INDUSTRIAL LIAISON PROGRAM

MIT and Chemical Industries

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 areas – 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 liaison@ilp.mit.edu, or visit http://ilp.mit.edu.

MIT and Chemical Industries

The Massachusetts Institute of Technology (MIT) is a leading center of research and education on topics important to chemical industries such as:

- Biochemical / biomedical
- Analysis, computation, modeling
- Cancer / disease research
- Chemical processing and selection
- Chemical synthesis and catalysis
- Electrochemical processes, energy conversion and storage
- Geochemistry, climate / environment
- Microsystems / nanotechnology

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 the center or lab, etc., may fall into more than one category.

BIOCHEMICAL / BIOMEDICAL

The ***Center for Biomedical Innovation's (CBI)*** mission 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 Program (BioMAN), the Consortium on Adventitious Agents in Biomanufacturing (CAACB), and New Drug Development Paradigms (NEWDIGS).

The ***Center for Materials Science and Engineering (CMSE)*** fosters research and education in the science and engineering of materials. Example research areas: Harnessing in-fiber fluid instabilities for scalable and universal multidimensional nanosphere design, manufacturing, and applications; chemically modified carbon cathodes of high capacity Li-O2 batteries; simple engineered biological motifs for complex hydrogel function.

The goal of the ***Department of Biological Engineering (BE)*** is to develop effective biology-based technologies for application across a broad spectrum. Research areas include: Biomaterials; biophysics; cell & tissue engineering; energy; environment; microbes; microdevices; molecular therapeutics; nanotechnology; pharmacology; synthetic biology; systems biology; and toxicology.

The ***Department of Biology*** academics provide a strong foundation for research and careers in the biomedical industry, medicine, pharmaceutical and biotech management and finance, intellectual property law, bioethics, forensics, and teaching. Areas of research in the department include: biochemistry and biophysics, bioengineering, cancer biology, computational and systems biology, developmental biology, genetics, human genetics, immunology, microbiology, molecular medicine and human disease, neurobiology, plant molecular biology, stem cells and epigenetics, and structural biology.

The ***Emergent Behaviors of Integrated Cellular Systems (EBICS)*** initiative will develop novel experimental and computational tools that are essential for understanding and actively controlling cellular and cell network behaviors. The broader scientific goals of EBICS are to establish a fundamental understanding of cell-cell and cell-environment interactions, and their control by biochemical and mechanical cues; assemble and characterize the properties and performance of multi-cellular machines, and thereby create the nascent discipline for building living, multi-cellular machines for a wide range of applications. (MIT is the lead institution.)

The ***Laboratory for Material Chemomechanics*** is focused on understanding the coupling between chemistry and mechanics at material interfaces. The overarching motivation for this study of chemomechanics is the biological cell. The group investigates cell interfaces and environments relevant to wound healing and inflammation, cancer, and stem/precursor cell development. To aid the development of new tools and models of such complex interfaces, the group also studies engineered nanocomposites and nanostructures that share this strong chemomechanical coupling.

The ***Laboratory for Multiscale Regenerative Technologies (LMRT)*** miniaturization tools from the world of engineering to impact human health. The lab leverages micro- and nanotechnologies to interface living and synthetic systems in order to improve 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.

ANALYSIS, COMPUTATION, MODELING

The ***Computational Biophysics Group*** is focused on understanding conformational changes in biomolecules that play an important role in common human diseases. The group combines computational modeling with biochemical experiments to make connections between conformational changes in macromolecules and disease progression. By employing two types of modeling, molecular dynamics and probabilistic modeling, hypotheses can be developed and then tested experimentally.

The ***Computational and Experimental Design of Emerging materials Research Group (CEDER)*** aims to better design high quality functional materials by mapping the relationship between materials structures and their physical and chemical properties by combining computational approaches in quantum mechanics, solid-state physics and statistical mechanics, with selected experiments to investigate materials in the energy field.

The ***Molecular Engineering Laboratory*** at MIT 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.

CANCER / DISEASE RESEARCH

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 Gynepathology*** research brings new frontiers of engineering to bear on understanding the basic biology, physiology, and pathophysiology of the female reproductive tract, in collaboration with biologists and clinicians. It also includes research efforts focused on developing new technologies for diagnosis and treatment of these diseases, and fosters liaisons with industry. Research in the Center leverages all facets of engineering, with an emphasis on biological engineering—fusing approaches from tissue engineering and systems biology to understand disease etiology and progression.

The ***David H. Koch Institute for Integrative Cancer Research at MIT*** brings together biologists and chemists along with biological, chemical, mechanical, and materials science engineers, computer scientists, clinicians and others, to bring fresh perspectives and an interdisciplinary approach to advancing the fight against cancer. Koch Institute research is strategically focused on five target areas: 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 ***Ludwig Cancer Research Center at MIT*** is focused on the processes associated with malignant progression, specifically on the mechanisms that allow cancer cells originating in primary tumors to disseminate and ultimately form metastatic colonies. This multi-step process involves a series of cell-biological and biochemical changes in malignant cells, which are being investigated at several levels. The research includes the biological determinants that allow disseminated cancer cells to gain a foothold in foreign tissue microenvironments, where they can succeed in spawning rapidly growing metastatic colonies.

The ***Whitehead Institute*** scientists run pioneering programs in cancer research, immunology, developmental biology, stem cell research, regenerative medicine, genetics, and genomics. Research example areas: Understanding the role of cancer stem cells in tumor recurrence and metastasis, investigating the origins of Parkinson's disease, developing new platforms for the use of stem cells in personalized medicine, exploring the biology of fat cells to broaden understanding of obesity and diabetes.

CHEMICAL SELECTION AND PROCESSING

The ***Program in Polymers and Soft Materials (PPSM)*** is an interdisciplinary program offering graduate education in the field of polymer science and engineering. delivery, nanostructured polymers, polymers at interfaces, self-assembly, polymer synthesis, molecular modeling, polymer physics, polymer mechanics and rheology, biomimetic materials, polymers in energy.

The MIT ***Process Systems Engineering Laboratory (PSEL)*** combines the academic and industrial experience of its three principal investigators. A broad program of research is conducted on the analysis, modeling, simulation, optimization, design, control, and operation of process systems. Applications are primarily to chemical, petrochemical, electrochemical, pharmaceutical, biochemical, and biomedical systems spanning length scales from the molecular to the nano- and micro-scales to very large-scale production facilities and even complete supply chains.

CHEMICAL SYNTHESIS AND CATALYSIS

The ***Department of Chemistry*** is focused on discovering new chemical synthesis, catalysis, creating sustainable energy, theoretical and experimental understanding of chemistry, improving the environment, detecting and curing disease, developing materials new properties, and nanoscience. Teaching and research programs span the breadth of chemistry, including biological chemistry, environmental chemistry, inorganic chemistry, materials chemistry and nanoscience, organic chemistry, physical chemistry.

MIT's ***Chemical Engineering Department (ChemE)*** explores the terrain of chemistry, biology, and physics through groundbreaking investigation into areas such as nanotechnology, biomedical processes, molecular computation, and catalysis.

Research projects fall into at least one of nine broad areas: Thermodynamics and molecular computations; catalysis and reaction engineering; systems design and engineering; transport processes; biological engineering; materials; polymers; surfaces and structures; and energy and environmental engineering.

ELECTROCHEMICAL PROCESSES, ENERGY CONVERSION AND STORAGE

Research in the ***Electrochemical Energy Laboratory (EEL)*** concerns the science and engineering of electrochemical energy conversion and storage. Research activities of the lab are centered on nanomaterials for clean energy; electrocatalysis at low temperatures; photoelectrocatalysis; electrocatalysis at high temperatures.

The ***Extreme Electrochemistry Group*** works toward establishing the scientific underpinnings for technologies that make efficient use of energy and natural resources in an environmentally sound manner, focused on thin film polymer batteries, liquid metal batteries, and multivalent batteries.

The ***Laboratory for Electrochemical Interfaces*** focuses on laying the scientific groundwork and proof-of-principle material systems for the next generation of high-efficiency devices for energy conversion and information processing, based on solid state ionic-electronic materials. The scientific insights derived from our research impact the design of novel surface/interface chemistries for efficient and durable solid oxide fuel cells, efficient and durable thermo/electro-chemical splitting of water and CO2, and more.

The ***Laboratory for Energy and Microsystems Innovation (LEMI)*** investigates the intersections between electrochemistry, electrokinetics, and microfluidics engineering for energy systems. Applications of interest include proton exchange membrane fuel cells, electrolyzers, and microbial fuel cells. The lab's interdisciplinary research thrusts lie at the boundaries mechanical engineering, chemistry, and biology.

Mechanical Engineering Department Research in Energy Science and Engineering focuses on technologies for efficient and clean energy conversion and utilization, aiming to meet the challenge of rising energy demands and prices, while simultaneously addressing the concomitant environmental impact. Research areas include: Engines, transportation, combustion, and control; solar energy and photovoltaics; transport phenomena and water desalination; carbon dioxide capture and hydrogen research; electrochemical energy storage and conversion; and energy conservation.

The ***Sustainable Materials Extraction & Manufacturing Group*** investigates the development of a new electrochemical route for metals production in extreme environments (molten sulfides or rare-earth oxides); the direct forming of alloys by electrochemical techniques in collaboration with a large end-user of precious metals toward providing a manufacturing tool that eliminates numerous unit-operations; and is pursuing an understanding of the minerals leaching process from a chemical and materials science viewpoint.

GEOCHEMISTRY, CLIMATE / ENVIRONMENT

The ***Carbon Capture & Sequestration Technologies Program at MIT*** conducts research into technologies to capture, utilize, and store CO2 from large stationary sources. The program's research examines carbon sequestration from multiple perspectives, including technical, economic, and political. Research interests include technology assessments, economic modeling, analysis of regulatory and political aspects, and development of a Carbon Management Geographic Information System (GIS). The program has a strong commitment to stakeholder outreach and education to complement the research.

The ***Carbon Sequestration Initiative (CSI)*** is an industrial consortium formed to investigate carbon capture and storage technologies. The consortium aims to provide an objective source of assessment and information about carbon sequestration; to establish an information network to provide timely updates on relevant activities and new findings; to explore the societal and technical aspects of carbon sequestration; to educate a wider audience on the possibilities of carbon sequestration; to link industry to expanding government activities on these topics; to stimulate and seed new research ideas; and to create an annual forum for strategic thinking and identification of new business opportunities.

The MIT ***Center for Global Change Science (CGCS)*** builds on existing programs of research and education in the Schools of Science and Engineering at MIT, fostering studies on topics as varied as, for example, oceanography, meteorology, hydrology, atmospheric chemistry, ecology, biogeochemical cycling, paleoclimatology, applied math, data assimilation, computer science, and satellite remote sensing. CGCS sustains a program of basic scientific research on the natural processes controlling global climate, with a concentration on the cycles, circulations and interactions of water, air, energy, and nutrients in the Earth system.

Department of Civil & Environmental Engineering (CEE): Environmental Chemistry area focuses on processes governing natural and man-made ecosystems. An understanding of the mechanisms that regulate the flow of energy and cycling of materials through natural and man-made ecosystems is essential to address and avoid environmental problems. Water is one of the key media through which elements are transported within and between ecosystems, and it is also an important vehicle for the transport of anthropogenic toxic chemicals.

The ***Department of Earth, Atmospheric, and Planetary Sciences (EAPS)*** work encompasses atmospheres, climate, geobiology, geochemistry, geology, geophysics, oceans, and planetary sciences. Through fieldwork, theory, experimentation, and modeling, EAPS seeks to advance understanding of the natural world. EAPS research falls into eight distinguishable categories: atmospheric science, climate, geobiology, geochemistry, geology, geophysics, oceanography, and planetary science.

The MIT ***Environmental Solutions Initiative (ESI)*** is a campuswide initiative to promote transformative, cross-disciplinary research relating to the environment. Seed Grants for faculty and student teams encourages research partnerships that advance progress and solutions on issues of environmental significance in areas such as sustainability, metals and mining, climate risk/mitigation.

The ***Abdul Latif Jameel World Water and Food Security Lab (J-WAFS)*** was created to coordinate and promote water and food research at MIT. By spearheading the efforts of MIT's faculty, labs, and centers to work towards solutions for water and food security that are energy-efficient and environmentally benign, J-WAFS promotes the development and commercialization of the next generation of technologies that can be broadly applied to food safety, urban water supply, agriculture and irrigation, and watershed protection.

The ***Program in Atmospheres, Oceans, and Climate (PAOC)*** oversees a broad program of education and research in atmospheric, oceanic, and climate sciences. The phenomena under study involve a large array of scientific disciplines—geophysics, geochemistry, physical and chemical oceanography, meteorology, atmospheric chemistry, and planetary science. The program carries out research and gives instruction in all of these principal areas.

The ***Reacting Gas Dynamics Laboratory (RGD Lab)*** explores high efficiency, low-carbon energy from hydrocarbon sources, as well as hybridizing with concentrated solar thermal energy, through thermochemical conversion and combustion. The Lab develops, validates, and applies multiphysics multiscale simulation techniques, from the submicron scale to the systems scale, to engineer optimal, clean, low CO2-energy systems. These include innovations in clean combustion for propulsion and power, gasification for power and biofuel production, and oxy-combustion and electrothermochemical conversion in ion-transport membrane reactors and high-temperature fuel cells for CO_2 capture.

The ***Sloan Automotive Laboratory*** research interests in combustion include autoignition, hydrocarbon oxidation chemistry, turbulent and laminar flame structure and flame propagation. A major assessment of future automotive technologies and their fuel requirements is underway, focusing on greenhouse gas emissions reduction. Broad research focuses include: engine efficiency improvements; improve alternative fuel operation; advance the fundamental understanding of engine, technology and transportation policy processes; and vehicle life-cycle CO_2 emissions reductions.

MICROSYSTEMS / NANOTECHNOLOGY

The ***Institute for Soldier Nanotechnologies (ISN)*** team of MIT, Army, and industry partners collaborate 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 five strategic areas: Lightweight, multifunctional nanostructured materials; soldier medicine; blast and ballistic threats—materials damage, injury mechanisms, and lightweight protection; hazardous substances sensing; and nanosystems integration.

The ***Microphotonics Center (MPhC)*** is a research community in which industry, government, and academia collaborate to create new materials, structures, and architectures for the emerging microphotonics platform—the menu of on-chip and circuit-board level devices and components that will comprise future optoelectronics for telecommunications, computing, and sensing.

The ***Microsystems Technology Laboratories (MTL)*** supports microsystems research encompassing work in circuits and systems, MEMS, electronic and photonic devices, and molecular and nanotechnology. MTL research is enabled by a set of shared experimental facilities, as well as the Microsystems Industrial Group (MIG), and is home to the Center for Integrated Circuits and Systems, Medical Electronic Device Realization Center, Center for Graphene Devices and 2D Systems, and the Gallium Nitride (GaN) Energy Initiative.

The ***MIT/MTL Center for Graphene Devices and 2D Systems (MIT-CG)*** explores advanced technologies and strategies that enable graphene-based materials, devices, and systems to provide breakthrough capabilities for applications ranging from energy generation and smart fabrics and materials, to RF communications, sensing, or water purification.

The RLE ***Organic and Nanostructured Electronics (One Lab)*** studies the physical properties of organic thin films, structures, and devices. The group's fundamental findings are applied to the development of practical optoelectronic, electronic, and photonic organic devices of nano-scale thickness, including visible LEDs, lasers, solar cells, photodetectors, transistors, chemical sensors, and memory cells.

The mission of the Massachusetts Institute of Technology is to advance knowledge and educate students and others in science, technology, and additional areas of scholarship. MIT is committed to generating, disseminating and preserving knowledge and to working to bring this knowledge to bear on the world's great challenges. As part of its mission, MIT maintains relationships with industrial organizations that enable the exchange of ideas in the context of real-world problems and demonstrate how principles studied at MIT are applied to generate practical benefits for industry and society. MIT's Industrial Liaison Program helps develop these relationships by facilitating industry's access to MIT and its vast resources.