Roy J. Carver Department of Biomedical Engineering

Chair

- Joseph M. Reinhardt

Undergraduate major: biomedical engineering (B.S.E.)
Graduate degrees: M.S. in biomedical engineering; Ph.D. in biomedical engineering
Faculty: https://bme.engineering.uiowa.edu/people
Website: https://bme.engineering.uiowa.edu/

Facilities

Undergraduate Teaching Laboratories

Seven dedicated undergraduate teaching laboratories are associated with the required and elective courses in biomedical engineering: the Bioimaging and Bioinformatics Laboratory; the Biomechanics and Biomaterials Laboratory; the Carver Biomechanics and Mechanobiology 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 Bioinformatics Laboratory

The Bioimaging and Bioinformatics Laboratory provides computer and experimental equipment to allow students to become familiar with biomedical imaging hardware and software for biomedical image analysis. The laboratory has four lab benches with computers for teamwork, two desktop ultrasound machines, and two desktop magnetic resonance imaging devices. 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 verses 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, and for senior design projects.

Biomechanics and Biomaterials Laboratory

The Biomechanics and Biomaterials Laboratory is equipped 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; two cone-and-plate viscometers; compact stress-strain devices for characterizing cardiovascular tissues; goniometers; human structures biomechanical modeling sets and associated sensors; digital still, video, and motion-capture 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, and senior design projects.

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 with a mission to enhance teaching, training, and research in the field of biomechanics and mechanobiology. Biomechanics and mechanobiology involve the study of how cells, fluids, tissues, and organs respond to physical forces. The lab contributes to the understanding of cardiovascular disease, cancer metastasis, wound healing, medical device function, and stem cell therapies.

The lab houses a planar biaxial stress-strain test apparatus, a pulse duplicator apparatus for characterizing blood flow through mechanical and tissue heart valves, a micron-resolution particle image velocimetry (micro-PIV) system for quantifying flow and particle dynamics at the microscale, a stent crimper for characterizing vascular stent designs, a multimode plate reader for quantifying cell activity and extracellular matrix (ECM) remodeling, a lyophilizer for quantifying elastin and collagen content in soft tissue samples, a micromanipulator for performing micropipette aspiration studies, and a controlled microscope room for imaging live cells over long durations. The lab is used for courses in cardiovascular biomechanics and cellular engineering, other elective courses, 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, microscopes, an automated microplate reader, and various support apparatus used in cell-based studies. This teaching lab is used for the courses, BME:2400 Cell Biology for Engineers and BME:5421 Cell Material Interactions.

Carver Medical Device Design Laboratory

The Carver Medical Device Design Laboratory provides a space for students to gather to collaborate on the design of medical implants, fixtures for testing such implants, and software for modeling, analyzing, and optimizing the function of these devices. Space and equipment are provided for progressing from a back-of-the napkin sketch to a finalized computer-aided design (CAD) model and through multiple iterations of physical prototypes.

A variety of tools and equipment are available such as a micro 24 laser system, a benchtop milling machine, a bandsaw and lathe, a soldering station, an expanded plasma cleaner, a micro pulse arc welder, and five computer workstations. The lab was established to serve students with an interest in medical device design and in required and elective courses in the areas of biomaterials, biomechanics (cardiovascular and musculoskeletal), and the senior design sequence.

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 electronics measurement devices, soldering tools, Dremel tools, 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 is equipped to measure biomedical variables of clinical and physiological interest, to design and build electronic instrumentation, and to conduct modeling experiments in physiology. The lab is designed to give practice in designing and building electronic circuits to measure, acquire, and analyze signals; and acquire and analyze images. It is used for the elective courses, BME:2200 Systems, Instrumentation, and Data Acquisition and BME:4710 Medical Device Design Studio, for biomeasurements and biological systems analysis, and senior design projects.

Research Facilities and Laboratories

Bioinformatics and Computational Biology Laboratory

The Bioinformatics and Computational Biology Center 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) houses 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.

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. The laboratory is a transformational space that enables the biomedical engineering faculty and students (graduate and undergraduate research assistants) to interact with one another by bringing together investigators with similar yet varying fields of study, all with an emphasis on cellular and tissue engineering. The laboratory has a direct impact on training graduate students and contributes to numerous research projects across campus. The laboratory has 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.

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 growth, maintenance, and characterization of mammalian cells, the lab also houses biosafety cabinets, incubators, a transfection system, automated cell counter, low-volume spectrophotometer, 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.

Collaborative Computational Laboratory

The Collaborative Computational Laboratory is a shared research computing resource. Research focus areas include computational fluid dynamics, medical image analysis, magnetic resonance imaging, machine learning, 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, located in the Bowen Science Building, 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, rare renal diseases, and vision loss. Heavy use is made of the University of Iowa Argon compute cluster, including dedicated availability of 30 compute nodes, 50 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 also is being used to predict how pharmaceuticals crystalize (i.e., into drug tablets) and to understand their thermodynamic properties (e.g., solubility).

Large Scale Digital Cell Analysis Laboratory

The Large Scale Digital Cell Analysis System (LSDCAS) is an automated microscopy system designed to perform non-perturbing live cell imaging. LSDCAS has been used in studies designed to determine mechanisms of cell death following treatment with anti-cancer therapies. Current studies involve the adaptation of the LSDCAS technology toward the development of automatic single-cell analysis techniques to be used in drug discovery. LSDCAS consists of two computer-controlled inverted Hoffman modulation contrast microscopes outfitted with environmental control chambers, motorized stages, shutters, focusing systems, and high-resolution digital camera systems.

LSDCAS is housed in a dedicated microscopy room that provides the dark environment necessary for systems that operate around the clock automatically recording cell growth and other phenomena. LSDCAS data is stored and analyzed using a data center consisting of an 8 processor Linux server with 16 gigabytes of RAM, a 30 terabyte hardware RAID storage system, and a 30 terabyte robotic tape backup system. Web application software and many other programs provide robust analysis capabilities for the large variety of data produced by the system. The LSDCAS code base contains over one hundred thousand lines of program code developed over the past two decades to provide automatic single cell analysis capabilities of general interest in cell biology. In addition, the lab has equipment and technologies generally used in cell and molecular biology, including protein and nucleic acid gel electrophoresis analysis systems, real-time reverse transcription polymerase chain reaction (RT-PCR) systems, cell culture incubators, a laminar flow cell culture biosafety cabinet, a chemical fume hood, -80°C freezer, other refrigerators and freezers, an ice machine, water purification system, autoclave, and many other tools, reagents, and devices.

Orthopedic Biomechanics Laboratory

The Orthopedic Biomechanics Laboratory occupies 20 rooms on the ground floor of Westlawn. It is configured primarily for macroscopic-level physical testing of musculoskeletal constructs (e.g., bones, articular joints, orthopedic implants) and for 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, and a specimen storage area. The computational modeling area is arranged around eight separate workstation seats in two adjoining partially partitioned areas. Adjacent to these core operational areas are offices for faculty, research staff, students, and fellows; a secretarial/reception area; a conference room; and a library.

Regenerative Engineering Laboratory

The Regenerative Engineering Laboratory inhabits over 1,000 square feet of the Pappajohn Biomedical Discovery Building. 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, 37°C bead bath, and centrifuges. A separate four-color fluorescence microscope also is 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 allows for the capture and analysis of three-dimensional z-stacks.

The chemistry part 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.

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 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 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, 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.