MIT ILP
INDUSTRIAL LIAISON PROGRAM

# INDUSTRY BRIEF

## LIFE SCIENCE AND HEALTHCARE INDUSTRIES

*New and emerging technologies are creating transformative opportunities for the life sciences and health care industries. The pace and extent of change offered by these technologies in these industries impact a breadth of areas, including the use of big data and AI, changing regulatory environment and geopolitics, aging population, personalized medicine, medical devices, drug development and production, etc.*

*What makes MIT unique in its ability to generate advances in the aforementioned fields?*

- MIT is a world class research university: The 2018 QS World University Rankings identified MIT as the #1 university in the world in engineering and technology as well as the natural sciences.
- MIT is solutions-focused, entrepreneurial, and impact driven: As of 2014 MIT faculty and alumni had founded more than 30,000 companies and continue to spin-out 80-100 new companies each year.
- MIT is at the center of the Boston/Cambridge innovation ecosystem: Its ability to engage and leverage this ecosystem is unmatched.
- MIT is a convener of global thought leadership: Through this network MIT helps address strategic and technical solutions to the major challenges facing society.
- MIT's interdisciplinary culture: Allowing thought leaders from multiple disciplines and fields to collaborate freely and reach for the previously unimaginable.

MIT Corporate Relations provides access to MIT through two integrated programs, the MIT Industrial Liaison Program (ILP) (ilp.mit.edu) and MIT Startup Exchange (startupexchange.mit.edu)

In the following pages, a selection of MIT centers, departments, groups, and labs are presented. These entities are actively involved with research and education related to topics of relevance to the defense industries bulleted below.

- Bioengineering
- Bioinformatics, Computation, Data
- Biomaterials, Biosensors
- Bio Micro- and Nano-technologies
- Brain & Neuroscience
- Drug and Medical Device Development
- Genomics, Microbiome
- Imaging, Lasers, Spectroscopy
- Machine Learning /Intelligence, AI
- Medical Diagnosis and Therapeutic Intervention
- Medicine, Engineering, and Science
- Pathology: Cancer, HIV, Other
- Sensory Research: Speech & Hearing Science
- Synthetic Biology / Systems Biology
- Wellness / Lifestyle Issues

# INDUSTRY BRIEF

## LIFE SCIENCE AND HEALTHCARE INDUSTRIES

Below are brief descriptions of a selection of MIT centers, departments, groups, and labs conducting research and education in these areas.

Please note that this is not a comprehensive summary of research being conducted at MIT in the topic areas listed above and that some of these groups may fit within multiple topic areas.

MIT's Industrial Liaison Program (ILP) can bring the intellectual power of MIT to your organization by providing a direct connection to the knowledge, experience and resources at MIT in these fields--giving you the ideas to stay ahead.

For more information about how the ILP can put the resources of MIT to work for you, call us at 1-617-253-2691, e-mail us at ilp-info@mit.edu, or visit ilp.mit.edu/.

## BIOENGINEERING

The **Center for Biomedical Engineering (CBE)** focuses at the interface between engineering and molecular and cellular biology to develop new approaches to biomedical technology with applications to medicine and biology. CBE facilitates interdepartmental, multidisciplinary approaches to biomedical research to create an outstanding training environment for a new generation of students/leaders in Bioengineering. CBE has been a leader in tissue engineering at MIT by making fundamental discoveries in mechanobiology with advances for applications in musculoskeletal and cardiovascular tissue repair. Other initiatives focus on the structure and function of biomembrane proteins for applications in sensors.

The **Center for Extreme Bionics** is driven by addressing questions such as the possibility of inventing and deploying novel technologies that could control biological processes within the body in order to repair or even eradicate them; and, What if there were no such thing as human disability? These questions drive the work of the Center's researchers. This dynamic interdisciplinary organization draws on the existing strengths of research in synthetic neurobiology, biomechatronics, and biomaterials, combined with enhanced capabilities for design development and prototyping.

The mission of the **Department of Biological Engineering (BE)** is to educate leaders and generate new knowledge at the interface of engineering and biology. Research areas in which BE faculty are recognized as pioneering leaders include: Biomaterials; biophysics; cell & tissue engineering; energy; environment; microbial systems; macromolecular biochemistry; nanoscale engineering; pharmacology; synthetic biology; systems biology; toxicology; transport phenomena.

## BIOINFORMATICS, COMPUTATION, DATA

The aim of the **Clinical Decision-Making Group** is to bolster the urgent and critical nature of medical practice and timely clinical decision-making. The group's methods include improving the gathering, availability, security and use of medical information throughout the human life-cycle and beyond. Some recent work includes establishing a scalable informatics framework, creating advanced ICU patient-monitoring systems, implementing tools and techniques to "read" text from clinical data, and developing personal medical-record systems for patients.

The **Computational Biophysics Group** is focused on three areas: 1) Understanding conformational changes in biomolecules that play an important role in common human diseases, 2) Using machine learning to develop models that identify patients at high risk of adverse clinical events, and 3) Developing new methods to discover optimal treatment strategies for high risk patients. The group uses an interdisciplinary approach combining computational modeling and machine learning to accomplish these tasks.

The **Computational Cognitive Science Group** studies the computational basis of human learning and inference. Through a combination of mathematical modeling, computer simulation, and behavioral experiments, the group works to uncover the logic behind everyday inductive leaps: constructing perceptual representations, separating "style" and "content" in perception, learning concepts and words, judging similarity or representativeness, inferring causal connections, noticing coincidences, predicting the future.

The **Computational Connectomics Group**'s goal is to create, based on such microscopic connectivity and functional data, new mathematical models explaining how neural tissue computes. Modeling spans the connectomics gamut from the behavior of individual neurons in exiguous circuits to collections of neurons in increasingly complex networks. The group collaborates with neurobiologists to design experiments based on its theoretical models, and works to analyze the resulting data in order to confirm or disprove theoretical predictions.

The **Integrative Neuromonitoring and Critical Care Informatics Group** leverages data and models to understand the physiology of the injured brain, to improve diagnoses, and to accelerate treatment decisions for the critically ill. To achieve these objectives, the group leverages critical care data and mathematical models derived from physiology, along with signal processing and estimation methods, to extract relevant information from clinical data. The models provide the constraints that allow readily observable data streams to be related to physiological variables and parameters that are unmeasured but more directly reflective of changes in pathological state.

The **Laboratory for Computational Immunology** is focused on understanding the mechanistic underpinnings of the adaptive immune response to pathogens and to harness this understanding to help design better vaccines and therapies. Lab members work on developing and applying theoretical and computational approaches (rooted in statistical physics) to study the collective, dynamic, and stochastic processes that underlie a systemic immune response. Interests are divided into three broad categories: understanding the network of biochemical interactions that enable T cells to translate engagement of membrane receptors to cognate ligands in to functional responses, how T cell development results in T cells that are specific for unknown and emerging pathogens, and the human immune response to HIV.

The **Laboratory for Computational Biology & Biophysics (LCBB)** has the long-term mission of facilitating synthetic structural biology to impact molecular imaging and diagnostics, therapeutic delivery, vaccine development, nanoscale energy harvesting and transport, and memory storage using nucleic acids.

## BIOMATERIALS, BIOSENSORS

The **Laboratory for Atomistic and Molecular Mechanics** focuses on the development of a new paradigm to enable the design, synthesis and manufacturing of materials and structures from the molecular scale. This requires the combination of multi-scale modeling, additive manufacturing, 3D printing, and experimental synthesis, which is then applied to bio-inspired materials, biological materials, nanomaterials, and biomass materials, just to mention a few. By utilizing a computational materials science approach that includes Density Functional Theory (DFT) calculations, Molecular Dynamics (MD) simulations, coarse-grained and finite element modeling, the group aims to understand and design materials along all different length scales, from a fundamental level.

The **Olsen Group (Biofunctional and Bioinspired Materials)** focuses on engineering new biofunctional and bioinspired materials and understanding the novel polymer physics required to control the nanoscale structure and properties of these complex systems. The group's efforts are aimed at applying biological components or biological design principles to dramatically extend the capability of soft materials such as engineering plastics, energy converters, catalysts, and biomedical hydrogels. Through the study of natural polymer systems, the group also hopes to produce a new sustainable source of functional polymers.

The **Biomolecular Materials Group** evolves simple organisms using directed evolution to work with the elements in the rest of the periodic table. These hybrid organic-inorganic electronic and magnetic materials have been used in applications as varied as solar cells, batteries, medical diagnostics and basic single molecule interactions related to disease. The group has capitalized on many of the wonderful properties of biology–using only non-toxic materials, employing self-repair mechanisms, self-assembling precisely and over longer ranges, and adapting and evolving to become better over time.

The **Center for Materials Science and Engineering (CMSE)** of the MIT Materials Research Laboratory is one of a nation-wide network of Materials Research Science and Engineering Centers sponsored by the National Science Foundation. The center fosters collaborative interdisciplinary research and education in the fundamental science of materials and in the engineering of materials. Example recent projects: simple engineered biological motifs for complex hydrogel function; bottlebrush hydrogels as tunable tissue engineering scaffolds.

The **Institute for Soldier Nanotechnologies (ISN)** team of MIT, Army, and industry partners work together to create new materials, devices, processes, and systems, and on applied research to transition promising results toward practical products useful to the soldier. ISN research is organized into the following strategic areas: Soldier protection, battlefield care and sensing; augmenting situational awareness; and transformational nano-optoelectronic soldier capabilities.

The **Laboratory for Bio-Inspired Interfaces (LBI)** studies bio-inspired materials with the goal of employing design principles extracted from nature in the development of novel synthetic materials that help overcome global challenges in energy, the environment and health. Inspired by the self-healing, adhesive and tunable properties of biological material interfaces, the group designs and characterizes molecular material systems for novel uses in medicine, adhesive technology, and metal sequestration.

The **Soft Active Materials Laboratory** seeks to understand and design soft materials with unprecedented properties, such as extremely tough and strong, ultrasensitive to stimuli, programmable, biocompatible and bioactive, to merge human and machine and their intelligence. These new materials and structures capable of extraordinary applications in diverse technologies. In order to achieve this goal, the researchers are advancing fundamental science and technology on interfaces between solid mechanics, soft materials and 3D printing.

The **Department of Chemistry** program of teaching and research spans the breadth of chemistry. Current research spans the breadth of chemistry, including research in the areas of biological chemistry, environmental chemistry, inorganic chemistry, organic chemistry, materials chemistry, nanoscience, and physical chemistry. Specialized areas such as bioinorganic chemistry, biophysical chemistry, organometallic chemistry, physical organic chemistry, synthesis, surface chemistry, and chemical physics are also covered. Many fundamental discoveries made in the department have found their way into practical applications ranging from polymer synthesis to medical imaging.

## BIO MICRO- AND NANO-TECHNOLOGIES

The **Laboratory for Multiscale Regenerative Technologies (LMRT)** leverages micro- and nanotechnologies to interface living and synthetic systems toward improving tissue regeneration, disease modeling, medical diagnostics and drug delivery. The lab's long-term goals are to improve cellular therapies for liver disease and develop nanotechnology for the diagnosis and treatment of cancer.

The **Micro/Nanofluidic BioMEMS Group** is applying micro-/nano-fabrication methods to solve various technological problems. The group is focused on micro / nanofluidics, nanofluidic biomolecule separation and detection and nanostructure-biomolecule interactions.

## BRAIN AND NEUROSCIENCE

The Media Lab's **Autism & Communication Technology Initiative** fosters the development of innovative technologies that can enhance and accelerate the pace of autism research and therapy. Researchers are especially invested in creating technologies that promote communication and independent living by enabling non-autistic people to understand the ways autistic people are trying to communicate; improving autistic people's ability to use receptive and expressive language along with other means of functional, non-verbal expression; and providing telemetric support that reduces reliance on caregivers' physical proximity, yet still enables enriching and natural connectivity as wanted and needed.

The **Bioelectronics Group** is working at the interface of materials science, electronics and neurobiology with the goal of advancing understanding and treatment of disorders of the nervous system. The group designs, synthesizes and fabricates optoelectronic and magnetic devices that manipulate and record neuronal activity and development.

The **Center for Brains, Minds & Machines (CBMM)** is a multi-institutional NSF Science and Technology Center dedicated to the study of intelligence. The aim is to create a new field (Science and Engineering of Intelligence) by bringing together computer scientists, cognitive scientists, and neuroscientists to work in close collaboration in the areas of: Development of Intelligence, Neural Circuits for Intelligence, Vision and Language, Social Intelligence, Theoretical Frameworks for Intelligence and Exploring Future Directions.

The **MIT Center of Neurobiological Engineering (CNBE)** brings together MIT's transdisciplinary set of engineers and scientists to tackle the challenges of understanding the body's complex nervous system. To that end, CNBE works to create next-generation tools for comprehensive and systematic experimental investigation of the nervous system; strategies for engineering neurons, neural tissue, and their interactions with other cells, devices, and prosthetics; novel engineering-based strategies for the analysis of neural systems and data; as well as education and exchange of ideas at the interfaces between neurobiology and engineering.

The **McGovern Institute for Brain Research at MIT** is a neuroscience research institute committed to understanding the brain in health and disease. Employing the full range of modern neuroscience techniques, from molecular genetics to functional neuroimaging, and computational modeling, the Institute's research is contributing to the understanding of brain injury & neurodegenerative disorders such as Parkinson's, Alzheimer's, Huntington's, ALS, traumatic brain injury and stroke; psychiatric disorders such as bipolar, depression, schizophrenia and anxiety; developmental disorders such as autism and dyslexia; and vision loss and other sensory deficits.

The **Picower Institute for Learning and Memory** is a community of scientists dedicated to understanding the mechanisms that drive learning and memory and related functions such as cognition, emotion, perception, and consciousness. Institute researchers explore the brain at multiple scales, from genes to molecules, to cells and synapses, to circuits and systems, producing novel insights into how disruptions in these mechanisms can lead to developmental, psychiatric, or neurogenerative disease.

The **Synthetic Neurobiology Group** develops tools that enable the mapping of the molecules and wiring of the brain, the recording and control of its neural dynamics, and the repair of its dysfunction. The group distributes its tools as freely as possible to the scientific community, and also applies them to the systematic analysis of brain computations, aiming to reveal the fundamental mechanisms of brain function, and yielding new, ground-truth therapeutic strategies for neurological and psychiatric disorders.

The mission of the **Department of Brain and Cognitive Sciences (BCS)** is to reverse engineer the human mind. To do that the faculty, researchers, and students delve deeply into the mechanisms of the brain at all levels — from molecules to synapses to neurons to circuits to algorithms to human behavior and cognition, building links between those levels, and training the next generation of scientific leaders. The department's research initiatives strives to deeply understand human cognitive functions such as vision, audition, speech, movement, attention, learning and memory.

## DRUG AND MEDICAL DEVICE DEVELOPMENT

The **Analog Circuits and Biological Systems Group** performs wet molecular biology experiments in living cells and dry experiments with analog nanoelectronic chips. The group creates: novel analog synthetic biology circuits; biological and bio-inspired supercomputers based on analog computation in cells; ultra-energy-efficient and energy-harvesting systems like glucose-powered neural prosthetics; and, ultra-low-power implantable medical devices such as cochlear implants or diagnostic devices. The group's work has wide applications in medicine, biotechnology, electromicrobiology, bioelectronics, ultra-low-power, analog, and bio-inspired systems.

The mission of the **Center for Biomedical Innovation (CBI)** is to improve global health by overcoming obstacles to the development and implementation of biomedical innovation. CBI is addressing profound challenges in the global biomedical industry by developing, testing, and disseminating new knowledge and tools designed for real world application through the following programs: the Biomanufacturing Research Program, the Consortium on Adventitious Agents in Biomanufacturing, and New Drug Development Paradigms.

The mission of the **Emergent Behaviors of Integrated Cellular Systems (EBICS)** is to create a new scientific discipline for building living, multi-cellular machines that solve real world problems in health, security, and the environment through integrated research and education efforts, human resource development, diversity and outreach programs, and knowledge transfer activities. EBICS is focused on building two biological machines: BetaCell Factory, an implantable cellular machine for glucose sensing and insulin release for the treatment of diabetes; and BioBot, an autonomous cellular machine for detecting and neutralizing toxins in the environment. MIT is the lead institution.

The **Harvard-MIT Biomedical Engineering Center (Edelman Lab)** is a collaborative research environment with teams of clinicians, engineers, and scientists from both academia and industry that work together to create translatable solutions to clinically relevant problems. The lab uses elements of continuum mechanics, digital signal processing, molecular biology,

and polymeric controlled release technology, and projects range from examining the interplay between mechanical support devices and native physiology to the cellular and molecular mechanisms that transform stable coronary-artery disease to unstable coronary syndromes.

The **Medical Electronic Device Realization Center (MEDRC)** is a partnership between the microelectronics industry, the medical devices industry, medical professionals, and MIT to revolutionize medical diagnostics and treatments, bringing health care directly to the individual; and to create enabling technology for the future information-driven healthcare system. Specific areas showing promise are wearable or minimally invasive monitoring devices, medical imaging, laboratory instrumentation, and the data communication from these devices and instruments to healthcare providers and caregivers.

The **Molecular Engineering Laboratory (Trout Group)** develops and applies sophisticated computational, theoretical, and experimental methods to probe complex chemical systems on the molecular level and engineer them for high value chemical applications with maximum specificity. Applications are in the fields of continuous pharmaceutical manufacturing, stabilization and formulation of biopharmaceuticals, and nucleation and crystallization. In parallel, the group develops new computational methods that are generally applicable for the engineering of complex chemical systems.

The mission of the **Ragon Institute of MGH, MIT and Harvard** is to contribute to the accelerated discovery of an HIV/AIDS vaccine and to establish itself as a world leader in the collaborative study of immunology. The scientific leadership comprises a diverse group of world class immunologists, geneticists, infectious disease specialists, and computational and systems biologists from MIT, the Massachusetts General Hospital (MGH), Harvard, the Broad Institute, Harvard-affiliated hospitals in Boston and from other leading institutions.

## GENOMICS, MICROBIOME

The **BioMicro Center** is an integrated genomics facility that provides both expertise and equipment for systems biology. The core has significant resources in microarrays, next-generation sequencing and in high-throughput screening as well as bioinformatics and BioIT. The Center is a joint endeavor between the Departments of Biology and Biological Engineering, the Koch Institute for Integrative Cancer Research (Genomics Core and Bioinformatics and Computing Core), and the MIT Center for Environmental Health Sciences (Genomics and Imaging Facilities Core).

The **Center for Environmental Health Sciences (CEHS)** studies the biological effect of environmental agents, individually and in combination, with specific emphasis on how such exposures affect human health and the health of our ecosystem. CEHS research can be sorted into five research themes: DNA damage, DNA repair and genomic stability; inflammation chemistry and biology; microbiomes and environmentally induced diseases susceptibility; bioengineering for environmental health; and chemistry and transport of pollutants in the atmosphere, water, and soil.

The **Center for Microbiome Informatics and Therapeutics (CMIT)** is a New England regional center with the goal of improving human health by diagnosing, treating, and preventing diseases associated with the human microbiome. The center is fostering high-risk translational research designed to positively impact patient lives and collaborating on clinical studies to reveal how the microbiome impacts human physiology, immune system, metabolome, and the course of disease. Located at MIT, with co-directors from MIT and Massachusetts General Hospital (MGH), the center is dedicated to fostering and supporting a research ecosystem involving the participation of hospitals, other universities, and research institutes in the region.

The **Computation & Biology Group** focuses on designing algorithms to gain biological insights from advances in automated data collection and the subsequent large data sets drawn from them. The group works on a diverse set of problems, including compressive genomics, network inference, structural bioinformatics, genomic privacy, and medical genomics.

The **Computational Biology Group** seeks to understand the mechanistic basis of human disease, using a combination of computational and experimental techniques. Techniques involve developing methods for the systematic discovery and characterization of functional elements in the human genome, the discovery and validation of the gene-regulatory circuitry controlling these elements, the use of epigenomic information for annotating regulatory regions and their activity across different

cell types, and the use of comparative genomics for recognizing coding and non-coding regions of functional importance for evolutionary fitness. Topics include variation and disease, genome interpretation, gene regulation, epigenomics, and genome evolution.

The **Computational Genomics Group** develops new machine learning techniques and algorithms to model the transcriptional regulatory networks that control gene expression programs in living cells. The group is examining how to computationally model chromatin modifying complexes that are associated with the genome of living yeast cells. In particular, the group is investigating new modular graphical models that use mechanistic constraints to describe biological mechanism, and is also looking at how to build computational models of the transcriptional regulatory networks that control the differentiation of specific cell types.

## IMAGING, LASERS, SPECTROSCOPY

The **MGH / HST Athinoula A. Martinos Center for Biomedical Imaging** is one of the world's premier research centers devoted to development and application of advanced biomedical imaging technologies. The center's mission is to advance imaging in healthcare through technology development, translational research and education. Located on the MGH Research Campus (Charlestown, MA), the center is home to roughly 100 faculty researchers and more than 200 affiliated and visiting faculty, postdoctoral research fellows and graduate students, who use advanced imaging technologies both separately and in concert to investigate a broad range of biologically and medically important questions.

The **Martinos Imaging Center at the McGovern Institute at MIT** provides access to state-of-the-art brain imaging technologies for MIT researchers and their collaborators throughout the Boston area. The center offers a variety of imaging technologies, including human magnetic resonance imaging (MRI), small-animal MRI, electroencephalography (EEG) and magnetoencephalography (MEG). Major research themes at the center include: brain mechanisms of perception, memory, emotion, executive function and social cognition; developmental studies of children, including developmental disorders such as autism and dyslexia; and translational studies on the neural basis of many different psychiatric and neurological disorders.

The **MIT-Harvard Center for Magnetic Resonance (CMR)** focus combines expertise and instrumentation in solution-state Nuclear Magnetic Resonance (NMR), solid-state NMR, Electron Paramagnetic Resonance (EPR), Dynamic Nuclear Polarization (DNP), microwave technology, magnet design, probe and console design, synthesis of polarizing agents for DNP, and the development of biochemical labeling strategies. In essence the center's combined core and collaborative research effort covers essentially all aspects of magnetic resonance that are important for structural biology and many areas of magnetic resonance imaging.

The **Laser Biomedical Research Center (LBRC)** provides integrative photonic solutions to complex problems in biological research, pharmaceutical development, and medical diagnosis. Equally important, the center maintains a diverse array of collaborative and service research projects covering many biomedical areas that includes neuronal connectomics, liver fibrosis diagnosis, nerve regeneration imaging, improving selectivity of photodynamic therapy, sickle cell biomechanics, identifying mesenchymal stem cell, novel imaging with carbon nanotube, and developing chemometric algorithms for cancer biopsy specimens.

The **Magnetic Resonance Imaging Group** conducts investigations in medical imaging with MRI technology, focusing on optimal methods for acquisition, reconstruction and processing of in vivo imaging data. The group's interests include techniques for efficient sampling and spatial encoding of spectroscopic magnetic resonance data, whereby small signals, originating, for example, specifically from neurons in the brain, yield information not observed with conventional structural imaging. Applications of these and related methods include a study of the progression of Alzheimer's disease and characterization of multiple sclerosis.

## MACHINE LEARNING / INTELLIGENCE, AI

The Media Lab's **Health 0.0** research focuses on: 1) New models and technologies for health research; early discovery; safer and faster clinical trials; digitally empowered researchers, clinicians, regulators, and patient; and reducing healthcare costs; 2) Addressing current and near-term artificial intelligence (AI), machine learning (ML), medical imaging and neural network capabilities as they pertain to clinical development and health, and developing a sustainable model to bridge the gap between AI and data science experts and the life sciences community; 3) Encrypted ML, AI and other data sharing platforms to protect

confidential information; and 4) Collaborations with leaders and experts from MIT, government, foundations, life sciences, universities, biotechnology, and technology corporations.

**Machine Learning for Pharmaceutical Discovery and Synthesis Consortium (MLPDS)** is a collaboration between the pharmaceutical and biotechnology industries and the departments of Chemical Engineering, Chemistry, and Computer Science at MIT. This collaboration will facilitate the design of useful software for the automation of small molecule discovery and synthesis.

The **MIT Quest for Intelligence (The Quest)** will advance the science and engineering of both human and machine intelligence. Launched in February 2018, this effort seeks to discover the foundations of human intelligence and drive the development of technological tools that can positively influence virtually every aspect of society. Some of the anticipated advances may be foundational in nature, involving new insight into human intelligence, and new methods to allow machines to learn effectively. Others may be practical tools for use in a wide array of research endeavors, such as disease diagnosis, drug discovery, materials and manufacturing design, automated systems, synthetic biology, and finance.

## MEDICAL DIAGNOSIS AND THERAPEUTIC INTERVENTION

The **Consortia for Improving Medicine with Innovation & Technology (CIMIT)** is a network of world-class academic and medical institutions partnering with industry and government. The mission is to foster collaboration among clinicians, technologists, and entrepreneurs to accelerate innovation and catalyze the discovery, development, and implementation of innovative healthcare technologies. The group has created a successful model for accelerating translational medical research, devices, procedures, and clinical systems by working together with clinicians, scientists, researchers, and engineers to identify gaps, areas of unmet need, and the innovative ideas to address those gaps. Then collaboration is facilitated across institutions and with companies, foundations, and those invested new medical technologies to quickly push forward these leading-edge ideas to where they will directly impact patient care. MIT is a founding member of CIMIT.

A partnership between **MIT and Massachusetts General Hospital (MGH)** is addressing three major challenges in clinical medicine: Make diagnosis cost-effective and accurate and guide individual clinical decisions based on real-time monitoring and massive patient data sets; Enable systematic design of vaccines and therapies for existing and emerging infectious and autoimmune diseases, and the partner institutions are also collaborating through the Ragon Institute to develop an effective HIV/AIDS vaccine; and Enhance human cognitive function by developing more accurate diagnostic and therapeutic approaches for neurodegenerative and neuropsychiatric disorders.

## MEDICINE, ENGINEERING, AND SCIENCE

The **Harvard-MIT Division of Health Sciences and Technology (HST)** brings together MIT, Harvard Medical School (HMS), Harvard University, Boston area teaching hospitals in a unique collaboration that integrates science, medicine, and engineering to solve problems in human health. HST's interdisciplinary approach to biomedicine has led to stunning innovations, such as the drug regimen that transformed HIV/AIDS into a treatable disease and the first noninvasive technology for observing the brain in action.

The **Institute for Medical Engineering and Science (IMES)** is a hub that brings together the community of students, postdoctoral fellows, and faculty who work at the convergence of engineering, science, and translational medicine. IMES aims to accelerate innovation across a spectrum of activities that span discovery, design, and delivery of new medical devices and products. IMES research centers on MIT's strengths in devices, imaging, computation, big data, regenerative medicine, drug delivery, technology transfer, and entrepreneurship. IMES initiatives include the Medical Electronic Device Realization Center (MEDRC), MIT-MGH (Massachusetts General Hospital) Partnership, Center for Microbiome Informatics and Therapeutics (CMIT), and MIT's Clinical Research Center (CRC). In addition, IMES is the home for the Harvard-MIT Health Science & Technology (HST) program, which has a rich history of educating leaders in medicine and health-related technologies.

**MIT linQ** is a collaborative initiative focused on increasing the potential of innovative research to benefit society and the economy. linQ comprises a portfolio of international innovation programs focused on transforming the academic research paradigm—to accelerate the impact of research on health and wellbeing. An action-oriented organization, MIT linQ is initially focused on the

biomedical innovation; linQ's people and programs bring together healthcare, research, and business to improve healthcare through need-driven research and training.

The **Whitehead Institute for Biomedical Research** is a leading, nonprofit research and educational institution dedicated to improving human health through basic biomedical research. All Whitehead faculty are also professors at MIT. Whitehead scientists run pioneering programs in cancer research, immunology, developmental biology, stem cell research, regenerative medicine, genetics, and genomics.

The **Department of Biology** explores a wide range of fundamental biological questions with a focus on molecular cell biology at all levels, from molecular structure to human disease. For over 50 years, the department has played a central role in the growth of molecular life sciences and the revolution in molecular and cellular biology, genetics, genomics, and computational biology. Areas of research in the department include: biochemistry, biophysics, and structural biology; cancer biology, cell biology; computational biology; genetics; human disease; immunology; microbiology; neurobiology; stem cell and developmental biology.

MIT's **Chemical Engineering Department's (ChemE)** explores the terrain of chemistry, biology, and physics through groundbreaking investigation into areas such as nanotechnology, biomedical processes, molecular computation, and catalysis. Broadly, research projects fall into the areas of: Biomedical and biotechnology; catalysis and reaction engineering; energy and environment; materials; math and computational systems; and transport and thermodynamics.

The **Biomechatronics Group** seeks to advance technologies that promise to accelerate the merging of body and machine, including device architectures that resemble the body's own musculoskeletal design, actuator technologies that behave like muscle, and control methodologies that exploit principles of biological movement.

## PATHOLOGY: CANCER, HIV, OTHER

The **David H. Koch Institute for Integrative Cancer Research at MIT** brings scientists and engineers together to solve the problems of cancer. Five areas of research have been identified that the Institute believes are critical for rapid progress toward controlling cancer. Research and development in each of these target areas involves cross-disciplinary teams of faculty, students, and staff – and also encompass collaborations with clinical centers and industry: Developing nanotechnology-based cancer therapeutics; creating novel devices for cancer detection and monitoring; exploring the molecular and cellular basis of metastasis; advancing personalized medicine through analysis of cancer pathways and drug resistance; and engineering the immune system to fight cancer.

The **Center for Gynepathology Research**, co-directed by an MIT engineer and a Harvard Medical School clinician, the Center for Gynepathology Research brings together over 15 laboratories and clinical practices in the Boston area and around the world to foster both basic and clinical research in endometriosis, infertility, pre-term birth, sexually-transmitted disease, and other pathologies of the female reproductive tract.

The **Ludwig Center for Molecular Oncology** unites members of the Koch Institute and MIT's extended cancer research community in a mission to unravel the mysteries of metastasis. As part of its focus on tumor invasion and dissemination, the Center is developing new approaches in molecular imaging and cellular detection to identify sites of metastasis early in the disease course and to follow the navigation of metastatic cells throughout the body.

The **Marble Center for Cancer Nanomedicine** brings together leading faculty from the Koch Institute for Integrative Cancer Research to focus on grand challenges in cancer detection, treatment, and monitoring that could benefit from the emerging biology and physics of the nanoscale. Marble Center members are collaborating on a wide variety of efforts, from detecting cancer earlier than existing methods allow, to harnessing the immune system to fight cancer even as it evolves, to exploiting therapeutic insights from cancer genomics in order to design therapies for previously undruggable targets, to combining existing drugs for synergistic action, to creating tools for better surgical intervention.

The **MIT Center for Precision Cancer Medicine (CPCM)** is devoted to translational research to help the subset of patients who do not respond well to traditional therapies. By focusing on the use of drug combinations, CPCM investigators believe it is possible to significantly alter patient outcomes by determining the right combination of therapies for the right patients. In addition, the Center will concentrate efforts on innovative ways to give drugs, be it in time-staggered dosages, or formulations that target the therapy directly to the tumor.

The **Singapore-MIT Alliance for Research and Technology (SMART)** is a major research enterprise established by MIT in partnership with the National Research Foundation of Singapore. Headed by senior MIT faculty members, research projects are organized into Interdisciplinary Research Groups (IRGs), including: Antimicrobial Resistance (AMR) IRG, a unique translational research and entrepreneurship program that aims to solve the growing threat of resistance to antimicrobial drugs; and BioSystems and Micromechanics (BioSyM) IRG aims to develop new technologies to address critical medical and biological questions applicable to a variety of diseases, further development of these technologies to provide novel solutions for the healthcare industry, and to provide a constant source of new technologies to the broader Singapore research infrastructure.

## SENSORY RESEARCH: SPEECH AND HEARING SCIENCE

The **Harvard-MIT Program in Speech and Hearing Bioscience and Technology (SHBT)** is the only one of its kind in the country–a tight-knit research community dedicated to multi-disciplinary training in basic, clinical and applied approaches to the study of all aspects of human communication and the treatment of its disorders. SHBT faculty and students pursue research questions related to auditory neuroscience, signal processing, perception and cognition, and speech-language pathology, combining rigorous training in a range of rigorous scientific disciplines with valuable exposure to clinical practice.

The **Sensory Communication Group** conducts research on hearing aids, the tactile communication of speech, and auditory perception and cognition. The goal of the hearing aid research is to develop improved hearing aids for people suffering from sensorineural hearing impairments and cochlear implants for the deaf. The goal of the tactile communication research conducted by the group is to develop tactual aids for persons who are profoundly deaf or deaf-blind to serve as a substitute for hearing in the reception of speech and environmental sounds.

## SYNTHETIC BIOLOGY / SYSTEMS BIOLOGY

The **MIT Computational and Systems Biology Initiative (CSBi)** fosters links among biology, engineering, and computer science and creates interdisciplinary, multi-investigator teams to undertake the systematic analysis of complex biological phenomena. CSBi research objectives include the development of methods and devices that can measure, in a systematic and precise manner, the biochemical properties of biomolecules in cells, tissues, and whole organisms; and building mathematical models of biological systems that link mechanistic information on molecular function to systems-wide understanding of networks and interactions.

The **Molecular Machines Group** is focused on pioneering the field of Avogadro scale engineering, which seeks to understand and approach the fundamental limit of engineered complexity deliverable per unit cost. The group has a particular focus on applications within genome engineering, machine learning, bioinformatics, and protein and drug design.

The **Synthetic Biology Center** conducts foundational research in the areas of genetic programming, DNA synthesis and assembly, genome design, simplifying genetics; and systems bioengineering in areas of analog synthetic biology and systems biology, and genetic circuits. Grand challenge application areas include medical, materials, industrial, and agricultural. In the agriculture area–biological sensing and circuitry enables agricultural organisms to see and respond to their environment.

The **Synthetic Biology Group** is focused on advancing fundamental designs and applications for synthetic biology. Using principles inspired by electrical engineering and computer science, the group is developing new techniques for constructing, probing, modulating, and modeling engineered biological circuits. Application areas include infectious diseases, amyloid-associated conditions, and nanotechnology.

## HEALTHCARE / LIFESTYLE ISSUES / WELLNESS / AND INNOVATION

The Media Lab's **Advancing Wellbeing** initiative addresses the role of technology in shaping our health, and explores new approaches and solutions to wellbeing. The program is built around education and student mentoring; prototyping tools and technologies that support physical, mental, social, and emotional wellbeing; and community initiatives.

The Media Lab's **Community Biotechnology Initiative** is developing tools and technologies to enable the broadest possible participation in biotechnology. The initiative's projects include the creation of low-cost enabling hardware, infrastructure for sharing, and new interfaces for artistic expression with biology.

The **MIT AgeLab** is a multidisciplinary research program that works with business, government, and NGOs to improve the quality of life of older people and those who care for them. The AgeLab applies consumer-centered systems thinking to understand the challenges and opportunities of longevity and emerging generational lifestyles to catalyze innovation across business markets. Research themes include Caregiving & Wellbeing; Retirement & Longevity Planning; Home Services & Logistics; and Transportation & Livable Communities.

The mission of **MIT Connection Science** is to revolutionize technology-mediated human networks through analysis, prediction, data-driven design, and evaluation. Its novel "Living Labs" paradigm brings together interdisciplinary experts to develop, deploy, and test new technologies and strategies for design in actual living environments. In collaboration with Harvard Medical School and Massachusetts General Hospital, MIT is conducting a comprehensive analysis of health and behavior by linking behavioral data with personal health records to understand and identify opportunities to improve population health and well-being.

The **MIT Little Devices Lab** explores the design, invention, and policy spaces for DIY health technologies around the world. The group develops empowerment technologies for health, believing that innovation and design happens at the frontline of healthcare where providers and patients can invent everyday technologies to improve outcomes. By radically democratizing the tools of medical creation, the group seeks to enable front-line patients and providers to invent answers to disease burdens.