Biomedical Engineering

Graduate Programs: ME, MS, and PhD in Biomedical Engineering

Description of the Program

The graduate degree programs in Biomedical Engineering are a joint effort between the College of Engineering and Computing (CEC), the School of Medicine (SOM), and the College of Arts and Sciences (A & S). Graduate degrees in Biomedical Engineering will focus on the quantitative methods characteristic of engineering that are not a primary focus of traditional medical or biological education. CEC is responsible for the primary administration of the program. The curriculum calls for four core lecture courses, two of which are taught primarily by CEC faculty and two primarily by SOM faculty. Engineering, Medicine, and Arts & Sciences also offer course for elective credit within the curriculum. Faculty from all three colleges and schools collaborate in research.

Purpose and Objectives of the Program

The Biomedical Engineering discipline combines elements of biological and life sciences, engineering sciences, design, manufacturing and operation of biomedical processes and devices. The graduate degree programs (MS, ME, and PhD) will:

1. Prepare graduates of the program to meet the growing demands for advanced level research, development, and entrepreneurial positions in the biomedical industry.

2. Respond to the rapidly growing national demand for new biomedical technologies and the supporting industry, and to provide opportunities for economic development and entrepreneurial growth for the State of South Carolina.

3. Meet the goals of the University of South Carolina in its emphasis area of biomedical sciences.

The **Master of Engineering (ME) in Biomedical Engineering** offers intensive, focused coursework training in the professional practice of biomedical engineering. The program is specifically designed for students who plan to pursue industrial careers, as a graduate degree could enhance their job application, yield a higher starting salary, and enable rapid promotion within many corporate structures. Moreover, the program will provide students who plan to pursue further graduate education a means to distinguish themselves from typical candidates with a BS degree only, and insomuch facilitate admission to leading Biomedical Engineering graduate programs and medical schools nationwide.

The **MS degree** combines course work and a research-based thesis to serve three student populations. First, traditional biomedical, chemical, and mechanical engineers who wish to obtain advance training in biological areas prior to entering industry will be attracted to the MS. Second, science majors who wish to receive quantitative training will use the MS to enhance their qualifications for industry. Third, the MS will also be ideal for students who wish post-

baccalaureate training before entering medical school. Thus, we expect that the MS will ultimately lead to careers in industry or in medical practice.

The **PhD program** equips students with training in core and elective biomedical engineering topics coupled with research design and execution to advance students into a more focused area of the biomedical engineering field. As such, this program will prepare graduates to enter a research-based career in academia or industry.

Admission Criteria Specific to the Program

The admission criteria generally conform to those currently required by the University of South Carolina Graduate School. Admissions are based on the quality of the applicant's prior college work, letters of recommendation, GRE scores, and appropriate coursework in preparation for study in the biomedical field. In general, an applicant must have a baccalaureate degree in biomedical, chemical, or mechanical engineering or its equivalent from an accredited college or university. Students with a baccalaureate degree in chemistry, biology, biochemistry, or other related fields and who have completed appropriate coursework during their baccalaureate degree are also eligible. Undergraduate preparation should include two semesters of each of biology, physics, and general chemistry, as well as four semesters of calculus, including differential equations. In addition, undergraduate preparation may include coursework in topics such as material balances, mechanics, dynamics, thermodynamics, transport, kinetics, etc. For otherwise exceptionally qualified students, admission may be granted with the proviso that the student undertakes coursework in areas not fully covered during undergraduate preparation. Typically, however, additional coursework would be required.

For additional information, please contact Dr. Tarek Shazly (BME Graduate Program Director) at shazly@cec.sc.edu or Dr. Mark Uline (BME Program Director) at uline@cec.sc.edu.

Curriculum

The table below lists the required curriculum for the ME, MS, and PhD degree programs. All hours listed are beyond the BS degree. Students may be admitted directly to the PhD program.

Program Element	ME	MS	PhD
No. of Required BMEN core courses and credits	4 (BMEN 710, 720, 713, 723), 12 credits	4 (BMEN 710, 720, 713, 723), 12 credits	4 (BMEN 710, 720, 713, 723), 12 credits
No. of Required BMEN seminars and credits		BMEN 795, 798 for 1.0 credit ea., 2 credits total	BMEN 795, 798, 898 for 1.0 credit ea., 3 credits total
No. of Required BMEN elective courses	2 BMEN courses, 6 credits	2 BMEN courses, 6 credits	3 BMEN courses, 9 credits
No. of other electives required	12 hours of additional approved electives	1 course, BMEN or from approved list, 3 credits	2 courses, BMEN or from approved list, 6 credits
SUBTOTAL Lecture and seminar credits	**30 credits**	**23 credits**	**30 credits**
Required Thesis or Dissertation Prep (designation determined by the primary appointment of the student's major advisor)	None	BMEN 799, 7 credits	BMEN 899, 12 credits
Required Research (designation determined by the primary appointment of the student's major advisor)	None	Fulfilled by BMEN 799	BMEN 797, 18 credits
TOTAL Lecture and research credits	**30 credits**	**30 credits**	**60 credits**
Admission to Candidacy Exam	None	None	Yes
Comprehensive Exam	Yes	Yes	Yes (written and oral)
Written thesis or dissertation	None	Yes	Yes
Final oral defense	None	Yes	Yes

Core Course Description

The following are brief catalog course descriptions of the required biomedical engineering core and seminar courses in the graduate curriculum.

- BMEN 710 — Modeling and Simulation of Biomedical Systems (3 Credits): Analytical and quantitative techniques applied to engineering problems in biomedical transport, tissue mechanics, cellular and organ physiology, and control of medical devices.

- BMEN 713 — Human Cell and Molecular Biology for Biomedical Engineers (3 Credits): Advanced examination of the organization and function of the cell with emphasis on the biophysical and quantitative aspects of cellular function. Emphasis will be on the biomedical engineering applications of regulation of cell division, protein transcription and translation within the cell, cellular energetics, and intracellular networks for cell signaling and cell function.

- BMEN 720 — Transport Phenomena in Biomedical Systems (3 Credits): Conservation of momentum, energy, mass, physico-chemical properties of biofluids, blood rheology, circulation models and cardiovascular regulation, solute and oxygen transport in tissues, gas transport in lungs and respiratory gas exchange models, kinetics and compartmental modeling, modeling of artificial organs.

- BMEN 723 — Anatomy and Physiology for Biomedical Engineers (3 Credits): An examination of human biological structure and function from an engineering perspective. Engineering principles will be used to analyze anatomical structures and physiological functions at the tissue, organ, and systems levels.

- BMEN 795 — Biomedical Engineering Literature (1 Credit): Critical reading and literacy in the biomedical engineering discipline as it relates to students' research. Graduate Standing in the Biomedical Engineering Program.

- BMEN 798 — Graduate Seminar in Biomedical Engineering (1 Credit): Graduate seminar on current topics in biomedical engineering. Instruction on critical analysis and communication in the discipline.

- BMEN 898 — Doctoral Seminar in Biomedical Engineering (1 Credit): Seminar for doctoral students on current biomedical engineering topics and instruction in professional preparation in the discipline. Graduate Standing in the Biomedical Engineering Program.

BME FACULTY

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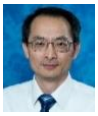
	James Otto Blanchette	Instructor	Biomedical Engineering	300 Main St, Room A213 Phone: 803-777-0926 Fax: 803-777-0106 blanchej@cec.sc.edu
	Nicholas D. Boltin	Instructor	Biomedical Engineering	Swearingen, Room 3C08 Phone: 803-576-6894 boltinn@mailbox.sc.edu
	Wayne Carver	Professor	Cell Biology and Anatomy Biomedical Engineering	Bldg 1, Room B-15 School of Medicine Ph: 803-216-3803 wayne.carver@uscmed.sc.edu
	John F. Eberth	Associate Professor	Cell Biology and Anatomy Biomedical Engineering	Bldg 1, Room C-43 School of Medicine Ph: 803-216-3891 john.eberth@uscmed.sc.edu
	Daping Fan	Professor	Cell Biology and Anatomy Biomedical Engineering	Bldg. 1, Room B-12 School of Medicine Ph: 803-216-3834 Fax: 803-216-3846 daping.fan@uscmed.sc.edu
	Edward P. Gatzke	Associate Professor	Chemical Engineering Biomedical Engineering	Swearingen, Room 3C05 Phone: 803-777-1159 Fax: 803-777-8265 gatzke@sc.edu
	Richard Lance Goodwin	Professor	School of Medicine Greenville Biomedical Engineering	School of Medicine Greenville Ph: 864-455-7476 goodwirl@greenvillemed.sc.edu

	R. Michael Gower	Assistant Professor	Chemical Engineering Biomedical Engineering	Swearingen, Room 2C21 Ph: 803-777-1541 Fax: 803-777-0973 gowerrm@mailbox.sc.edu
	Esmaiel Jabbari	Professor	Chemical Engineering Biomedical Engineering	Swearingen, Room 2C11 Ph: 803-777-8022 Fax: 803-777-8265 jabbari@cec.sc.edu
	Ehsan Jabbarzadeh	Professor; CEC Director of Entrepreneurship	Chemical Engineering Biomedical Engineering	Swearingen, Room 3C15 Ph: 803-777-3297 Fax: 803-777-8265 jabbarza@cec.sc.edu
	Susan Lessner	Professor	Cell Biology and Anatomy Biomedical Engineering	Bldg. 1, Room C-38 School of Medicine Ph: 803-216-3819 Fax: 803-216-3846 susan.lessner@uscmed.sc.edu
	Chang Liu	Assistant Professor	Chemical Engineering Biomedical Engineering	Swearingen, Room 2C07 Ph: 803-777-3182 changliu@cec.sc.edu
	Michael A. Matthews	Associate VP for Research | Senior Associate Dean for Research and Graduate Programs; Professor	Chemical Engineering Biomedical Engineering	Swearingen Ph: 803-777-0556 Fax: 803-777-9597 matthews@cec.sc.edu
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	Jay Potts	Associate Professor	Cell Biology and Anatomy Biomedical Engineering	Bldg. 1, Room C-50 School of Medicine Ph: 803-216-3820 Fax: 803-216-3846 jay.potts@uscmed.sc.edu
	John R. Rose	Professor	Computer Science and Engineering Biomedical Engineering	550 Assembly, Storey Innovation Center, Room 2257 Ph: 803-777-2405 Fax: 803-777-3767 rose@cec.sc.edu
	Frank G. Spinale	Professor	Cell Biology and Anatomy Biomedical Engineering	Basic Science Bldg 3 School of Medicine Ph: 803-216-3867 Fax: 803-216-3868 cvctrc@uscmed.sc.edu
	Michael Sutton	Distinguished Professor	Mechanical Engineering Biomedical Engineering	300 Main St, Room A129 Ph: 803-777-7158 Fax: 803-777-0106 sutton@cec.sc.edu
	Nader Taheri-Qazvini	Assistant Professor	Chemical Engineering Biomedical Engineering	Swearingen Ph: 803-576-7313 ntaheri@cec.sc.edu

	Wenbin Tan	Associate Professor	Cell Biology and Anatomy Biomedical Engineering	Bldg 1, Room B26 School of Medicine Ph: 803-216-3816 wenbin.tan@uscmed.sc.edu
	Chuanbing Tang	Professor	Chemistry and Biochemistry Biomedical Engineering	Horizon I Bldg, HZN1 239 Ph: 803-3628 Fax: 803-777-8100 tang4@mailbox.sc.edu
	Homayoun Valafar	Professor; Associate Chair of Research; Associate Infrastructure Director (Visualization)	Computer Science and Engineering Biomedical Engineering	550 Assembly, Storey Innovation Center, Room 2251 Ph: 803-777-2404 Fax: 803-777-3767 homayoun@cse.sc.edu
	Guiren Wang	Associate Professor	Mechanical Engineering Biomedical Engineering	300 Main St, Room A221 Ph: 803-777-8013 Fax: 803-777-0106 guirenwang@sc.edu

BME Staff

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FACULTY RESEARCH INTERESTS

Mark J. Uline
Program Director, Biomedical Engineering
Associate Professor, Chemical Engineering, Biomedical Engineering
Dr. Uline is the Program Director of the Biomedical Engineering Program at UofSC. His research group is working toward the fundamental understanding of how the complex interactions at interfaces couple together to give the rich phenomena observed in various chemical and biological systems.

Silke Henrich
Undergraduate Director, Biomedical Engineering
Lab Manager/Instructor
Dr. Henrich is the undergraduate director, lab manager and an instructor in the Biomedical Engineering Program.

Tarek Shazly
Graduate Director, Biomedical Engineering
Associate Professor, Mechanical Engineering, Biomedical Engineering
Dr. Shazly is the Graduate Director of the Biomedical Engineering Program at the University of South Carolina. His research is focused on defining and characterizing relevant tissue properties for clinical applications and rationally designing polymeric biomaterials that leverage local biology to enhance therapeutic gain. His specific interests include physiological mechanical testing of soft matter, mechanical modeling, multiphysics-based computational modeling, tissue-material adhesion and tissue scaffold engineering.

Mohamad Azhar
Associate Professor, Cell Biology and Anatomy, Biomedical Engineering
Dr. Azhar's current focus involves using genetically engineered mouse models to investigate the biological function of the transforming growth factor beta (TGFβ) ligands in cardiovascular development and cardiovascular disease, including calcific aortic valve disease, congenital heart disease, and aortic calcification and thoracic aortic aneurysm.

Seongtae Bae
Assistant Professor, Electrical Engineering, Biomedical Engineering
Assistant Professor Bae has focused his research on magnetic nanofluid hyperthermia and its clinical applications, magnetic(ferrite) nanoparticles/nanofluids for nano-theranostics in nanomedicine, magnetically-labeled point-care-of biosensors, in vivo & in-vitro magnetic based biosensors/bioMEMS, extremely low frequency nanomagnetic biomedical devices and medical instrumentation for neural engineering and neuromodulation, and Nanostructure spintronics materials/devices for advanced electronics and energy sustainability.

Abdel-Moez E. Bayoumi
Professor, Mechanical Engineering, Biomedical Engineering;
Associate Dean; Director, Center for Predictive Maintenance
Dr. Bayoumi's current areas of interest are: (1) study of Condition-Based Maintenance (CBM) on military aircraft, (2) Micro-Electro Mechanical Systems (MEMS) and Mechatronics, and (3) design and applications of efficient energy resources and systems.

James Otto Blanchette

Instructor, Biomedical Engineering
Dr. Blanchette's research interests fall into the areas of: design of cell-instructive materials, delivery of therapeutics and tissue engineering.

Nicholas D. Boltin
Instructor, Biomedical Engineering
Dr. Boltin's focus lies in software design, biomedical informatics, data mining, and machine learning/artificial intelligence.

Wayne Carver
Professor, Cell Biology and Anatomy, Biomedical Engineering
Dr. Carver's research focuses on understanding how fibroblast behavior and gene expression are regulated in the heart. He uses cell culture and animal models to examine the regulation of fibroblasts in cardiovascular disease.

John F. Eberth
Associate Professor, Cell Biology and Anatomy, Biomedical Engineering
Dr. Eberth leads the Translational Biomechanics Lab (TBL), which adapts fundamental engineering principles to understand, manipulate, and control the behavior of healthy and diseased cardiovascular tissue.

Daping Fan
Professor, Cell Biology and Anatomy, Biomedical Engineering
Dr. Fan's current research interests include the interaction between lipoprotein metabolism and innate immunity in atherogenesis, the tumor microenvironment of breast cancer, and development of natural compounds as anti-inflammatory and anti-cancer therapies.

Edward P. Gatzke
Associate Professor, Chemical Engineering, Biomedical Engineering
Dr. Gatzke's research interests are in the area of process modeling, control, and optimization. Application areas of interest include particulate processing, bio-processes, and large scale systems.

Richard Lance Goodwin
Professor, Biomedical Sciences – School of Medicine Greenville, Biomedical Engineering
Dr. Goodwin's research lab investigates mechanisms of cardiovascular embryonic development and disease.

R. Michael Gower
Assistant Professor, Chemical Engineering, Biomedical Engineering
Dr. Gower's research focuses on understanding the immune system in order to develop bio-instructive materials that stimulate specific immune responses.

Esmaiel Jabbari
Professor, Chemical Engineering, Biomedical Engineering
Dr. Jabbari's research draws upon chemistry, biology, macromolecular science and exploits biomimetic strategies to engineer cellular constructs for regeneration of skeletal tissues. His research interests include tissue engineering, biomimetic materials, bioinspired nanocomposites, and peptide-mediated drug delivery.

Ehsan Jabbarzadeh

Professor, Chemical Engineering, Biomedical Engineering
Dr. Jabbarzadeh's lab is interested in the interdisciplinary areas of biomaterials, stem cells and nano/micro-electromechanical systems with applications in tissue engineering and regenerative medicine. His research activities focus on understanding the principles by which microenvironmental signals regulate cellular responses.

Susan Lessner
Professor, Cell Biology and Anatomy, Biomedical Engineering
Dr. Lessner's research interests center on processes which lead to the destabilization and rupture of atherosclerotic plaques. In humans, plaque rupture leads directly to clinical events such as heart attack and stroke.

Chang Liu
Assistant Professor, Chemical Engineering, Biomedical Engineering
Dr. Liu's research group is interested in biosensor development and biomarker discovery using nanomaterials, with a focus on their clinical applications on in vitro diagnostics, point-of-care tests, and liquid biopsy for cancer and infectious diseases.

Michael A. Matthews
Associate VP for Research | Senior Associate Dean for Research and Graduate Programs; Professor, Chemical Engineering, Biomedical Engineering
Dr. Matthews is the Senior Associate Dean for Research and Graduate Programs and a professor of chemical and biomedical engineering. He conducts research in the broad field of thermodynamics, and his research interests include supercritical fluids, ionic liquids, green chemical engineering, and carbon dioxide technology for sterilization, disinfection, modification of tissue scaffolds, and deactivation of allergenic proteins and asthma triggers.

Melissa A. Moss
Department Chair of Chemical Engineering
Professor, Chemical Engineering, Biomedical Engineering
Dr. Moss is the Chair of the Department of Chemical Engineering at the University of South Carolina. Her research focuses on understanding the role of amyloid-β protein (Aβ) aggregation in Alzheimer's disease and inhibiting Aβ aggregation as a therapeutic approach to this widespread and devastating illness.

Chandrashekhar Patel
Research Associate Professor, Biomedical Engineering
Dr. Patel's research interests include molecular regulation of vascular endothelial and smooth muscle cells.

Jay D. Potts
Associate Professor, Cell Biology and Anatomy, Biomedical Engineering
Dr. Pott's research team is working toward understanding how the early heart and in particular, the AV canal is formed, laying the foundation for future therapeutic measures for congenital cardiac defects.

John R. Rose
Professor, Computer Science and Engineering, Biomedical Engineering
Dr. Rose's research interests are in the areas of bioinformatics, normative reasoning and planning, DAI and multiagent systems, and computational chemistry.

Frank G. Spinale

Professor, Cell Biology and Anatomy, Biomedical Engineering
Francis G. Spinale, an internationally renowned cardiovascular scientist, has directed a translational research effort in the thematic area of remodeling with a particular focus upon heart failure. His mechanistic, translational, and clinical studies will advance our understanding and treatment for major causes of heart failure in patients.

Michael Sutton
Distinguished Professor, Mechanical Engineering, Biomedical Engineering
Dr. Sutton's research and interests include coherent and incoherent optics applications, experimental mechanics, digital image processing, computer vision, applications of integral methods and experimental mechanics, boundary valve problems, plastic fracture mechanics, and finite elements modeling of cracked bodies.

Nader Taheri-Qazvini
Assistant Professor, Chemical Engineering, Biomedical Engineering
Dr. Taheri-Qazvinis' research includes bio-nano hybrid and biomimetic materials, charge-driven self-assembly, structure-dynamics relations in polymer networks, hydrogels, soft glassy materials and living cells, microfabrication and 3D bioprinting and tissue engineering, and collective cell migration.

Wenbin Tan
Associate Professor, Cell Biology and Anatomy, Biomedical Engineering
Dr. Tan’s research team mainly focuses on the molecular pathogenesis of congenital vascular malformations. His research is interested in the mechanism how vascular and nervous systems interact with each other during the diseases’ pathogenesis and progression as well as development of new treatments for them.

Chuanbing Tang
Professor, Chemistry and Biochemistry, Biomedical Engineering
Dr. Tang's research combines synthesis of innovative polymeric materials, including both renewable biobased polymers, nanostructured polymers, and metal-containing polymers, which can find applications ranging from novel biodegradable thermoplastics, drug delivery, antimicrobials, nanolithography, etc.

Homayoun Valafar
Professor, Computer Science and Engineering, Biomedical Engineering;
Associate Chair of Research; Associate Infrastructure Director (Visualization)
Dr. Valafar's research activities fall into two broad categories: computational medicine and computational biology.

Guiren Wang
Associate Professor, Mechanical Engineering, Biomedical Engineering
Dr. Wang's research and interests include micro/nanofluidics, lab-on-a-chip, far field optical nanoscopy, super-resolution imaging, cancer detection, fluorescence spectroscopy, tissue engineering, fluid dynamics, turbulence and mixing.

List of BMEN Approved Electives

The following is a list of existing courses that may be accepted for graduate elective credit

COEIT Graduate Courses
ECHE 710 Advanced Chemical Engineering Thermodynamics
ECHE 720 Advanced Fluid Flow Analysis
ECHE 721 Advanced Heat Flow Analysis
ECHE 722 Advanced Mass Transfer
ECHE 725 Rheology
ECHE 730 Chemical Reactor Design
ECHE 750 Process Dynamics and Control
ECHE 770 Electrochemical Engineering
ECHE 772 Principles of Polymer Systems
EMCH 717 Advanced Finite Element Methods
EMCH 722 Plasticity
EMCH 741 Viscous and Turbulent Flow
EMCH 751 Advanced Heat Transfer
EMCH 771 Design Properties of Plastics
EMCH 794 Thermodynamics

Arts & Sciences Graduate Courses
CHEM 751 Biosynthesis of Macromolecules
CHEM 752 Regulation and Integration of Metabolism
CHEM 753 Enzymology and Protein Chemistry
CHEM 754 Biomedical Biochemistry I
CHEM 755 Biomedical Biochemistry II
BIOL 714 Advanced Cell Biology
BIOL 736 Advanced Developmental Biology

Computer Science & Engineering
CSCE 555 Algorithms in Bioinformatics
CSCE 561 Numerical Analysis
CSCE 563 Systems Simulation
CSCE 564 Computational Science
CSCE 580 Artificial Intelligence
CSCE 758 Probabilistic System Analysis
CSCE 763 Digital Image Processing
CSCE 768 Pattern Recognition and Classification
CSCE 769 Computational Structural Biology
CSCE 784 Neural Information Processing
CSCE 822 Data Mining and Warehousing

SOM Graduate Courses
ANAT 700 Principles of Electron Microscopy
ANAT 701 Human Embryology and Gross Anatomy
ANAT 720 Special Topics in Microscopic Anatomy
ANAT 740 Biological Microscopic Imaging
BMSC 720 Signal Transduction
BMSC 730 Cardiovascular Science
CBNS 702 Human Microscopic Anatomy
MBIM 710 Advanced Immunobiology
MBIM 720 Comprehensive Microbiology
MBIM 739 Medical Bacteriology
MBIM 740 Virology
PATH 710 Neoplasia
PATH 741 Pathology I

PATH 742 Pathology II
PATH 760 Topics in Pathobiology
PHPH 705 Biomedical Pharmacology
PHPH 735 Cardiovascular Pharmacology
PHPH 740 Neuroscience
PHPH 745 Neurophysiology
PHPH 750 Fundamental Neuroscience I
PHPH 751 Fundamental Neuroscience II
BMSC 700 Biomedical Science Interdisciplinary Laboratory I
BMSC 701 Biomedical Science Interdisciplinary Laboratory II
BMSC 702 Medical Cell Biology I
BMSC 705 Medical Cell Biology II
BMSC 710 Medical Molecular Biology
BMSC 720 Signal Transduction
BMSC 730 Cardiovascular Science