OIT 587) This course examines the development and commercialization of innovative medical technologies in different global settings. Faculty and guest speakers from the medtech field will discuss the status of the industry, as well as opportunities in and challenges to medical technology innovation unique to seven primary geographic regions: Africa, China, Europe, India, Japan, United States and Latin America. Students will be exposed to the biodesign innovation process, which provides a proven approach for identifying important unmet medical needs and inventing meaningful solutions to address them. They will also explore key differences between the covered geographies, which range from emerging markets with vast bottom-of-the-pyramid and growing middle class populations, to well-established markets with sophisticated demands and shifting demographics. The class will utilize real-world case studies and class projects (for 3-unit students) to promote engagement and provide a hands-on learning experience. There is no 2 unit option for this course.
Same as: MED 271

BIOE 372. Design for Service Innovation. 4 Units.
(Same as OIT 343/01) Open to graduate students from all schools and departments. An experiential project course in which students work in multidisciplinary teams to design new services to address the needs of medically patients. Project teams partner with "safety net" hospitals and clinics to find better ways to deliver care to the low income and uninsured patients these institutions serve. Students learn proven innovation processes from experienced GSB, d. school, and SoM faculty, interface with students from across the university, and have the opportunity to see their ideas translated into improvements in the quality and efficiency of healthcare in the real world. Prerequisite: admission to the course is by application only. Applications available at http://DesignForService.stanford.edu. Applications must be submitted by November 16, 2011.
Same as: HRP 274, MED 274

BIOE 374A. Biodesign Innovation: Needs Finding and Concept Creation. 4 Units.
This is the first quarter of a two-quarter course series (OIT 384/OIT 385). In this course, students learn how to develop comprehensive solutions (most commonly medical devices) to some of the most significant medical problems. The first quarter includes an introduction to needs finding methods, brainstorming and concept creation. Students learn strategies for understanding and interpreting clinical needs, researching literature and searching patents. Working in small entrepreneurial multidisciplinary teams, students gain exposure to clinical and scientific literature review, techniques of intellectual property analysis and feasibility, basic prototyping and market assessment. Students create, analyze and screen medical technology ideas, and select projects for future development. Final presentations at the end of the winter quarter to a panel of prominent inventors and investors in medical technology provide the impetus for further work in the spring quarter. Course format includes expert guest lecturers (Thu: 4:15 to 6:15 pm), faculty-led practical demonstrations and coaching sessions, and interactive team meetings (Tues: 4:15 to 6:15 pm). Projects from previous years included: prevention of hip fractures in the elderly; methods to accelerate healing after surgery; less invasive techniques for bariatric surgery; point of care diagnostics to improve emergency room efficiency; novel devices to bring specialty-type of care to primary care community doctors. More than 300,000 patients have been treated to date with technologies developed as part of this program and more than thirty venture-backed companies were started by alums of the program. Students must apply and be accepted into the course. The application is available online at http://biodesign.stanford.edu/bdn/courses/bioe374.jsp.
Same as: ME 368A, MED 272A

BIOE 374B. Biodesign Innovation: Concept Development and Implementation. 4 Units.
Two-quarter sequence (see OIT384 for complete description of the sequence). The second quarter focuses on how to take a conceptual solution to a medical need forward into development and potential commercialization. Continuing work in teams with engineering and medical colleagues, students will learn the fundamentals of medical device prototyping; patent strategies; advanced planning for reimbursement and FDA approval; choosing a commercialization route (licensing vs. start-up); marketing, sales and distribution strategies; ethical issues including conflict of interest; fundraising approaches and cash requirements; financial modeling; essentials of developing a business or research plan/canvas; and strategies for assembling a development team. Final project presentations are made to a panel of prominent venture and corporate investors. New students (i.e. students who did not take OIT384 in the winter quarter) may be admitted, depending on team needs. Candidates need to submit an application at http://biodesign.stanford.edu/bdn/courses/bioe374app.jsp by March 1.
Same as: ME 368B, MED 272B

BIOE 375A. Biodesign Innovation: Needs Finding and Concept Creation. 2 Units.
Enrollment limited to SCPD students. Two quarter sequence. Inventing new medical devices and instrumentation, including: methods of validating medical needs; techniques for analyzing intellectual property; basics of regulatory (FDA) and reimbursement planning; brainstorming and early prototyping. Guest lecturers and practical demonstrations.

BIOE 375B. Biodesign Innovation: Concept Development and Implementation. 2 Units.
Enrollment limited to SCPD students. Two quarter sequence. How to take a medical device invention forward from early concept to technology translation and development. Topics include prototyping; patent strategies; advanced planning for reimbursement and FDA approval; choosing translation route (licensing versus start-up); ethical issues including conflict of interest; fundraising approaches and cash requirements; essentials of writing a business or research plan; strategies for assembling a development team. Prerequisite: BIOE 375A.

BIOE 376. Startup Garage: Design. 4 Units.
A hands-on, project-based course, in which teams identify and work with users, domain experts, and industry participants to identify an unmet customer need, design new products or services that meet that need, and develop business models to support the creation and launch of startup products or services. This course integrates methods from human-centered design, lean startup, and business model planning. Each team will conceive, design, build, and field-test critical aspects of both the product or service and the business model.

BIOE 377. Startup Garage: Testing and Launch. 4 Units.
STRAMGT 356/BIOE 376 teams that concluded at the end of fall quarter that their preliminary product or service and business model suggest a path to viability, may continue with STRAMGT 366/BIOE 377 in winter quarter. Teams develop more elaborate versions of their product/service and business model, perform a series of experiments to test key hypotheses about their product and business model, and prepare and present an investor pitch for a seed round of financing to a panel of seasoned investors and entrepreneurs.

BIOE 381. Orthopaedic Bioengineering. 3 Units.
Engineering approaches applied to the musculoskeletal system in the context of surgical and medical care. Fundamental anatomy and physiology. Material and structural characteristics of hard and soft connective tissues and organ systems, and the role of mechanics in normal development and pathogenesis. Engineering methods used in the evaluation and planning of orthopaedic procedures, surgery, and devices.
Same as: ME 381

BIOE 386. Neuromuscular Biomechanics. 3 Units.
The interplay between mechanics and neural control of movement. State of the art assessment through a review of classic and recent journal articles. Emphasis is on the application of dynamics and control to the design of assistive technology for persons with movement disorders.
Same as: ME 386

BIOE 390. Introduction to Bioengineering Research. 1-2 Unit.
Preference to medical and bioengineering graduate students with first preference given to Bioengineering Scholarly Concentration medical students. Bioengineering is an interdisciplinary field that leverages the disciplines of biology, medicine, and engineering to understand living systems, and engineer biological systems and improve engineering designs and human and environmental health. Students and faculty make presentations during the course. Students expected to make presentations, complete a short paper, read selected articles, and take quizzes on the material.
Same as: MED 289

BIOE 391. Directed Study. 1-6 Unit.
May be used to prepare for research during a later quarter in 392. Faculty sponsor required. May be repeated for credit.

BIOE 392. Directed Investigation. 1-10 Unit.
For Bioengineering graduate students. Previous work in 391 may be required for background; faculty sponsor required. May be repeated for credit.

BIOE 393. Bioengineering Departmental Research Colloquium. 1 Unit.
Bioengineering department labs at Stanford present recent research projects and results. Guest lecturers. Topics include applications of engineering to biology, medicine, biotechnology, and medical technology, including biodesign and devices, molecular and cellular engineering, regenerative medicine and tissue engineering, biomedical imaging, and biomedical computation. Aut, Win, Spr (Lin, Riedel-Kruse, Barron).

BIOE 450. Advances in Biotechnology. 3 Units.
Guest academic and industrial speakers. Latest developments in fields such as bioenergy, green process technology, production of industrial chemicals from renewable resources, protein pharmaceutical production, industrial enzyme production, stem cell applications, medical diagnostics, and medical imaging. Biotechnology ethics, business and patenting issues, and entrepreneurship in biotechnology.
Same as: CHEMENG 450

BIOE 454. Synthetic Biology and Metabolic Engineering. 3 Units.
Principles for the design and optimization of new biological systems. Development of new enzymes, metabolic pathways, other metabolic systems, and communication systems among organisms. Example applications include the production of central metabolites, amino acids, pharmaceutical proteins, and isoprenoids. Economic challenges and quantitative assessment of metabolic performance. Pre- or corequisite: CHEMENG 355 or equivalent.
Same as: CHEMENG 454

BIOE 459. Frontiers in Interdisciplinary Biosciences. 1 Unit.
Students register through their affiliated department; otherwise register for CHEMENG 459. For specialists and non-specialists. Sponsored by the Stanford BioX Program. Three seminars per quarter address scientific and technical themes related to interdisciplinary approaches in bioengineering, medicine, and the chemical, physical, and biological sciences. Leading investigators from Stanford and the world present breakthroughs and endeavors that cut across core disciplines. Pre-seminars introduce basic concepts and background for non-experts. Registered students attend all pre-seminars; others welcome. See http://biox.stanford.edu/courses/459.html. Recommended: basic mathematics, biology, chemistry, and physics.
Same as: BIO 459, BIOC 459, CHEM 459, CHEMENG 459, PSYCH 459

BIOE 484. Computational Methods in Cardiovascular Bioengineering. 3 Units.
Lumped parameter, one-dimensional nonlinear and linear wave propagation, and three-dimensional modeling techniques applied to simulate blood flow in the cardiovascular system and evaluate the performance of cardiovascular devices. Construction of anatomic models and extraction of physiologic quantities from medical imaging data. Problems in blood flow within the context of disease research, device design, and surgical planning.
Same as: ME 484

BIOE 485. Modeling and Simulation of Human Movement. 3 Units.
Direct experience with the computational tools used to create simulations of human movement. Lecture/labs on animation of movement; kinematic models of joints; forward dynamic simulation; computational models of muscles, tendons, and ligaments; creation of models from medical images; control of dynamic simulations; collision detection and contact models. Prerequisite: 281, 331A,B, or equivalent.
Same as: ME 485

BIOE 500. Thesis. 1-15 Unit.
(Staff).
Same as: Ph.D.

BIOE 802. TGR Dissertation. 0 Units.
(Staff).