Biomedical Engineering

Modern biomedical engineers face a far different world than those trained even two decades ago. Explosive advances in our ability to probe and understand molecular and cellular processes and their interconnections now make it imperative that the powers of engineering be brought to bear at ever smaller, as well as at systemwide, levels. This will not only produce new discoveries at the most fundamental levels but also accelerate the translation of these discoveries into practical applications.

Our vision is that future leaders and lasting impact will arise from successfully integrating engineering concepts and approaches across molecular to whole body levels. Moreover, those also trained to integrate the analytical, modeling and systems approaches of engineering with the complex, and sometimes overwhelming, descriptive details of biology will be uniquely positioned to address new and exciting opportunities. We are committed to educating and training the next generation of biomedical engineers with this vision in mind. Consequently, we have leveraged our existing strengths to build our department around the five research programs representing some of the most exciting frontiers: Biomaterials/Tissue Engineering; Cardiovascular Engineering; Imaging; Molecular, Cellular and Systems Engineering; and Neural Engineering. These areas provide exciting training opportunities for students with a variety of backgrounds and interests.

Students seeking the **PhD in Biomedical Engineering** focus on five overlapping research programs that represent frontier areas of biomedical engineering and leverage the existing strengths of our current faculty and resources. Our core and more than 90 affiliated faculty work together in a number of interdisciplinary research centers and pathways offering students the opportunity to work in a diverse and rich spectrum of BME research areas. The **MD/PhD in Biomedical Engineering**, given jointly with the top-ranked School of Medicine, gives students in-depth training in modern biomedical research and clinical medicine. The typical MD/PhD career combines patient care and biomedical research but leans toward research.

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**Faculty**

**Chair**

Steven C. George  
Elvera and William Stuckenberg Professor and Chair  
MD, University of Missouri  
PhD, University of Washington in Seattle  
Tissue engineering; microphysiological systems; vascularizing engineered tissues

**Endowed Professors**

Rohit V. Pappu  
Edwin H. Murty Professor of Engineering  
PhD, Tufts University  
Macromolecular self assembly and function; computational biophysics

Yoram Rudy  
Fred Saigh Distinguished Professor of Engineering  
PhD, Case Western Reserve University  
Cardiac electrophysiology; modeling of the cardiac system

Lori A. Setton  
Lucy and Stanley Lopata Distinguished Professor of Biomedical Engineering  
PhD, Columbia University  
Biomaterials for local drug delivery; tissue regenerations specific to the knee joints and spine

Larry A. Taber  
Dennis and Barbara Kessler Professor of Biomedical Engineering  
PhD, Stanford University  
Mechanics of growth and development; cardiac mechanics

Lihong Wang  
Gene K. Beare Distinguished Professor of Biomedical Engineering  
PhD, Rice University  
Biophotonics and multimodality optical imaging

Frank Yin  
Stephen F. and Camilla T. Brauer Distinguished Professor of Biomedical Engineering  
MD, PhD, University of California, San Diego  
Tissue and cell biomechanics; hemodynamics

**Professors**

Mark Anastasio  
PhD, University of Chicago  
Imaging sciences; phase-contrast; x-ray imaging
Jianmin Cui (https://engineering.wustl.edu/Profiles/Pages/Jianmin-Cui.aspx)
PhD, State University of New York–Stony Brook
Ion channels; channel structure-function relationship; biophysics

Daniel Moran (https://engineering.wustl.edu/Profiles/Pages/Daniel-Moran.aspx)
PhD, Arizona State University
Motor control; neural engineering; neuroprosthetics; movement biomechanics

Quing Zhu
PhD, University of Pennsylvania
Biophotonics and multimodality ultrasound and optical imaging

Associate Professors

Dennis L. Barbour (https://engineering.wustl.edu/Profiles/Pages/Dennis-Barbour.aspx)
MD, PhD, Johns Hopkins University
Auditory physiology; sensory cortex neurocircuitry; novel perceptual diagnostics and therapeutics

Vitaly Klyachko (https://engineering.wustl.edu/Profiles/Pages/Vitaly-Klyachko.aspx)
PhD, University of Wisconsin-Madison
Synaptic function and plasticity; neural circuits; information analysis; neurological disorders

Baranidharan Raman (https://engineering.wustl.edu/Profiles/Pages/Barani-Raman.aspx)
PhD, Texas A&M University
Computational and systems neuroscience; neuromorphic engineering; pattern recognition; sensor-based machine olfaction

Jin-Yu Shao (https://engineering.wustl.edu/Profiles/Pages/Jin-Yu-Shao.aspx)
PhD, Duke University
Cell mechanics; receptor and ligand interactions; molecular biomechanics

Kurt A. Thoroughman (https://engineering.wustl.edu/Profiles/Pages/Kurt-Thoroughman.aspx)
PhD, Johns Hopkins University
Human motor control and motor learning; neural computation

Assistant Professors

Jan Bieschke (https://engineering.wustl.edu/Profiles/Pages/Jan-Bieschke.aspx)
PhD, Max Planck Institute for Biophysical Chemistry/University of Braunschweig
Single molecule fluorescence and other biophysical methods to probe the mechanistic underpinnings of protein misfolding

Hong Chen (https://engineering.wustl.edu/Profiles/Pages/Hong-Chen.aspx)
PhD, University of Washington
Physical acoustics; therapeutic ultrasound and ultrasound imaging

Kristen Naegle (https://engineering.wustl.edu/Profiles/Pages/Kristen-Naegle.aspx)
PhD, Massachusetts Institute of Technology
Computational systems biology with emphasis on cellular networks involved in cancer and diabetes

Jon Silva (https://engineering.wustl.edu/Profiles/Pages/Jonathan-Silva.aspx)
PhD, Washington University
Ion channel biophysics

Lecturer

Patricia Widder
MS, Washington University

Degree Requirements

PhD and Combined MD/PhD in Biomedical Engineering

The department offers programs leading to the doctor of philosophy (PhD) in Biomedical Engineering and combined MD/PhD degrees. The latter degree is given jointly with the School of Medicine.

The doctoral degree requires a minimum of 72 credits beyond the bachelor’s level, with a minimum of 36 being course credits (including the core curriculum) and a minimum of 24 credits of doctoral dissertation research.

The core curriculum that must be satisfied by all PhD students consists of the following:

- One graduate-level course in life sciences
- One graduate-level course in mathematics
- One graduate-level course in computer science or exemption by proficiency
- Four BME courses from an approved list

Please visit the Biomedical Engineering (BME) website (https://bme.wustl.edu/graduate/phd/Pages/default.aspx) for a comprehensive list of the approved and core curriculum courses.

The core requirements represent 6-7 courses, with a total of 9 graduate courses required for the PhD. Up to 9 units of BME 601C Research Rotation (https://courses.wustl.edu/CourseInfo.aspx?sch=E&dept=E62&crs=601C) and/or BME 501C Graduate Seminar (https://courses.wustl.edu/CourseInfo.aspx?sch=E&dept=E62&crs=501C) may be counted toward the 36 units of graduate course work required for the PhD. Up to two 400-level courses may be counted toward the 9 courses of graduate course work required for the PhD (not including independent study courses, journal clubs or seminar-based courses). Graduate courses may be transferred in (up to 24 units) but must be evaluated and approved by the Director of Doctoral Studies. The evaluation and approval may occur at any
time but course transfer does not become official until after one year in residence at Washington University.

Students seeking the PhD in Biomedical Engineering enroll in two to three courses each semester and participate in two or three laboratory rotations in the first year. At the end of that year, they take their oral qualifying exam consisting of a 15-20 minute presentation of their research done to date in the mentor’s laboratory followed by an oral exam addressing any issues directly related to their rotation report or their oral presentation. Upon successfully passing the qualifying examination, they advance to candidacy and complete the balance of their requirements. During the second and third years, students complete their remaining courses, perform their one-semester teaching assistantship, and begin their thesis research. By the end of the third year, students must complete their thesis proposal. Students must also complete one accepted first author publication and complete a dissertation.

Students pursuing the combined MD/PhD in Biomedical Engineering must complete the degree requirements for both schools. MD/PhD students typically complete the first two years of the medical school pre-clinical curriculum while also performing one or more research rotations, then the remaining requirements for the doctoral degree, and finally the clinical training years of the medical degree. The department generally gives graduate course credits for some of the medical school courses toward fulfillment of course requirements for the PhD degree. This is arranged on an individual basis between the student, his or her academic adviser, and the director of graduate studies.