With two medical schools, nursing, veterinary medicine — along with engineering and the new Department of Computational Mathematics, Science and Engineering — MSU has many assets to leverage to become a leader in research and development in biomedical engineering.

Christopher H. Contag, Director
MSU Institute for Quantitative Health Science and Engineering

engages faculty across disciplines, departments, and colleges to explore the intersection of medicine, human biology, and engineering research, design, and practice.

Transdisciplinary programs will be essential in the development of new areas of research. Engineering faculty within the MSU departments of Mechanical Engineering, Chemical Engineering and Materials Science, Electrical and Computer Engineering, and Biosystems Engineering, as well as in the newly created Department of Biomedical Engineering, work to develop new methods for understanding, diagnosing, and treating medical conditions, and

BIOMEDICAL ENGINEERING
at Michigan State University

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translating discoveries from the laboratory to the classroom and the clinic.

Biomedical research and resources of the College of Engineering are enhanced by collaborations with many other MSU units, including the Colleges of Human Medicine, Osteopathic Medicine, Veterinary Medicine, Nursing, Natural Science, and Communication Arts and Sciences.

The new MSU Institute for Quantitative Health Science and Engineering — a collaboration between the Colleges of Engineering, Human Medicine, and Natural Science — is an interdisciplinary research center devoted to basic and applied research at the interface of life sciences, engineering, information science, and other physical and mathematical sciences.

We’ll help you get ideas to market. MSU also provides a host of services to help your healthcare solutions make it to market. The MSU Innovation Center houses MSU Technologies, Spartan Innovations, and MSU Business CONNECT in support of entrepreneurship — facilitating technology transfer, and providing the educational and financial support to turn your research technologies into successful businesses.

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Christopher Contag, the inaugural James and Kathleen Cornelius Endowed Chair, leads MSU’s Institute for Quantitative Health Science and Engineering, and is chair of the Department of Biomedical Engineering. A pioneer in molecular imaging, he is developing imaging approaches aimed at revealing molecular processes in living subjects, including humans, and the earliest markers of cancer. Through advances in detection we can redirect healthcare from precision medicine to precision health and aim our new therapies at early disease and restoration of health.

Contag joined Michigan State University in November 2016 as the inaugural director of the Institute for Quantitative Health Science and Engineering and chairperson of the new Department of Biomedical Engineering. He was previously at Stanford University as a professor in the departments of Pediatrics, Radiology, Bioengineering, and Microbiology and Immunology. At Stanford he held the titles of associate chief of Neonatal and Developmental Medicine, director of Stanford’s Center for Innovation in In Vivo Imaging, and co-director of the Molecular Imaging Program.
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Environmental factors + the genetic landscape contribute to regulation and control of stem cell differentiation, development, and disease.

Sudin Bhattacharya
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Sudin Bhattacharya is an assistant professor in the Departments of Biomedical Engineering and Pharmacology & Toxicology. His research at the interface of computation and biology uses quantitative tools to study the signaling and transcriptional networks that regulate cell fate, and the perturbation of these networks by environmental pollutants. His group is integrating diverse genomic data sets to map and model transcriptional regulatory networks and their environmental perturbation in the immune system and the liver. They are also interested in pharmacokinetic modeling and development of multiscale “virtual tissue” models.

Prof. Chan is pioneering work at the interface of biology, chemistry, chemical engineering, and computer science, in an integrative approach to studying medical and biological problems. Her research focuses on bioinformatics and systems biology, as well as cellular and molecular engineering to analyze cellular processes and disease mechanisms. Her lab works to understand how molecular and environmental events influence one another within a system, and together provide information that can improve the precision with which patients are categorized and treated.

Christina Chan
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Computed epigenetic landscape underlying cell fate specification.

Environmental factors + the genetic landscape contribute to regulation and control of stem cell differentiation, development, and disease.
Assaf Gilad

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Professor Gilad’s lab focuses on building biological devices. His team is developing innovative technologies to replace electronic devices with live (stem) cells and tissue. They seek to identify rare genes in nature and engineer them to perform new tasks that currently performed by electronic circuits. They reverse-engineer synthetic genes based on desire function to preformed biomedical applications such as probing intracellular signaling and differentiation. Prof. Gilad recently moved to MSU from Johns Hopkins University.

Marcos Dantus

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www2.chemistry.msu.edu/faculty/dantus/

Photons provide an ideal means to diagnose and treat disease. Dr. Marcus’ research group develops lasers and optical systems optimized for sensing disease markers, non-invasive imaging at the subcellular level, and for ablating tissue. Their technical expertise focuses on ultrafast computer controlled lasers and nonlinear optics. They have developed optical biopsy approaches capable of unstained tissue/chemical specific sensing using our computer optimized laser pulses.

Top: Multimodal tissue/chemistry selective nonlinear optical imaging of an unstained breast cancer tumor. All images are taken from the same region. Bottom: Ultrafast femtosecond fiber laser designed in our laboratory being optimized by a computer controller (MIIPS Box) designed and commercialized by our group.

Xuefei Huang is a professor in the Departments of Biomedical Engineering and Chemistry. The multi-disciplinary approach of his group interfaces biology, chemistry, and engineering. A particular emphasis is on an important class of biomolecules — i.e., carbohydrates, which play roles in many biological processes including inflammation, tumor development, and bacterial and viral infections. His research program encompasses several areas including synthetic chemistry, nanoscience, and immunology to develop next-generation tools for diagnosis and treatment of diseases.

Masako Harada

haradam1@msu.edu

Prof. Harada’s current research involves understanding the biology and the function of extracellular vesicles (EVs) both in physiological and pathophysiological condition, aiming to develop a novel tool for disease diagnosis and treatment. Engineered EVs are used for visualization, monitoring, and targeted delivery of oligonucleotide therapeutics, including non-coding RNAs (microRNAs), DNAs, and CRSPR-CAS, as well as low-molecular-weight drugs to develop an advanced therapeutic approach. The ultimate goal of her research is to translate basic scientific findings into clinical applications.

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Novel immunotherapy significantly reduced the growth of solid tumor.

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Synthetic biological circuits are manufactured by combining several genes in a fashion similar to electronic circuits. Bioengineering of those genes allows manipulation of the output signal.
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![Chemical transfection vs. EV-mediated RNA transfer (top); in vivo model of engineered EV for targeting and visualization (bottom).](image)

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Prof. Lillehoj’s research interests include microfluidic biosensors, lab-on-a-chip, and point-of-care diagnostics. Specifically, his work focuses on the development of microsystems for current and emerging applications in disease diagnosis, food/water safety, and biosecurity. He also has interests in the development of simple and low-cost technologies for sample preparation and bioprocessing, and innovative approaches to manufacture disposable biosensors for global healthcare diagnostics.

Prof. Lee’s broad research interest is in computational mechanics. His current research focus is in the development of computational cardiovascular models that integrate clinical and experimental data. These include models that couple multiscale cardiac electrophysiology, mechanics, and long-term growth processes. The ultimate goal is to use these computational models to better understand the mechanisms behind heart diseases so that better treatments can be developed.

Wen Li’s broad research interests include inorganic and organic MEMS/NEMS technologies and systems, micro-/nano-sensors and actuators, neuroprosthetic devices, microsystem integration, and polymer-based biocompatible packaging technologies. Her current work is focused on developing highly miniaturized, implantable, hybrid systems for seamless communication with nervous systems.

Fiber stress in the heart of a pulmonary hypertensive patient.

Implantable, diamond-based neural probe (top) and LED-coupled optical waveguide array for optogenetic neuromodulation (bottom).
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Prof. Pelled’s research focuses on understanding how injury changes neuronal connections, how these changes affect neurorehabilitation, developing novel neurostimulation technologies, and testing how neuromodulation can facilitate recovery. The team studies the neuronal system at the single neuron level all the way up to the whole organism level with multimodal methods and a holistic approach. Before Prof. Pelled joined Michigan State University she was a professor at Johns Hopkins School of Medicine.
Prof. Purcell’s research is focused on improving the integration of electrodes implanted in the brain with the cells they interface. These devices are used in research settings to understand brain function and in the clinic to treat neurological disorders. Current lab projects employ novel optical approaches to pattern neural circuits from non-neuronal cells, develop new approaches to understand device-tissue integration, and create techniques to genetically modify cells at the electrode interface.

Non-neuronal cells are genetically reprogrammed to adopt the appearance and signaling characteristics of neurons.

Prof. Bush uses in vivo experiments, methods development, and modeling to understand clinically motivated problems connected with human movement and force generation. Dr. Bush’s team is involved in numerous research projects including: mechanics of lower leg prosthetics, seating mechanics (office and automotive), hand function (healthy and arthritic), soft tissue studies, and pressure ulcer formation.

Collection of hand kinematics for patient assessment and model development.
Dr. Reimers integrates statistical analysis with biological theory while analyzing and interpreting the very large data sets now being generated in neuroscience, especially from the high-throughput technologies developed by the BRAIN initiative. He focuses on analysis of new technologies such as measuring brain activity by light, and motion capture. He also analyzes large gene expression and regulation datasets to understand mental illness.

The Molecular and Cellular Imaging Laboratory (MCIL) develops and uses magnetic resonance imaging (MRI) and x-ray computed tomography (CT) for molecular and cellular imaging of biological phenomena, regenerative medicine, and early detection of disease. The MCIL has three main cores: developing novel nanoparticle contrast agents for MRI and CT; using molecular and cellular imaging for monitoring cell migration, such as after stem cell transplant; and using targeted contrast agents to detect specific molecular epitopes, such as in cancer.

Magnetic and fluorescent polymer nanoparticles are fabricated and can be used to label stem cells, which can be detected by MRI.
A schematic of our deep sequencing pipeline to assess the sequence determinants to protein function.

The Spence group is investigating and defining new roles for red blood cells in such autoimmune diseases as Type 1 diabetes and multiple sclerosis. Key to our studies is C-peptide, the 31-amino acid peptide that is co-secreted with insulin from the pancreatic β-cells. When formulated correctly, preliminary evidence from our lab suggests that this peptide may be the missing link in complications associated with both diseases listed above. Importantly, we develop new technologies using 3D printing to facilitate our studies and help answer important biomedical questions.

A 3D printed device helps monitors cell-to-cell communication between pancreatic secretions and the circulation on a controlled in vitro platform.

Prof. Whitehead’s laboratory focuses on protein engineering and design, biomolecular recognition, renewable energy production, antibody and antibody mimics, antigen design, synthetic biology, and biochemical engineering. His group has pioneered experimental approaches to assess the effect of a protein’s sequence on its desired function, and have imparted evolutionary and computational ideas to formulate efficient routes to optimize protein function. They are now interested in developing proteins for diverse applications like vaccine design and creating the next generation of biofuels.
A schematic of our deep sequencing pipeline to assess the sequence determinants to protein function.

Tim Whitehead
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www.egr.msu.edu/whitehead-lab

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Dana Spence
dspence@chemistry.msu.edu

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Mark Worden
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R. Mark Worden is Associate Chair of MSU’s Biomedical Engineering Department. He has a bachelor’s degree with a double major in chemistry and cell biology, and master’s and doctorate degrees in chemical engineering. Dr. Worden has developed several interdisciplinary programs that integrate research and education. His research on nanostructured biointerfaces and multiphase biocatalysis has resulted in over ten patents issued or pending on technologies including microbiosensors, bioelectronics, and multiphase bioreactors.

Schematic showing diverse ENM interactions with a bilayer lipid membrane (in form of a liposome), including (A) aggregation in the bilayer forming a disruptive nanopore; (B) adsorption to and potential deformation and modification of phase behavior of bilayer; (C) high aspect ratio ENM (i.e., carbon nanotube) penetration and disruption of bilayer; (D) ENM partitioning into the hydrophobic core of the bilayer; and (E) single particle disrupting bilayer forming nanopore and possibility for increased permeability to molecules and ENM.

Kurt Zinn
kurtzinn@gmail.com

Prof. Zinn develops translational approaches that have great potential to positively impact human health, emphasizing preclinical animal models that can enable phase I clinical trials. Areas of focus include early detection of cancer, monitoring effective therapy, and development of novel therapeutics for cancer and neurodegenerative diseases. Appropriate molecular imaging modalities are applied to monitor delivery of the therapeutic agents, and to assess their treatment efficacy.

Imaging gene transfer of the type 2 somatostatin receptor (hSTTr2). Arrows show the location of the non-small cell lung tumor on the CT image (left) and hSSTr2 expression on the fusion image (right).
BIOMEDICAL ENGINEERING at MSU is poised for rapid and significant growth.

GRADUATE OPPORTUNITIES
A new PhD program in the Department of Biomedical Engineering began matriculating its first graduate students in the fall of 2016. A Master of Science program has since been added. In addition, Biomedical graduate students and post-docs can apply for the MSU Broadening Experiences in Scientific Training (BEST) program.

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Participation in MSU BEST offers biomedical graduate students and post-docs a unique opportunity to, as a complement to their academic and scientific training, develop a parallel set of skills and experiences which will position them for a wide variety of career options, including academic, government, industry, nonprofit, law, and other fields.

If you are interested in learning more about this program or would like to apply to the MSU BEST program, please visit http://best.msu.edu/

STATE-OF-THE-ART FACILITIES
The opening of the 130,000-square-foot Bioengineering Research Facility in October 2016, marked the start of a new era of scientific research at MSU.

The facility is located on the south side of campus and brings together engineers and basic science researchers with medical researchers to help solve some of the world’s biggest challenges. The facility’s laboratory space is designed to integrate bench experiments and computational analysis to allow a systems approach to biomedical research, as well as space for an on-site imaging facility.

The laboratories have an open-floor design to enhance collaborative research. The modular construction of the labs will provide flexibility as the nature of research evolves over the years. In addition, the building connects to both the Clinical Center and Life Sciences buildings, and is in proximity to the Radiology building, facilitating the sharing of core resources and establishing a biomedical research hub on campus.

The facility also houses the new IQ: Institute for Quantitative Health Science and Engineering, for which Dr. Contag serves as inaugural director. 🌟
FOR MORE INFORMATION
ABOUT BIOMEDICAL ENGINEERING AT MSU

■ FACULTY POSITIONS

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■ GRADUATE STUDIES

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