Roy J. Carver Department of Biomedical Engineering

Chair

Kim L. Blackwell

Undergraduate major: biomedical engineering (BSE)

Graduate degrees: MS in biomedical engineering; PhD in biomedical engineering

Faculty: https://engineering.uiowa.edu/bme/people

Website: https://engineering.uiowa.edu/bme

Facilities

Undergraduate Teaching Laboratories

Six dedicated undergraduate teaching laboratories are associated with the required and elective courses in biomedical engineering: the Bioimaging and Cardiovascular Engineering Laboratory; the Biomechanics and Biomaterials Laboratory; the Carver Cellular Engineering Laboratory; the Carver Medical Device Design Laboratory; the Senior Design Laboratory; and the Systems, Instrumentation, and Data Acquisition Laboratory.

Bioimaging and Cardiovascular Engineering Laboratory

The Bioimaging and Cardiovascular Engineering Laboratory provides computer and experimental equipment to allow students to become familiar with biomedical imaging hardware and software for biomedical image analysis as well as cardiovascular engineering devices. The laboratory has four lab benches with computers for teamwork, two desktop ultrasound machines, and two desktop magnetic resonance imaging devices, a pulse duplicator apparatus for characterizing blood flow through mechanical and tissue heart valves, and a stent crimper for characterizing vascular stent designs. In addition, the lab has 12 sets of in-house-built optics laboratory kits that use light sources and semitranslucent objects to simulate basic x-ray physics. Students are introduced to concepts such as image magnification as it relates to source-object distance (SOD)/ source-image distance (SID), depth-dependent magnification, ideal point source versus parallel beam source effects, and projection image formation with lack of depth information artifacts. An instructor workstation and computer projector are available for presentations and software demonstrations. The lab is used primarily for the core course BME:2210 Bioimaging and Bioinformatics, the elective course BME:5210 Medical Imaging Physics, BME:5510 Cardiovascular Engineering, BME:5525 Cardiopulmonary Design and Modeling and senior design projects.

Biomechanics and Biomaterials Laboratory

The Biomechanics and Biomaterials Laboratory allows students to perform experiments relating to the cardiovascular and human musculoskeletal systems as well as the various properties of biomaterials. The laboratory houses a table-top material testing machine; a Tekscan I-scan system with associated sensors; two cone-and-plate viscometers; compact stress-strain devices for characterizing cardiovascular tissues; goniometers; human structures biomechanical modeling sets and associated sensors; still, video, and motion-capture digital cameras for kinematic analysis; a ski binding tester; a drop tower for impact testing; digital calipers; various skeletal/bone models; an assortment of hand tools; and dissecting tools. The lab is used for the course BME:2500 Biomaterials and Biomechanics, elective courses in cardiovascular and musculoskeletal biomechanics like BME:4710 Medical Device Design Studio, and senior design projects.

Carver Cellular Engineering Laboratory

This laboratory trains students in cell culture and biochemical analysis techniques as a foundation for future work in quantitative cell-based studies. Students learn basic cell culture techniques, protein and nucleic acid analysis, as well as techniques for studying the effects of engineered materials on cellular systems.

Major equipment in the lab includes laminar flow hoods, cell culture incubators, centrifuges, spectrophotometers, an ultracold freezer, protein and nucleic acid electrophoresis equipment, thermal cyclers, an automated multimode microplate reader for quantifying cell activity and extracellular matrix (ECM) remodeling, microscopes, a nanodrop spectrophotometer, PCR maching, and various support apparatus used in cell-based studies. This teaching lab is used for the courses BME:2400 Cell and Tissue Engineering Fundamentals and BME:5421 Cell Material Interactions.

Carver Medical Device Design Laboratory

The Carver Medical Device Design Laboratory is used for prototyping and fabrication by biomedical engineering students in design-related courses. It allows students to engage in industry-relevant hands-on projects and develop important skills related to prototyping, fabrication, and design. The lab houses computer workstations with a large LED display, 250W laser cutter, a medical-grade adhesive station, a benchtop computer numerical control (CNC) machine, 3D scanner, a manual drill-mill, a bandsaw, lathe, and micro pulse arc welder. It also has an assortment of hand and power tools, as well as several 3D printers for rapid prototyping and development. The Carver Medical Device Design Laboratory is utilized by students taking BME:3710 Medical Device Design: The Fundamentals, BME:4710 Medical Device Design Studio, & BME:5715 Advanced Medical Device Design Studio. It also used for prototyping and fabrication by students taking BME:4910 Biomedical Engineering Senior Design I and BME:4920 Biomedical Engineering Senior Design II, as well as, BME:5101 Biomaterials and Implant Design, and BME:2200 Systems, Instrumentation, and Data Acquisition.

Senior Design Laboratory

The Senior Design Laboratory provides a collaborative atmosphere for student groups as they create working prototypes. It has computer workstations, project workspace, and storage space for the development of senior design projects. In addition, a variety of tools and equipment are available in the lab, including hand tools, electronics, measurement devices, soldering stations, dremels, a 3D printer, miscellaneous sample medical equipment, and other resources for students. It is used by students taking BME:4910 Biomedical Engineering Senior Design I and BME:4920 Biomedical Engineering Senior Design II.

Systems, Instrumentation, and Data Acquisition Laboratory

The Systems, Instrumentation, and Data Acquisition Laboratory provides a collaborative environment for student teams to gain practical experience designing and testing electronic biomedical devices. It is equipped to measure, acquire, and analyze biomedical signals of clinical and physiological interest; to design, build, and test electronic instrumentation; and to conduct modeling experiments in physiology. The equipment includes computer workstations, power supplies, multimeters, function generators, oscilloscopes, breadboards, electrical components, integrated circuits, various transducers, Arduino microprocessors, and National Instruments data acquisition boards. It is used for the courses BME:2200 Systems, Instrumentation, and Data Acquisition and BME:4710 Medical Device Design Studio, biomeasurements and biological systems analysis, and senior design projects.

Research Facilities and Laboratories

The following laboratories are transformational spaces that enable the biomedical engineering faculty and students (graduate and undergraduate research assistants) to interact with one another by bringing together investigators with complementary fields of study. The laboratories have a direct impact on training graduate students and contribute to numerous research projects across campus. They have been designed to be responsive to current and future needs; to encourage interaction among engineers, scientists, and physicians from various disciplines; to help recruit and retain qualified faculty and students; and to facilitate partnerships and development.

Carver Biomechanics and Mechanobiology Laboratory

The Carver Biomechanics and Mechanobiology Laboratory (CBML) is a shared resource in the Roy J. Carver Department of Biomedical Engineering that supports tissue biomechanics, mechanobiology, and biomaterials research across health and disease. The lab’s mission is to advance discovery and translation related to the biological processes that regulate tissue mechanics and to develop biomaterials that better model physiological and pathological environments.

The laboratory houses equipment for both soft-tissue and cellular mechanics, including an Agilent Cytation 5 for cellular contractility imaging, a Discovery HR-30 rheometer for extracellular matrix (ECM) viscoelastic characterization, a Stellaris 5 confocal microscope for high-resolution imaging, and a lyophilizer and cryomill for hydrogel preparation. The CBML supports experiments investigating how changes to the ECM alter fibroblast contractility and tissue mechanics in models of aging and fibrosis, as well as the design and testing of biomaterial scaffolds engineered to mimic or modulate these microenvironmental cues.

Coordinated Laboratory for Computational Genomics (CLCG)

The Coordinated Laboratory for Computational Genomics (CLCG) aims to catalyze the development of new areas of study and expanded research opportunities in informatics areas related to the basic biological sciences and applied medical research. Founded in 2002 as a joint enterprise between the College of Engineering and Carver College of Medicine, the CLCG involves faculty from five colleges, seven affiliated centers, institutes, and cores, and more than 19 departments. It serves as a coordinating home for interdisciplinary research, undergraduate, pre- and post-doctoral training, as well as faculty recruiting and professional development. At the hub of an inherently interdisciplinary field, the goal of the CLCG is to assist in overcoming traditional disciplinary hurdles to collaboration and assist in utilizing state-of-the-art instrumentation and analysis methods needed by 21st-century biomedical and basic science research.

Bioinformatics and Computational Biology Laboratory

The Center for Bioinformatics and Computational Biology is wired for high-speed networking (100-megabit and gigabit ethernet, hardwired and wireless). It includes two dedicated Linux clusters, 126 computing systems, 178 CPUs, more than 20 terabytes of RAM, and 250 terabytes of disk space. Computer resources include a dedicated experimental, reconfigurable computer cluster of 18 Linux systems (36 CPUs) connected with a dedicated, switched, copper Gigabit Ethernet intranet and a second dedicated computer server cluster of 16 Linux systems (32 CPUs) connected with a dedicated, switched fiber-optic Gigabit Ethernet intranet. An additional 78 computers are used as compute servers, web servers, database servers, file servers, workstations, laptops, and for other developmental and experimental needs.

Biomechanics of Soft Tissues Laboratory

The Biomechanics of Soft Tissues Laboratory (BioMOST) seeks to leverage principles from biomechanics, biomaterials, and medical imaging to develop tools for plumbing the human body with a focus on the heart, arteries, and lungs. It houses a ViVitro Pulse duplicating left-heart simulating flow loop system, mechanical extension testers, durability testers for accelerated testing of valves, flow loop with programmable pump, resisters and compliance chambers, optical micrometer, a furnace for nitinol shape memory alloy stent fabrication, and the Vascular Simulations Replicator (a portable realistic angio-suite friendly blood flow simulator). The lab also houses high-end image and data processing workstations.

Bioinspired and Bioengineered Microsystems Laboratory

The Bioinspired and Bioengineered Microsystems Lab is interested in exploiting bioinspired and multidisciplinary approaches (cellular, material, and bioengineering) to help understand respiratory diseases and develop effective treatments and accessible diagnostic tests to benefit patients. Structural and proteinaceous materials, such as silk fibroin, are a central research focus, as these materials enable aqueous and ambient processing, facilitate host-implant integration, and exhibit rare immunogenicity, a promising alternative to most synthetic polymers.

The laboratory is equipped with major equipment for material and bioengineering research, including a Leica Stellaris 5 confocal microscopy, a Cellink Inkcredible 3D printer, an Eppendorf 5804R centrifuge, a Laurell spin coater, an OptiMelt Automated Melting Point System, a Class 100 vertical laminar chamber, and a SpectraMax iD3 microplate detection system. The lab also has access to other shared equipment, including a biosafety hood, CO2 incubators, a chemical fume hood, -80°C and -20°C freezers, a fridge, an ice machine, a Thermofisher Barnstead water purification system, and a Tuttnauer 2540E autoclave.

Carver Laboratory for Regenerative Engineering and Translational Science

The Carver Laboratory for Regenerative Engineering and Translational Science is a state-of-the-art multi-investigator wet laboratory devoted to cell and tissue-based research. Housed within this facility are the 3MT (multi-scale mechanics, mechanobiology, and tissue engineering) lab and Worthington lab.

The laboratory is equipped with major equipment to synthesize and characterize biomaterials, including a chemical fume hood, rotary evaporator, freeze-dryer, rheometer, and several light-based curing systems. To enable the growth, maintenance, and characterization of mammalian cells, the lab also houses biosafety cabinets, incubators, a transfection system, an automated cell counter, a low-volume spectrophotometer, a microplate reader, thermal cyclers, quantitative polymerase chain reaction (PCR) instruments, electrophoresis units, and a gel imaging system. The dedicated microscope room includes an atomic force microscope and several fluorescent microscopes, which are equipped with confocal and live cell imaging capabilities.

Computational Laboratory

The Collaborative Computational Laboratory is a shared research computing resource, providing space and computational equipment for research in several fields, including computational fluid dynamics, medical image analysis, magnetic resonance imaging, machine learning, computational neuroscience, and artificial intelligence. Desktop computers, compute servers, and access to the campus research data storage and high-performance computing cluster are available through the lab.

Computational Biomolecular Engineering Laboratory

The Computational Biomolecular Engineering Laboratory focuses on molecular biophysics theory and high-performance computational algorithms used for engineering drugs and organic biomaterials. Located in the Bowen Science Building, the lab is a collaboration between the Roy J. Carver Department of Biomedical Engineering and the Department of Biochemistry and Molecular Biology. It includes eight workstations used to simulate biomolecular phenotypes in the context of understanding the genetics of hearing loss, autism spectrum disorder, and vision loss. Heavy use is made of the University of Iowa Argon compute cluster, including dedicated availability of 22 compute nodes, 76 Nvidia graphics processing units (GPUs), and 100 terabytes of backed-up storage. The lab distributes a high-performance physics-based molecular simulation code called Force Field X (FFX) that is being used to produce a family of protein structures for genes associated with hearing loss, available in the Deafness Variation Database. The software is also used to predict how pharmaceuticals crystalize (i.e., into drug tablets) and to understand their thermodynamic properties (e.g., solubility).

Computational and Experimental Neuroplasticity Laboratory

The Computational and Experimental Neuroplasticity Laboratory (CENlab) is a multidisciplinary research group devoted to investigating the biophysical and biochemical mechanisms of long-term memory storage in neurons and networks. The computational research takes place in the Collaborative Computational Laboratory. The experimental research, located in the Bowen Science Building, utilizes a whole cell patch recording rig, comprised of a vibration isolation table with faraday cage, IR-DIC microscope, temperature controller, LED light source for optogenetics, two micromanipulators, and a low-noise, ultra-fast, digital patch clamp amplifier with integrated A-D connected to a Windows computer for computerized experimental control and data acquisition. In addition, the laboratory contains a fume hood, vibratome, analytical balance, heating stir plate, and a refrigerator for solution and tissue preparation.

Orthopedic Biomechanics Laboratory

The Orthopedic Biomechanics Laboratory is located in the medical center in North Liberty. The purpose of the laboratory is macroscopic-level physical testing of musculoskeletal constructs (e.g., bones, articular joints, orthopedic implants) and corresponding computational modeling. The physical testing area includes a multipurpose wet lab, a multipurpose dry lab, a surgical preparation room, a mechanical testing room, a machine shop (includes a mill, lathe, and a 3D printer), and a specimen storage area. There is designated space for computational modeling as well as offices for faculty, research staff, students, and fellows.

Pulmonary Microfluidic Laboratory

The Pulmonary Microfluidic Laboratory integrates micro-engineering methods with biology to understand airway physiology, treat pulmonary disease, and improve human health.

Regenerative Engineering Laboratory

The Regenerative Engineering Laboratory inhabits over 1,000 square feet of the Pappajohn Biomedical Discovery Building. The lab leverages the principles of regenerative medicine to promote healing and resolution of disease in vivo and to build better models of human tissues in vitro. The lab is fully equipped to support research at the interface of materials, engineering, and cell biology. The Biosafety Level 2 (BSL-2) cell culture room in the lab has two Panasonic cell culture incubators, two Thermo Scientific biological safety cabinets, a fluorescent microscope, a 37°C bead bath, and centrifuges. A separate four-color fluorescence microscope is also available. The fully automated Leica DMI6000 captures four-color fluorescence images at up to 63x magnification. A built-in z-motor and post-acquisition analysis software allow for the capture and analysis of three-dimensional z-stacks.

The chemistry portion of the lab is equipped for biodegradable particle synthesis and analysis. In addition to a fume hood, sink, and laboratory counters, the lab has an analytical grade Mettler Toledo XS64 balance, water bath sonicator, homogenizer, syringe pumps, and a LabConco -86°C Cascade

Lyophilizer. To support long-term storage of the reagents required for the molecular biology and chemistry portions of the lab, a variety of cold storage options are available, including 4°C, -20°C, -80°C, and -130°C.

Respiratory Dynamics Laboratory

The Respiratory Dynamics Laboratory, located in Seamans Center, uses multiscale dynamic imaging and biomechanics to learn how lung structures move, stretch, and transport gas during breathing and mechanical ventilation. The facility houses equipment for isolated lung preparation and imaging, including a laminar flow clean bench, a dissecting microscope, an isolated organ perfusion system, purpose-built mechanical ventilators, and a high-resolution x-ray micro-CT scanner. The lab maintains an array of supplies and equipment for electropneumatic control and measurement of respiratory gas flows and pressures. The facility also includes pressurized air and vacuum outlets, a chemical fume hood, biosafety cabinet, ice machine, water purification system, and cold storage at 4ºC, -20ºC, and -80ºC.

Spine Biomechanics Research Laboratory

The Spine Biomechanics Research Laboratory is equipped for interdisciplinary research. The lab's MTS Bionix servohydraulic testing equipment (with extended columns) permits the application of uniaxial tension or compression together with axial torsion under displacement or load control. The lab also has a fully automated three-dimensional motion measuring system. These devices are used to test the mechanical properties of biomechanical joints and tissues and for biomechanical evaluation of the performance of surgical treatment modalities. Other equipment includes digital cameras, surgical tools, and sensors (i.e., linear variable differential transformers, six-degrees-of-freedom load cell, pressure transducers, and digital inclinometers).

A biaxial biomechanical culture system is available for application of controlled compression and/or shear forces onto the intervertebral disc during culture in order to investigate the disc's biological responses to mechanical loads. This culture system is used in conjunction with an incubator in which cells and tissues can be cultured. Basic equipment for histology and immunohistochemical analyses includes a microtome, ovens, a microscope, and glassware for chemical processes.