Biomedical Engineering (BME)

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Degrees awarded: M.S. in Biomedical Engineering; Ph.D. in Biomedical Engineering

Biomedical engineering is at the forefront of medicine's technologic revolution; its many successes have raised expectations for the prevention, diagnosis, and treatment of disease. Faculty at Stony Brook University have been active contributors to the cutting edge of this technology, and our University is building on internationally acclaimed strengths in Bioelectromagnetics, Biomaterials, Biomechanics, Biotechnology, Instrumentation, Medical Imaging, and Tissue Engineering. These disciplines thrive through active interdisciplinary collaborations among the faculty in the College of Engineering and Applied Sciences, the School of Medicine, and the College of Arts and Sciences, all of which are in close proximity. This ongoing biomedical research, combined with unique facilities at the University, Brookhaven National Laboratory, and Cold Spring Harbor Laboratory have helped distinguish Stony Brook as a superb resource for education in both the engineering and health sciences. With these intellectual and physical resources, the program in Biomedical Engineering is positioned to provide a rigorous, cross-disciplinary graduate training and research environment for our students.

This is a very exciting time for Biomedical Engineering. New areas are opening each day, ranging from the engineering of tissues to making outer space habitable for mankind. It is an excellent time to begin your studies in Biomedical Engineering and we believe you will find Stony Brook a superb place to train. Our faculty is diverse, our commitment is high, and our facilities are unique. If there are any questions we can address, please contact us directly.

The Graduate Program in Biomedical Engineering at Stony Brook University trains individuals with baccalaureate degrees in engineering, applied mathematics, and the sciences and provides them with the synthesis, design, and analysis skills necessary to contribute effectively to the advancement of technology in health and medical care. The M.S. and Ph.D. degree programs are specifically designed to provide graduate students and engineering professionals with the knowledge and skills necessary to transfer recent developments in the basic sciences into commercially viable products and processes. Training of the student is accomplished by exposing the individual to the biology, engineering, and business concepts critical to succeeding in the biomedical research and development environment.

Training in Biomedical Engineering is directed by faculty from the College of Engineering and Applied Sciences, School of Medicine, College of Arts and Sciences, Health Sciences Center, as well as from Brookhaven National Laboratory and Cold Spring Harbor Laboratory. These diverse faculty provide a spectrum of research opportunities. Breadth and depth of exposure is a hallmark of the program, and one which we believe emphasizes the importance of multidisciplinary, collaborative approaches to real-world engineering problems in biology and medicine. Graduate training includes course instruction, participation in seminar courses, and extensive involvement in selected projects emphasizing synthesis and design skills. The graduate program is based in the Health Sciences Center, adjacent to University Hospital, and in close proximity to the Basic Sciences, Engineering, and Business Schools.

Admission

Students may matriculate directly into either the M.S. or Ph.D. programs. For admission to the Program in Biomedical Engineering, the following are normally required:

A. A four-year undergraduate degree in engineering or related field such as the physical sciences or mathematics;

B. An official transcript of undergraduate record and of any work completed at the graduate level;

C. Letters of recommendation from three previous or current instructors/employers;

D. Submission of a personal statement outlining your background, interests, and career goals in the field of biomedical engineering;

E. Graduate Record Examination (GRE) General Test scores;

F. Acceptance by both the Program and the Graduate School.

Stipends and tuition scholarships are available for selected students. Distribution of these awards will be based on GRE test scores, undergraduate performance, professional experience, and research/career objectives as outlined in a personal statement.

Faculty

Distinguished Professors

Chu, Benjamin, Ph.D., 1959, Cornell University: Synthesis; characterization and processing of biomaterials; molecular manipulation and self-assembly in biomimetic mineralization; DNA complexation for gene therapy.

Rafailovich, Miriam, Ph.D., 1980, University at Stony Brook: Polymeric liquids; phase transitions; thin film wetting phenomena; biopolymers.

Rubin, Clinton, T., *Chair*, Ph.D., 1983, Bristol University: Tissue adaptation; biophysical treatment of musculoskeletal disorders.

Professors

Benveniste, Helene, Ph.D., 1991, University of Copenhagen, Denmark: Understanding diagnostic MR contrast parameters suitable to visualize neuro-pathology in neurodegenerative diseases.

Brink, Peter, Ph.D., 1976, University of Illinois: Biophysical properties of gap junction properties.

Chiang, Fu-Pen, Ph.D., 1966, University of Florida: Development and application of various optical techniques such as moiré, holographic, interferometry, and speckle interferometry for stress analysis; nondestructive evaluation and metrology.

Chon, Ki, Ph.D., 1993, USC Los Angeles: Signal processing; development of novel algorithms to understand dynamic processes.

Clark, Richard, M.D., 1971, University of Rochester: Tissue engineering in wound repair.

Cohen, Ira, M.D., Ph.D., 1974, New York University: Electrophysiology of the heart.

Djuric, Petar, Ph.D., 1990, University of Rhode Island: Acoustic signal processing.

Fowler, Joanna, Ph.D., 1967, University of Colorado: Radiotracer synthesis with positron emitters.

Grine, Fred, Ph.D., 1984, University of the Witwatersrand, Johannesburg, South Africa: Tooth enamel thickness and structure and the stresses experienced by tooth enamel during masticatory loading in primates.

Hannon, Gregory, Ph.D., 1992, Case Western Reserve University: Explores the mechanisms and regulation of RNA interference as well as its applications to cancer research.

Harrington, Donald, M.D., Ph.D., 1966, Marquette University: Magnetic Resonance Imaging in medicine.

Hsiao, Benjamin, Ph.D., 1987, Institute of Materials Science at University of Connecticut: Structural and morphological development of complex polymer systems during preparation and processing in real time.

Hurst, Lawrence C., M.D., 1973, University of Vermont: Etiology of carpal tunnel syndrome; etiology of Dupuytren's contracture.

Jacobsen, Chris, Ph.D., 1988, Stony Brook University: X-ray microscopy and holography.

Jesty, Jolyon, Ph.D., 1975, Yale University: Control mechanisms of coagulation, experimental and theoretical analyses.

Kaufman, Arie E., Ph.D., 1977, Ben-Gurion University: Computer graphics; visualization; interactive systems; 3-D virtual colonoscopy; computer architecture.

Krukenkamp, Irwin B., M.D., 1982, University of Maryland: Systolic and diastolic mechanics and myocardial oxygen consumption.

Liang, Jerome, Ph.D., 1987, City University of New York: Development of medical imaging hardware for single photon detection.

Mathias, Richard, Ph.D., 1975, UCLA: Research in biophysics seeks physical insights into how cells and tissues function.

Moore, Leon, Ph.D., 1976, University of Southern California: Renal physiology.

Qin, Yi-Xian, Ph.D., 1997, Stony Brook University: Physical mechanisms involved in the control of tissue growth, healing, and homeostasis, especially bone adaptation influenced by mechanical environment.

Reichek, Nathaniel, M.D., 1965, Columbia University: Cardiac Magnetic Resonance Imaging; myocardial mechanics, perfusion, viability.

Stein, Lincoln, Ph.D., 1989, Harvard University: Genome informatics; developing databases, data-analysis tools, and user interfaces to organize, manage, and visualize that vast body of information.

Associate Professors

Bluestein, Daniel, Ph.D., 1992, Tel Aviv University, Israel: Dynamics of fluid flow and cellular transport through vessels.

Button, Terry, Ph.D., 1989, University at Buffalo: High-resolution computer-aided tomography.

Chen, Weiliam, Ph.D., 1993, University of Michigan: Controlled release biodegradable DNA delivery vehicles for gene therapy; innovative drug delivery systems.

Dilmanian, F. Avraham, Ph.D., 1980, Massachusetts Institute of Technology: Computed tomography; radiation therapy.

Entcheva, Emilia, Ph.D., 1998, University of Memphis: Cardiac bioelectricity, electrical stimulation of cardiac tissue, mechanisms of cardiac arrhythmias, defibrillation and modulation of cell function through gene transfer.

Frame, Molly, Ph.D., 1990, University of Missouri: Microvascular flow control at the fluid dynamic and molecular levels.

Gindi, Gene, Ph.D., 1982, University of Arizona: Algorithm development for medical imaging.

Hadjiargyrou, Michael, Ph.D., 1992, City University of New York: Molecular mechanisms of bone development and regeneration.

Judex, Stefan, Ph.D., 1999, University of Calgary, Canada: Molecular bioengineering; mechanical, molecular, and genetic influences on the adaptation of bone and connective tissues to physiologic stimuli.

McCombie, Richard, Ph.D., 1982, University of Michigan: Structure and function in complex genomes.

Pan, Yingtian, Ph.D., 1992, National Laser Technology Laboratories, China: Optical/NIR spectroscopy and imaging methods and applying these techniques to provide clinical diagnostic information.

Powers, Scott, Ph.D., 1983, Columbia University: Cancer gene discovery; cancer diagnostics and therapeutics; cancer biology.

Mueller, Klaus, Ph.D., 1998, Ohio State University: Computer graphics, data visualization, medical imaging.

Rastegar, Jahangir, Ph.D., 1976, Stanford University: Robotics; biomechanics.

Reinitz, John, Ph.D., 1988, Yale University: Generation of body form, specifically the determination of morphogenetic fields.

Skiena, Steven, Ph.D., 1988, University of Illinois: Computational geometry; biologic algorithms.

Solomon, Irene, Ph.D., 1994, University of California at Davis: Reflex and central neural control of cardiovascular and respiratory function.

Simmerling, Carlos, Ph.D., 1994, University of Illinois, Chicago: Simulate known properties of molecules, assist in the refinement and interpretation of experimental data.

Stein, Lincoln, M.D., Ph.D., 1989, Harvard Medical School and University: Proactive approach to the genome information explosion by developing databases, data-analysis tools, and user interfaces to organize, manage, and visualize that vast body of information.

Zhang, Michael, Ph.D., 1987, Rutgers University: Identifying functional elements in eukaryotic genomes using mathematical and statistical methods.

Zhu, Wei, Ph.D., 1996, University of California, Los Angeles: Brain image analysis, design and analysis of clinical trials and other biomedical studies, and genetics modeling.

Assistant Professors

Dhundale, Anil, Ph.D., 1987, Stony Brook University: cDNA microarrays, functional genomics technologies; translational research.

Goldstein, Rita, Ph.D., 1999, University of Miami: Multidisciplinary approach to measure brain function such as functional (fMRI), (PET), (ERP) recordings, and neuropsychology.

Miura, Michiko, Ph.D., 1984, University of California, Davis: Drug delivery methods; developing new boron-carriers for BNCT.

Mujica-Parodi, Lilianne, Ph.D., 1998, Columbia University: Relationships between four simultaneously or near-simultaneously interacting systems: neural, cardiac, endocrine, and cognitive, to better understand the neurobiology of arousal, fear, and stress.

Neuwald, Andrew, Ph.D., 1987, University of Iowa: Statistical and algorithmic methods with their application to the classification and modeling of protein domains.

Rizzo, Robert, Ph.D., 2001, Yale University: Application of computational techniques to drug discovery.

Schlyer, David, Ph.D., 1976, University of California, San Diego: Cyclotron targetry development; nuclear cross-section measurement; biomedical imaging technology.

Sitharaman, Balaji, Ph.D., 2005, Rice University: Research related to related to the diagnosis/treatment of disease and tissue regeneration.

Strey, Helmut, *Graduate Program Director*, Ph.D., 1993, Technical University, Munich: Nanostructured materials for applications in bioseparation, drug delivery and biosensors.

Wagshul, Mark, Ph.D., 1992, Harvard University: Utilizing MRI techniques for better understanding, diagnosing, and treating disease.

Zhao, Wei, Ph.D., 1997, University of Toronto, Canada: Development of novel detector concept and new clinical applications for early detection of cancer.

Zhong, Zhong, Ph.D., 1996, Stony Brook University: Medical imaging and diagnosis using monochromatic X-rays, X-ray phase contrast, and X-ray optics.

Research Faculty

Ding, Yu-Shin, Ph.D., 1987, Stony Brook University: Investigation of biochemical transformations and drug mechanisms in primates and humans.

Gatley, John, Ph.D., 1975, University of Newcastle-upon-Tyme, England: Medical radionuclide imaging.

Goldfarb, James, Ph.D., 2000, Catholic University of Nijmegen: Application of magnetic resonance imaging (MRI) to the cardiovascular system, particularly in the areas of myocardial function and blood vessels.

Hainfeld, James, Ph.D., University of Texas-Austin: Development of organometallic cluster compounds to be used as high resolution molecular labels.

Kolsky, Kathryn, Ph.D., 1989, Carnegie Mellon University: Development and production of

radioisotopes using the BLIP facility, a high-energy charged particle accelerator.

Logan, Jean, Ph.D., 1976, Louisiana State University: Kinetic modeling of data from PET experiments.

Miller, Lisa, Ph.D., 1995, Albert Einstein College of Medicine: Chemical makeup of tissue in disease using high-resolution infrared and X-ray imaging.

Pena, Louis, Ph.D., 1991, University of California, Los Angeles: PET probes to detect the upregulation of cytokine receptors.

Thanos, Peter, Ph.D.: Gene therapy and dopaminergic mechanisms of alcohol and drug abuse.

Tracey, Kevin, M.D., 1983, Boston University: Research focuses on the roles of individual mediators of systemic inflammation, and their regulation by interactions between the brain and the innate immune system.

Vaska, Paul, Ph.D., 1997, Stony Brook University: Instrumentation for positron emission tomography.

Vazquez, Marcelo, M.D., Ph.D., 1990, National University of La Plata, Argentina: Study of the mechanisms of central nervous system damage induced by space radiation using *in vitro* (neural stem cells and neurons) and *in vivo* models.

Wang, Yi, ScD., 1999, Washington University, St. Louis: Noninvasive *in vivo* cardiovascular imaging for the heart functional and morphological assessment using magnetic resonance imaging and image processing techniques.

Degree Requirements

Requirements for the M.S. Degree

A minimum of 31 graduate credits are required to earn the Master of Science in BME (non-thesis option) or 37 credits for the M.S. degree (thesis option). The program of study can be chosen from any of the following approved tracks/specializations: Biomechanics, Biosignals, General, Medical Physics, or Molecular Bioengineering. The General program of study can be custom tailored in consultation with a student's faculty advisor/mentor to accommodate almost any BME area of interest. The following courses must be taken by all first-year graduate students:

BME 501 Molecular Principles in Cell Biology;

BME 502 Advanced Numerical and Computation Analysis to Biological Systems;

BME 505 Principles and Practice of BME;

BME 520 Laboratory Rotation I; and

BME 521 Laboratory Rotation II.

All students (except those pursuing the Medical Physics Track) must also fulfill a business/management course requirement, which can be met by taking BME 509 Fundamentals of the Bioscience Industry, or any MBA class (MBA 501 to 507, 511, or 589) from the School of Business. A given track/specialization will have additional requirements, which includes a minimum of six technical elective courses (three or which have to be BME).

Thesis or Non-Thesis Options

The student has the option of earning the Master of Science Degree in BME on either a thesis or non-thesis track. If non-thesis, the student undertakes elective graduate coursework to complete the 31 credits. In the thesis option, the student must additionally complete six credits of BME 599 Thesis Research and submit and defend a written thesis. A grade point average of B or better must be attained for the core BME courses taken, and an overall grade point average of 3.0 out of 4.0 must be maintained. For the non-thesis option, most students can complete this program within three academic semesters, and most students complete the thesis option in four academic semesters. The non-thesis option is recommended for students who wish to pursue a career in industry that does not involve research and development. Students pursing the non-thesis option cannot use BME 599 to fulfill any requirements (i.e., it is not a technical elective nor core course). The thesis option is recommended for students who will be continuing on for their doctoral degree and for students who wish to pursue an industrial career with an R&D focus. All BME students must also take GRD 500.

Requirements for the Ph.D. Degree

A. Completion of the M.S. degree in Biomedical Engineering or equivalent graduate program

B. Satisfactory completion of the BME qualifying exam

C. Plan of Study

Students matriculating into the doctoral (Ph.D.) degree program must complete all the requirements for the M.S. degree in BME at Stony Brook or enter the program with a relevant M.S. degree. This latter option is termed admission with "Advanced Standing." After completion of the M.S. degree or admission with Advanced Standing, there are no course requirements per se, though certain courses may be required to fill any gaps in the student's knowledge. Following completion of a qualifying exam, an independent basic research program will be undertaken. Subsequently, the student will present and defend his or her dissertation proposal. Successful completion of this stage will enable the student to "Advance to Candidacy." One semester of teaching practicum must be satisfactorily performed. Completion of the research program will culminate in the submission and oral defense of a doctoral dissertation. The University requires at least two consecutive semesters of full-time graduate study.

D. Teaching Requirements

The BME teaching requirement for the Ph.D. degree can be fulfilled in any of the following three manners:

1. Deliver four lectures in a BME undergraduate or graduate course and present a seminar that covers the state-of-the-art in your field of research.

2. Teach a BME course, either as the instructor of record (if you have G5 student status) or as the principal instructor (for G4 student status).

3. Petition for something else that is equivalent to the above.

E. Thesis Proposal Examination

After successful completion of the qualifying examination, the student selects a thesis advisor and writes a proposal for thesis research. After approval by the thesis advisor, the proposal is orally defended before a thesis committee.

F. Advancement to Candidacy

After successful completion of all required and elective courses, the qualifying examination, and the thesis proposal examination, the student will be recommended to the Graduate School for advancement to candidacy.

G. Dissertation

The research for the Ph.D. dissertation is conducted under the supervision of the thesis committee. The dissertation must represent a significant contribution to the scientific and/or engineering literature. Upon approval of the completed dissertation by the thesis committee, a formal public oral defense of the dissertation is scheduled at which the student presents his or her findings and is questioned by

members of the examining committee and by other members of the audience. On acceptance of the dissertation by the thesis committee, all requirements for the degree will have been satisfied.

H. Time Limit/Residency Requirements

All requirements for the Ph.D. degree must be completed within seven years after completing 24 credits of graduate study. The University requires at least two consecutive semesters of full-time graduate study.

Courses

The goal of the Program in Biomedical Engineering is to promote actively the development of a versatile engineering graduate. This requires that the engineering student understand biological concepts as well as engineering concepts outside of his or her defined major. The core set of biomedical engineering courses will expose the biomedical engineering student to the principles of cell, tissue, and organ biology, as well as ensure that the students attain a credible level of sophistication in the engineering and basic science concepts that lie outside of their major, and which traverse multiple areas of biomedical engineering.

BME 501 Engineering Principles in Cell, Tissue, and Organ Systems

Course content is directed toward describing the microscopic physical interactions between cells and their environment as electro-mechano-chemical processes occurring at surfaces. This is provided in the context of basic molecular biology and cell physiology concepts. Emphasis is placed on developing of the critical role of non-linear dynamics, physical chemistry of adsorption and desorption processes, self assembly in cellular automata, and how complexity arises within simple physical systems.
Fall, 3 credits, ABCF grading
May be repeated once for credit

BME 502 Advanced Numerical and Computation Analysis Applied to Biological Systems

Numerical analyses of biological data. A unified mathematical/time series framework for modeling and mining biological data. Applications range from cardio-respiratory, renal blood pressure/flow and sequence (DNA, RNA, proteins) to gene expression data. Tools of data analysis include linear algebra, interpolation and extrapolation, parametric and nonparametric spectral estimation with the FFT and singular value decomposition, statistical description of data and integration of ordinary differential equations. Special focus will be placed on the use of linear and nonlinear numerical methods for the identification of physiological system dynamics and the development of computer simulation techniques to study dynamic response of physiological systems.
Spring, 3 credits, ABCF grading
May be repeated once for credit

BME 503 Cell and Molecular Imaging

This course will cover basics of optics, microscopy, spectroscopy, and fluorescence in the context of imaging at the cellular and molecular level. Recently developed advanced imaging techniques for probing protein interactions and live cell functions are also discussed. The course is organized into three modules: optics and spectroscopy (e.g., properties of light, polarization, diffraction, spectra); fundamentals of fluorescence and applications to molecular and cellular measurements (e.g., Jablonsky diagram, Stokes' shift, emission, excitation spectra, fluorescence anisotropy); and signal processing, image analysis techniques, and scientific visualization (e.g., temporal and spatial filters, 1D and 2D Fast Fourier transform, spectral analysis, cross-correlation). Theory will be complemented by extensive use of Matlab and its Image Processing Toolbox.
Fall, 3 credits, ABCF grading

BME 504 Biomaterials Science and Analysis

Course content is directed toward providing an introductory treatment of the engineering issues implicit in understanding living tissue interactions with processed materials. Emphasis on identifying and eliminating surface contamination, corrosion, and optimizing material surface properties and compatibility.
Spring, 3 credits, ABCF grading

BME 505 Principles and Practice of Biomedical Engineering

Introduces first-year students to the basic and clinical research at the cutting edge of biomedical engineering. The course has two key components. The first is a seminar series presented by internationally renowned bioengineers. An interactive discussion of topic-specific scientific literature precedes the formal presentation. The second component of the course is teaming up with a physician in rounds, the operating theater, clinics, etc., to get exposure to the real-life problems that face the medical community. It is hoped that the mix of science and clinic will move students toward determining how they can make contributions to health and society.
2 credits, ABCF grading

BME 506 Principles and Practice of BME

The goal of this course is to expose students to the cutting edge of biomedical engineering, including the clinical challenges that arise in this discipline. The course has two key components. The first is a seminar series presented by internationally renowned bioengineers, including Stony Brook faculty, which cover areas such as biomechanics, medical imaging, biomaterials, tissue engineering, drug/medical device development, bioinformatics, and functional genomics. Topics related to the impact of technology on medicine are also addressed, including ethics. An interactive discussion of topic-specific scientific literature precedes the formal presentation. The second component of the course is teaming up with a physician in rounds, the operating theatre, clinics, etc., to get exposure to the real-life problems which face the medical community. It is hoped that the mix of science and clinic will move students toward determining how they can make contributions to health and society. Required course for BME M.S. and Ph.D. students.
Fall and spring, 1 credit, ABCF grading

BME 507 Fundamentals of Biomedical Engineering Management

This course exposes the engineering student to the responsibilities that focus on the management issues in biomedical engineering. Management functions are explored and the students learn how to integrate these functions with engineering responsibilities.
Fall, 3 credits, ABCF grading

BME 508 Molecular and Cellular Biomechanics

Course content revolves around the effects and interactions of mechanical forces at the cellular and molecular level. The topics will range from describing the molecular and cellular basis of the adaptation of tissues to physical signals, to prescribing specific mechanical environments for improved tissue engineering, to delineating relevant molecular, cellular, and biomechanical techniques, all the way to issues involved in the development and approval of diagnostics and therapeutics in molecular engineering. For a deeper understanding of the course material as well as to allow students to apply their newly gained knowledge, this course will contain a module on the design and analysis of experiments (i.e., applied biostatistics) and incorporate practical exercises in both laboratory (e.g., a real-time PCR experiment) or simulated computer settings (e.g., modeling of cell behavior).
Prerequisite: BME 501 or permission of instructor
Fall and spring, 3 credits, ABCF grading
May be repeated once for credit

BME 509 Fundamentals of the Bioscience Industry

A four-module course set up to provide students with a comprehensive introduction to the complexities of the bioscience business environment.
Prerequisite: Must be either a BME or M.B.A. graduate student (West Campus). All other students must obtain permission from the instructor
Spring, 3 credits, ABCF grading

BME 510 Biomechanics

This course emphasizes the application of continuum mechanics to living tissues and organs to describe the material properties and their behavior under loading and stress. The interrelationship between biomechanics and physiology is examined in normal function and in disease processes. This course focuses on the physiology of tissue and organ systems in the context of mechanics, stress, strain, viscoelasticity, and material behavior, and the constitutive equations and the field equations governing fluids and fluid flow, with an emphasis on the cardiovascular and musculoskeletal systems. Emphasis is placed on the utilization of engineering principles to analyze processes at the tissue and organ

levels, covering soft and hard tissues and organs (blood, cardiovascular system, bone, cartilage, etc.), and to understand how these principles could be applied towards the design and development of prosthetic devices.
Fall, 3 credits, ABCF grading
May be repeated once for credit

BME 517 Radiation Physics
This graduate offering provides an initial physical background required for the study of medical physics. Sources of ionizing radiation including radioactivity (natural and manmade) and X-ray producing devices are studied as well as sources of nonionizing radiation such as radiofrequency and ultrasound. The physical aspects of these radiations are characterized by their interaction with matter and methods for their detection. Each student will select and present a proposal for solving a clinical medical physics problem.
Prerequisites: Modern physics or equivalent
Fall, 3 credits, ABCF grading

BME 518 Radiobiology
The biological consequences of irradiation (ionizing, ultrasound, laser, RF, etc.) will be examined. Interaction mechanisms will first be examined followed by examination of the radiation impact at the molecular and cellular level. The use of radiation for therapeutic gain will be considered. As well, models will be developed for risk estimates. Topics to be covered will include target theory, biological response, NSD, and risk estimates.
Spring, 3 credits, ABCF grading

BME 519 Medical Health Physics
This course discusses the health physics and safety issues associated with radiological devices, facilities, and procedures.
Prerequisite: BME 517
Spring, 3 credits, ABCF grading
May be repeated once for credit

BME 520 Lab Rotation I
1-3 credits, S/U grading

BME 521 Lab Rotation II
1-3 credits, S/U grading

BME 525 Tissue Engineering
Course deals with basics of biomaterial formulation that are relevant to tissue engineering, leading to the principles and practice of designing an engineered tissue, which will be facilitated by a design project.
Spring, 3 credits, ABCF grading
May be repeated once for credit

BME 526 Biological Systems Engineering
This course is a hands-on study of systems engineering in biology, using computer modeling to conceptualize and simulate a wide variety of applications. Computer wizardry not required; all skills taught in class. Appropriate and applicable to all BME tracks.
Fall, 3 credits, ABCF grading
May be repeated once for credit

BME 530 Medical Image Formation
This course covers the physical aspects of medical image formation. Image receptor design/optimization, reconstruction techniques, device hardware, and performance characteristics are considered.
Fall, 3 credits, ABCF grading
May be repeated once for credit

BME 531 Biosensing and Bioimaging
Basic concepts of biosensing and bioimaging, which include the elements of biological systems and bioimmobilizers, traditional electrode and novel optical transducers, and advanced biomedical optical imaging systems.
Fall, 3 credits, ABCF grading
May be repeated once for credit

BME 532 Time Series Modeling of Biological Systems
A unified mathematical/time series framework for modeling and mining biological data. Applications range from cardio-respiratory, renal blood pressure/flow and sequence (DNA, RNA, proteins) to gene expression data. Tools of data analysis include neural networks, time-invariant and time-varying spectral methods, fractal and nonlinear dynamics techniques, hidden markov model, clustering analysis, and various system identification techniques.
Spring, 3 credits, ABCF grading

BME 534 Functional Genomics
Course provides foundation in concepts of functional genomics and proteomics. Topics include organization and complexity of the mammalian genome and mechanisms of expression of genes, gene expression analysis technologies with a strong focus on construction and utilization of DNA microarrays, and tools for determining gene function by perturbation of gene expression.
Spring, 3 credits, ABCF grading
May be repeated once for credit

BME 540 Radiation Oncology Physics
This course provides a background in therapeutic instrumentation, dosimetry, and treatment planning.
Fall, 3 credits, ABCF grading
May be repeated once for credit

BME 546 Statistical Analysis of Physiological Data
Statistical methods useful in analyzing common types of physiological data. Topics include probability, data distributions, hypothesis testing, with parametric and non-parametric methods, ANOVA, regression and correlation, and power analysis. Emphasis is on experimental design and appropriate and efficient use of statistical software.
Prerequisite: Permission is required
1 credit, ABCF grading

BME 547 Model-Based Analysis of Physiological Data
The analysis of common biochemical and physiological data by non-linear regression of data models and biophysical models of physiological and biochemical processes. Examples include binding kinetics, compartmental mass transfer, and spectral analysis.
Prerequisite: Permission is required
1 credit, ABCF grading

BME 548 Measurement and Analysis in Physiological Research
The acquisition and analysis of data-arising from common biochemical and physiological measurements. Topics include computer-based data acquisition and processing, densitometry, microscopy, and image analysis and processing. Emphasis is on experimental design and strategies for optimizing signal to noise ratio of measurements.
1 credit, ABCF grading

BME 549 Experimental Techniques in Systems Physiology
A series of lectures and laboratory exercises designed to introduce students to *in vitro* experimental techniques used in systems physiology. Emphasis will be placed on the ethical use of rodents in biomedical research and the measurement of physiological variables. Data acquisition and analysis procedures used in cardiovascular, respiratory, and neural and renal physiology will also be covered.
Prerequisite: permission is required
1 credit, ABCF grading

BME 550 Mathematical Models of Physiologic and Biophysical Systems
An introduction to mathematical modeling of cell and tissue function. Topics include the derivation and numerical solution of models of cell homeostasis, membrane transport and excitability, and cell signaling and metabolism. Grading is based on problems, student presentation, and completion of a modeling project.
Prerequisite: Permission is required
3 credits, ABCF grading

BME 571 Microfluids in Biological Systems
This course will outline theory and applications of special fluid handling conditions associated with living systems.
Fall, 3 credits, ABCF grading
May be repeated once for credit

BME 572 Biomolecular Analysis
This interdisciplinary course is intended for graduate students and advanced undergraduates in departments such as Biomedical Engineering, Chemistry, Physics, Biology, and Chemical Engineering. This course will give an introduction to single molecule experiments using fluorescence, optical traps, AFM cantilevers, microneedles, and magnetic microbeads as well as micro and nanofluidic devices.
Prerequisite: BME 501 and 502, or instructor approval
Fall, 3 credits, ABCF grading
May be repeated once for credit

BME 599 Biomedical Engineering Research
Research to be supported by a faculty member of the Department of Biomedical Engineering. Students must have permission of instructor and enroll in appropriate section. Faculty to be identified by the student.
Fall and spring, 1-9 credits, S/U grading
May be repeated for credit

BME 601 Cardiovascular Fluid Mechanics
The course will cover the application of fluid mechanics principles to the analysis of blood flow in the cardiovascular system under normal and pathological conditions. It will follow an historical time line by beginning with the most basic models of arterial blood flow, and proceed to the most advanced theories

related to physiology and pathology flow phenomena, including an examination of the most up-to-date research in the area and the development of devices and implants.
Spring, alternate years, 3 credits, ABCF grading

BME 602 Topics in Biomedical Applications of Neural Networks
This is a project-based course that includes weekly seminars discussing advanced topics in fuzzy logic and neural networks and their applications in biomedical devices. Applications include drug delivery, diagnostics, and management information handling. Students utilize simulation software to develop algorithms to deal successfully with training data sets of their own choosing.
Fall, alternate years, 3 credits, ABCF grading

BME 604 Finite Element Modeling in Biology and Medicine
Both finite difference and FEM are applied to solve the equations of incompressible and compressible fluid flow in porous media with emphasis on flows in skeletal tissues, i.e., bone and cartilage. Steady-state, transient flow, permeability, and surface boundary conditions are discussed. Practical and recent studies in the field are also discussed. Programming using FORTRAN or C languages will be required. The student is also introduced to commercially available software packages.
Spring, alternate years, 3 credits, ABCF grading

BME 605 Biomechanics of Tactile Sensory Systems
Detailed study of the biomechanics of tactile neurophysiology for engineers entering the field of haptics and robotics manipulations. Anatomy and electrophysiology of transducer cells and neurons starting at the fingertips and extending to the somatosensory cortex. Characteristics of the external stimulus and its peripheral transformation. Relations of these topics to perceptual and/or behavioral responses.
Spring, alternate years, 3 credits, ABCF grading

BME 606 Drug Gene Delivery
Applications of biodegradable and biocompatible polymers in the design of drug and gene delivery systems for site-specific applications. A broad overview on the origin and development of controlled release therapeutic devices will be provided. Existing and proven commercial products will be examined. The second half of the course will be devoted to the use of DNA as a therapeutic entity and issues relevant to DNA delivery will be explored. An assessment of the most up-to-date DNA delivery technologies will be presented. Students are required to write a term paper on a drug or gene delivery topics of their choice. Students are also expected to give presentations on drug delivery and gene therapy related topics during the course.
Fall, alternate years, 3 credits, ABCF grading
May be repeated for credit

BME 610 Magnetic Resonance
This course provides a comprehensive study of magnetic resonance and its applications in medical imaging. An introduction of NMR is followed with development of the hardware and processing aspects required for MR image formation. An overview of basic and advanced MR imaging techniques is provided. Each student will select a topic in MR imaging for presentation at the conclusion of the course.
Fall, 3 credits, ABCF grading
May be repeated for credit

BME 612 Biomedical Engineering Aspects for the Use of Radiation in Medicine
This course provides a comprehensive study of the use of radiation in medicine. Physical aspects of the interaction of radiation with matter and for the radiation production are initially considered. The underlying principles of current radiation-based medical imaging is considered next. Topics include radiography, fluoroscopy, radionuclide imaging, and computed tomography. The use of radiation for the treatment of malignancy is considered with the focus on required technology. Finally, advanced applications of radiation are considered with focus on imaging and treatment. Each student will select a topic examining the engineering or technical application of radiation in medicine for presentation at the conclusion of the course.
Spring, 3 credits, ABCF grading

BME 615 Clinical Nuclear Imaging
This course is designed to prepare the Medical Physics graduate student in the area of clinical medical imaging. In this clinical rotation, medical physics methods for planar film, DR, CR, mamography, fluoroscopy, CT, ultrasound, and MRI performance evaluations will be introduced. In addition, basic medical ethics, radiographic anatomy, and radiation safety will be covered. A total of 200 clinical hours will be completed in this program.
Prerequisites: BME 517; BME 518; BME 519; BME 530 or BME 540
Fall, every year, 4 credits, S/U grading
May be repeated once for credit

BME 616 Clinical Nuclear Medicine Imaging
This course is designed to prepare the Medical Physics graduate student in the area of clinical nuclear medicine imaging. In this clinical rotation, the students will be exposed to radionuclide processes, radiopharmaceuticlas including radioactive gases and aerosols-prepartio, characteristics and radiation dosimetry, *in vitro* and *in vivo* radiation detection systems, and imaging systems and their performance evaluations. In addition, basic medical ethics, clinical interpretations, and radiation safety will be covered. A total of 150 clinical hours will be completed in this program.
Fall, every year, 4 credits, S/U grading
May be repeated once for credit

BME 617 Clinical Radiation Oncology Physics
This course is designed to prepare the Medical Physics graduate student in the area of clinical radiation oncology physics. In this clinical rotation, the student will learn by observation and participation some of a selection of the following medical physics procedures: LINAC Beam Dosimetry (ion chamber measurement techniques), film dosimetry (radiographic and radiochromic), diode dosimetry, TLD dosimetry, water phantom scanning, implementation of photon and electron beam calibration protocols (AAPM TG51), LINAC beam data measurement and tabulation, commissioning a TPS system, LINAC, acceptance testing, LINAC monthly QA, HDR QA and planning, and IMRT inverse planning and IMRT clinical QA. A total of 120 clinical hours will be completed in this program.
Prerequisite: BME 517 and BME 540 with a B+ or better
Spring, every year, 4 credits, S/U grading

BME 620 Space Radiation Biology
An extensive series of lectures, training sessions, and laboratory activities sponsored by NASA's Radiation Health Program in collaboration with BNL. The material is oriented to cover basic and state-of-the-art concepts in space radiation environment, physics, and radiobiology. Content includes basic concepts in physics, dosimetry, radiobiology, space radiation problems, and accelerator operations. Concurrent sessions are provided to complete specific BNL training and plan and prepare experiments for low- and high-LET radiation exposures. Students are trained in NSRL operations and are able to run control experiments using gamma rays in preparation for NSRL runs, and subsequently, experiments at the NSRL using heavy ions. Data obtained from different endpoints are discussed and analyzed with the instructors. Homework is used to test the student's level of comprehension of the lectures and laboratory activities. The write-up of a full BNL beam time request proposal is required of each student.
4 credits, ABCF grading

BME 690 Biomedical Engineering Research
Biomedical engineering research for doctoral students who have already received their M.S. degree, but have not yet advanced to candidacy.
Fall and spring, 1-9 credits, ABCF grading
May be repeated for credit

BME 698 Practicum in Teaching
Undergraduate teaching to be supervised by a faculty member of the program in Biomedical Engineering. Course to be identified by the student and graduate studies director.
Fall and spring, 1-3 credits, S/U grading
May be repeated for credit

BME 699 Dissertation Research On Campus
Prerequisite: Students must be advanced to candidacy (G5); permission of instructor and enroll in appropriate section; major portion of research must take place on SB campus, at Cold Spring Harbor, or at Brookhaven National Lab
Fall, spring, and summer, 1-9 credits, ABCF grading
May be repeated for credit

BME 700 Dissertation Research Off Campus—Domestic
Prerequisite: Must be advanced to candidacy (G5); major portion of research will take place off campus, but in the U.S. and/or U.S. provinces (Brookhaven National Lab and Cold Spring Harbor Lab are considered on campus); all international students

must enroll in one of the graduate student insurance plans and should be advised by an International Advisor
Fall, spring, summer, 1-9 credits, S/U grading
May be repeated for credit

BME 701 Dissertation Research Off Campus—International
Prerequisite: Must be advanced to candidacy (G5); major portion of research will take place outside of the U.S. and/or U.S. provinces; domestic students have the option of the health plan and may also enroll in MEDEX; international students who are in their home country are not covered by mandatory health plan and must contact the Insurance Office for the insurance charge to be removed; international students who are not in their home country are charged for the mandatory health insurance (if they are to be covered by another insurance plan, they must file a waiver by the second week of classes; the charge will only be removed if the other plan is deemed comparable); all international students must receive clearance from an International Advisor
Fall, spring, summer, 1-9 credits, S/U grading
May be repeated for credit

BME 800 BME Research
O credit, S/U grading
May be repeated