

# BIOENGINEERING

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## Overview

### Mission Statement

The Department of Bioengineering bridges the fields of engineering and medicine with a core mission of applying engineering principles and analyses to improving human health. The department will fulfill this mission by providing opportunities for training, research, and service in bioengineering to faculty, students, and residents of Colorado and the greater Rocky Mountain region.

### Program Objectives

The Department of Bioengineering offers high-quality training in bioengineering that is both flexible and multidisciplinary. A design-based focus permeates every aspect of our training philosophy which can be summarized by the following question: what does the user want and how can I best utilize my bioengineering training to achieve this need? Our academic instruction focuses on developing core competencies in life sciences, quantitative methods, technology, and research methods.

## Graduate Program

All graduate students begin the program with intensive study of the bioengineering core. In consultation with an advisor, each student chooses elective courses, training pathways, and research to fit talents, preparation, and career plans. Students earn the MS, MS-MBA, MD-MS, MD/PhD, or PhD degree in bioengineering with a choice of training pathways in basic research, clinical applications, or commercialization of medical technologies. Graduate School Policies and Procedures (<http://catalog.ucdenver.edu/cu-denver/graduate/graduate-school-policies-procedures/>) apply to all programs. Please consult our website ([ucdenver.edu/bioengineering](http://ucdenver.edu/bioengineering) (<http://www.ucdenver.edu/bioengineering/>)) for more information on admissions requirements, degree requirements, core courses, training pathways and faculty research areas.

## Programs

- Bioengineering Dual, MS-MBA (<http://catalog.ucdenver.edu/cu-denver/graduate/schools-colleges-departments/college-engineering-design-computing/bioengineering/bioengineering-dual-ms-mba/>)
- Bioengineering, MD-MS (<http://catalog.ucdenver.edu/cu-denver/graduate/schools-colleges-departments/college-engineering-design-computing/bioengineering/bioengineering-md-ms/>)
- Bioengineering, MD-PhD (<http://catalog.ucdenver.edu/cu-denver/graduate/schools-colleges-departments/college-engineering-design-computing/bioengineering/bioengineering-md-phd/>)
- Bioengineering, MS (<http://catalog.ucdenver.edu/cu-denver/graduate/schools-colleges-departments/college-engineering-design-computing/bioengineering/bioengineering-ms/>)

- Bioengineering, PhD (<http://catalog.ucdenver.edu/cu-denver/graduate/schools-colleges-departments/college-engineering-design-computing/bioengineering/bioengineering-phd/>)

## Faculty

### Professors

**Robin Shandas**, PhD [robin.shandas@cuanschutz.edu](mailto:robin.shandas@cuanschutz.edu)  
Specialties: Novel methods for translational bioengineering

**Keith Neeves**, PhD [keith.neeves@cuanschutz.edu](mailto:keith.neeves@cuanschutz.edu)  
Specialties: Hematology and oncology

### Associate Professors

**Richard Benninger**, PhD [richard.benninger@cuanschutz.edu](mailto:richard.benninger@cuanschutz.edu)  
Specialties: Optical microscopy, pancreatic islet biology and biophysics, diabetes

**Cathy Bodine**, PhD [cathy.bodine@cuanschutz.edu](mailto:cathy.bodine@cuanschutz.edu)  
Specialties: Assistive technology, rehabilitation engineering

**Kendall Hunter**, PhD [kendall.hunter@cuanschutz.edu](mailto:kendall.hunter@cuanschutz.edu)  
Specialties: Soft tissue mechanics, vascular and cardiac imaging diagnostics, translational biomechanics

**Daewon Park**, PhD [daewon.park@cuanschutz.edu](mailto:daewon.park@cuanschutz.edu)  
Specialties: Biomaterials, drug delivery, tissue engineering and regenerative medicine

### Research Associate Professors

**Richard Weir**, PhD [richard.weir@cuanschutz.edu](mailto:richard.weir@cuanschutz.edu)  
Specialties: Neural engineering, biomechatronic design, and rehabilitation engineering

### Associate Clinical Professor

**Michael Yeager** [michael.yeager@cuanschutz.edu](mailto:michael.yeager@cuanschutz.edu)  
Specialties: Cardiopulmonary disease, autoimmunity, in vivo cell lineage tracing & imaging

### Assistant Professors

**Emily Gibson**, PhD [emily.gibson@cuanschutz.edu](mailto:emily.gibson@cuanschutz.edu)  
Specialties: Microfluidics technology, optical microscopy, and spectroscopy

**Jeffrey Jacot**, PhD [jeffrey.jacot@cuanschutz.edu](mailto:jeffrey.jacot@cuanschutz.edu)  
Specialties: Stem cells and heart tissue engineering

**Chelsea Magin**, PhD [chelsea.magin@cuanschutz.edu](mailto:chelsea.magin@cuanschutz.edu)  
Specialties: Bio-inspired materials for tissue engineering, R & D product development

**Bradford Smith**, PhD [bradford.smith@cuanschutz.edu](mailto:bradford.smith@cuanschutz.edu)  
Specialties: Lung structure-function relationships, optimized mechanical ventilation, and high performance computing

### Assistant Research Professors

**Vitaly Kheyfets**, PhD [vitaly.kheyfets@cuanschutz.edu](mailto:vitaly.kheyfets@cuanschutz.edu)  
Specialties: Vascular/ventricular function, cellular metabolism in cardiovascular disease, and pulmonary hypertension

**Brisa Pena**, PhD [brisa.penacastellanos@cuanschutz.edu](mailto:brisa.penacastellanos@cuanschutz.edu)  
Specialties: Material science, atomic force microscopy, cardiac tissue engineering, and miRNA delivery

## Instructors

**Cassandra Howard**, MSC [cassandra.howard@cuanschutz.edu](mailto:cassandra.howard@cuanschutz.edu)  
Specialties: Medical device innovation and biodesign

**Steven Lammers**, PhD [steven.lammers@cuanschutz.edu](mailto:steven.lammers@cuanschutz.edu)  
Specialties: 3D printing & design, bioprintable materials, tissue engineering of 3D cellularized scaffolds

**Jennifer Wagner** [jennifer.wagner@cuanschutz.edu](mailto:jennifer.wagner@cuanschutz.edu)  
Specialties: Medical imaging, 3D modeling, surgical guides/tools, tissue engineering, and material characterization

## Affiliated Faculty

Students receive instruction from affiliate faculty in the University of Colorado system, including CU Boulder and the CU School of Medicine. Faculty research areas include imaging and biophotonics, cardiovascular biomechanics and hemodynamics, orthopedic biomechanics, neuromuscular control and assistive technology, surgery and urological sciences, ophthalmology, neuroscience engineering, polymers and diabetes. Please consult our website ([ucdenver.edu/bioengineering](http://www.ucdenver.edu/bioengineering) (<http://www.ucdenver.edu/bioengineering/>)) for more information.

## Bioengineering (BIOE) Courses

**BIOE 5010 - Cell and Molecular Biology for Bioengineers (3 Credits)**  
Introduction to cellular and molecular biology, with a focus on using engineering methods and literature to analyze structure and function of cells throughout lifecycle and multiple scales. Design experiments to test hypotheses. Prereq: Graduate standing in Bioengineering or instructor permission. Max Hours: 3 Credits.  
Grading Basis: Letter Grade  
Restriction: Restricted to Bioengineering students with graduate student status.

**BIOE 5011 - Systems Physiology for Bioengineers (3 Credits)**  
Use engineering principles to study key physiological systems. Topics: cardiovascular, neuroscience, urological, or renal medicine. Related engineering principles: pressure-flow relationships, stress-strain, electromechanical coupling and signal transduction. Prereq: Graduate standing in Bioengineering or instructor permission. Max Hours: 3 Credits.  
Grading Basis: Letter Grade

**BIOE 5020 - Analytics and Machine Learning in Bioengineering (3 Credits)**  
This course provides mathematical tools essential for graduate level bioengineering work. Studies selected topics from probability, linear algebra, and vector calculus, with emphasis on bioengineering applications. Prereq: Graduate standing in Bioengineering or instructor permission. Max Hours: 3 Credits.  
Grading Basis: Letter Grade

**BIOE 5021 - Numerical Methods for Engineering Analysis (3 Credits)**  
Provides computational skills and knowledge of numerical methods for engineering/scientific computation using Matlab. Topics: root finding, interpolation, difference and integration rules, solution of initial and boundary value ODEs, and introduction to the solution of PDEs. Prereq: Graduate standing in Bioengineering or instructor permission. Max Hours: 3 Credits.  
Grading Basis: Letter Grade

**BIOE 5039 - Mechatronics and Embedded Systems (3 Credits)**  
The course focuses on the design and construction of microprocessor-controlled electro-mechanical systems. Lectures review critical circuit topics (Ohm's law, RLC circuits, DC and AC signals, diode and transistor circuits, operational amplifiers, and digital signals), introduce microprocessor architecture and programming, discuss sensor and actuator component selection, robotic systems, and design strategies for complex, multi-system devices. Lab work reinforces lectures and allows hands-on experience with robotic and embedded systems design. Students must design and build an embedded systems device related to assistive technology. Note: Project expenses may be incurred (\$50 maximum). Cross-listed with BIOE 4039. Restriction: Restricted to graduate students in the Department of Bioengineering. Max Hours: 3 Credits.

Grading Basis: Letter Grade  
Restriction: Restricted to Bioengineering students with graduate student status.

**BIOE 5040 - Research Methods for Bioengineers (2 Credits)**  
This course provides an introduction to research methods for bioengineers in order to prepare for basic research, clinical applications and commercialization of medical technologies. Topics include literature review, regulatory policy. Prerequisite: Graduate standing in Bioengineering (MS/PhD). Max Hours: 2 Credits.  
Grading Basis: Letter Grade  
Typically Offered: Fall.

**BIOE 5041 - Clinical Experiences for Bioengineers (1 Credit)**  
This course provides opportunities for clinical experiences such as observing surgeries and touring intensive care units to prepare students for clinical applications and foster collaborations with clinical practitioners. Experiences take place through the school year. Prerequisites: Graduate standing in Bioengineering (MS/PHD). Repeatable. Max Hours: 2 Credits.  
Grading Basis: Letter Grade  
Repeatable. Max Credits: 2.  
Typically Offered: Fall.

**BIOE 5053 - Optics & Microscopy in Biomedical Research (3 Credits)**  
Graduate overview of optical imaging, ranging from classical microscopy to advanced non-linear techniques and includes theory, technology and applications in biomedical sciences. This will prepare students for developing and applying state-of-the-art optical imaging in their research. Cross-listed with BIOE 4053. Prereq: Grad standing or permission from the instructor. Max Hours: 3 Credits.  
Grading Basis: Letter Grade

**BIOE 5054 - Regulatory Affairs (3 Credits)**  
This course covers standards of quality assurance and regulatory pathways that guide biomedical engineering industry. Cross-listed with BIOE 4054. Restriction: Restricted to BIOE majors or with instructor permission. Max hours: 3 Credits.  
Grading Basis: Letter Grade  
Restriction: Restricted to Bioengineering students with graduate student status.

**BIOE 5057 - Rehabilitation and Assistive Technology (3 Credits)**  
This course provides students with an overview of technologies and their use by and for persons with disabilities. Cross-listed with BIOE 4057. Restriction: Restricted to students with BIOE designation, or with instructor permission. Max hours: 3 Credits.  
Grading Basis: Letter Grade  
Restriction: Restricted to Bioengineering students with graduate student status.

**BIOE 5058 - Intro to Design, Disability, and Aging (3 Credits)**

This course provides an introduction to the topic of disability and aging and the application of bioengineering principles for persons living with functional impairment(s) across the lifespan. Cross-listed with BIOE 4058. Restriction: Restricted to BIOE majors or with instructor permission. Max hours: 3 Credits.

Grading Basis: Letter Grade

Restriction: Restricted to Bioengineering students with graduate student status.

**BIOE 5063 - 3D Modeling for Bioengineers (3 Credits)**

Course instills 3D modeling skills specific to biomedical industry. Topics include computer aided design, medical imaging, image processing, patient specific image to three-dimensional model reconstruction, non-uniform rational b-spline surfaces, finite element, computational fluid dynamics analyses, physical modeling using rapid prototyping.

Restrictions: Matriculated CEDC students. Max Hours: 3 Credits.

Grading Basis: Letter Grade

Typically Offered: Fall, Spring.

**BIOE 5064 - Advanced MatLab For Bioengineers And Life Scientists (3 Credits)**

MatLab programming for graduate bioengineers and life scientists. Topics include MatLab syntax and optimization as well as techniques for working with scalars, time-series, images and multi-dimension datasets. Surface/Curve fitting, modeling, automation and classification will be covered. Cross-listed with BIOE 4064. Max Hours: 3 Credits.

Grading Basis: Letter Grade

**BIOE 5067 - Human Factors and Usability Testing for Bioengineers (3 Credits)**

This course provides an introduction to human factors testing and evaluation in the context of medical devices and assistive technology (AT). Particular focus will be given towards designing and applying usability testing to inform product design decisions or improvements. Topics include human factor considerations for aging and disabled populations (and their care providers), usability techniques, user experience data collection and interpretation, etc. Students will engage in hands-on human factors assessments such as contextual inquiry of surgery patients, cognitive walkthroughs with simulating disability, and product usability testing and iteration. Max hours: 3 Credits.

Grading Basis: Letter Grade

**BIOE 5068 - Introduction to Medical Imaging (3 Credits)**

This course will introduce graduate students to the basic physics, technologies, and clinical methodologies underlying Ultrasound, MRI, CT, PET and SPECT imaging systems. The course will include lectures, and visits to campus hospital and research imaging systems as well as hands on ultrasound labs. Cross-listed with BIOE 4068. Restriction: Restricted to Bioengineering students with graduate student status. Max Hours: 3 Credits.

Grading Basis: Letter Grade

Restriction: Restricted to Bioengineering students with graduate student status.

**BIOE 5069 - Advanced Biomechanics for Graduates (3 Credits)**

This course covers advanced topics such as blood flow dynamics, introduction to non-linear finite deformation techniques, blood rheology, and computational techniques. Restriction: Restricted to Bioengineering students with graduate student status, or by Permission of Instructor. Crosslisted with BIOE 4069. Max Hours: 3 credits.

Grading Basis: Letter Grade

Restriction: Restricted to students with graduate standing.

**BIOE 5073 - Neural Interfaces and Bionic Limbs (3 Credits)**

This course will introduce graduate students to topics in neural interfaces (Brain machine interfaces, peripheral nerve interfaces etc), the issues involved in the design of mechatronic limb systems and the decoding algorithms used to map the neural interface to the mechatronic limb. Cross-listed with BIOE 4073. Restrictions: Matriculated CEDC students. Max Hours: 3 Credits.

Grading Basis: Letter Grade

Typically Offered: Spring.

**BIOE 5074 - Introduction to Laboratory Animal Research (3 Credits)**

This course provides basic theoretical and practical knowledge on those of the most common laboratory animal species, animal models and welfare, general concepts on animal biology and husbandry, and essential principles of anesthesia, analgesia, surgery and peri operative care. Max Hours: 3 Credits.

Grading Basis: Letter Grade

**BIOE 5083 - Polymers in Biomedical Applications (3 Credits)**

This course will introduce graduate students to fundamental synthetic method and basic characteristics of various polymeric biomaterials and their crucial roles in different biomedical applications. It will also cover how the polymers can be modified to enhance biomedical applications. Cross-listed with BIOE 4083. Prereq: Graduate standing at CU Denver or instructor permission. Max Hours: 3 Credits.

Grading Basis: Letter Grade

**BIOE 5420 - Special Topics in Bioengineering (1-6 Credits)**

Special topics of particular interest to graduate students in Bioengineering. Prereq: Graduate standing within the Department of Bioengineering or permission of instructor. Repeatable. Max hours: 12 Credits.

Grading Basis: Letter Grade

Repeatable. Max Credits: 12.

**BIOE 5840 - Independent Study in Bioengineering (1-6 Credits)**

Graduate level independent study in Bioengineering with a faculty mentor. Prereq: Graduate standing within the Department of Bioengineering or permission of instructor. Repeatable. Max Hours: 6 Credits.

Grading Basis: Letter Grade

Repeatable. Max Credits: 6.

**BIOE 5939 - Graduate Internship (1-6 Credits)**

Department of Bioengineering Internship. Credit may not be applied toward the MS in Bioengineering degree. Enrollment by department permission only. Max Hours: 6 Credits.

Grading Basis: Letter Grade

**BIOE 6655 - Foundations of Doctoring MS Years (1-5 Credits)**

This course is for CU MD-MS students who are on leave of absence from SOM and wish to maintain clinical exposure and training during the leave. Prereq: Phase I & II SOM classes and graduate standing in BIOE. Repeatable. Max Hours: 20 Credits.

Grading Basis: Letter Grade

Repeatable. Max Credits: 20.

Restriction: Restricted to BIOE graduate majors within the College of Engineering, Design and Computing

BIOE 6950 - Masters Thesis (1-6 Credits)

Research for Master Thesis under supervision of faculty thesis advisor.

Prerequisites: Consent of thesis advisor. Restrictions: Satisfactory progress toward MS-Bioengineering degree. Repeatable. Max hours: 6 Credits.

Grading Basis: Letter Grade with IP

Repeatable. Max Credits: 6.

Additional Information: Report as Full Time.

Typically Offered: Fall, Spring, Summer.

BIOE 6960 - Master's Project (1-6 Credits)

Training for Master's Project under the supervision of faculty project advisor. Prereq: Department Consent. Repeatable. Max hours: 6 Credits.

Grading Basis: Letter Grade with IP

Repeatable. Max Credits: 6.

Additional Information: Report as Full Time.

BIOE 8990 - Doctoral Dissertation (1-10 Credits)

Research for doctoral dissertation under supervision of faculty advisor.

Prerequisites: Consent of dissertation advisor. Restrictions: Satisfactory progress toward PhD-Bioengineering Degree. Repeatable. Max hours: 10 Credits.

Grading Basis: Letter Grade with IP

Repeatable. Max Credits: 10.

Additional Information: Report as Full Time.

Typically Offered: Fall, Spring, Summer.