Section 2
Major MIT Initiatives

National Policy Initiatives

MIT has had major involvement in technology policy at the national level since before World War II, with MIT faculty and administrators frequently serving as advisors to national policymakers. A more formal "policy initiative" model first emerged in 2005 when incoming MIT President Susan Hockfield announced that MIT would create a major cross-disciplinary, cross-school initiative around energy. Over the intervening decade, policy initiatives have been created to tackle several other science and technology issues with national, and often global, policy dimensions. Inherently cross-disciplinary, these initiatives draw on deep MIT expertise across science and engineering disciplines, the social sciences, economics, and management. Major policy initiatives to date are described below. Some have had relatively short-term, specifically defined goals, while others, such as the original energy initiative, address broader long-term goals.

Energy

The MIT Energy Initiative (MITEI) was formally launched in the fall of 2006, following the recommendations of the 2006 Report of the Energy Research Council regarding new approaches to multidisciplinary research, education across school and department boundaries, energy use on campus, and outreach to the policy world through technically grounded analysis.

MITEI is widely recognized as a leader in energy policy. It is a campus-wide energy program at a U.S. academic institution, with important educational, research, and policy components. Its policy outreach component has prospered, encompassing core MITEI activities and those under the auspices of programs such as the Tata Center for Technology and Design, Center for Energy and Environmental Policy Research (CEEPR) and the Joint Program on the Science & Policy of Global Change. MITEI, the Tata Center, CEEPR, and the Joint Program each hold workshops at least annually to bring MIT faculty, research staff, and students together with outside experts to address current technological, economic, and political challenges in energy and climate.

MITEI's best-known policy products are the in-depth, multidisciplinary "Future of..." studies addressing solar energy, the electric grid, natural gas, and other areas (see energy.mit.edu/futureof). New studies in the series will continue to inform future decisions regarding energy research, technology choices, and policy development.

A major consortium research study in collaboration with industry and government members, *The Utility of the Future: Preparing for a Changing Energy Sector*, was released in November 2016. Ongoing studies include *The Mobility of the Future*, which examines how modes of transportation are evolving, and *The Future of Nuclear Energy in a Carbon Constrained World*.

Now in its second decade, MITEI has reorganized its research around specific technology areas key to addressing climate change and meeting global energy needs. Eight Low-Carbon Energy Centers support sustained collaboration across academia, industry, government, and the philanthropic and NGO communities. The eight Centers are focused on carbon capture, utilization, and storage; electric power systems; energy bioscience; energy storage; materials for energy and extreme environments; advanced nuclear energy systems; nuclear fusion; and solar. (See energy.mit.edu/lcec.)

Convergence

"Convergence" is a term for the integration of engineering, physical sciences, computation, and life sciences with profound benefits for medicine and health, energy, and the environment. Convergence implies a broad rethinking of how all scientific research can be conducted, to capitalize on a range of knowledge bases, from microbiology to computer science to engineering design and more. It is a new organizational model for innovation, taking the tools and approaches of one field of study and applying them to another, paving the way for advances in all fields involved. At MIT, the policy focus has been on Convergences for biomedical advances.

In 2011, then-President Susan Hockfield appointed Institute Professors Phillip Sharp and Robert Langer to lead a faculty committee which developed a widely cited whitepaper entitled *Third Revolution: Convergence of The Life Sciences, Physical Sciences and Engineering*. Simultaneously, MIT created the Koch Institute for Integrative Cancer Research and

organized it around the convergence research model, with biologists, engineers and physical scientists working in close collaboration.

The National Academy of Sciences has also provided leadership in the convergence effort through its Board on Life Sciences which published *Convergence–Facilitating Transdisciplinary Integration of Life Sciences, Physical Science, Engineering and Beyond* (National Academies Press, 2014), co-chaired by MIT President Emerita Hockfield.

The National Science Foundation highlighted Convergence as one of its ten "Big Ideas" in summer 2016. The Big Ideas are proposed as visioning and organizing principles for future NSF investments.

MIT released a new policy report on June 24, 2016 titled, *Convergence: The Future of Health* at the National Academies in Washington, DC. The report was co-chaired by Philip Sharp, Susan Hockfield, and Tyler Jacks, Director, The Koch Institute, MIT. The report included 24 scientific advisors from 16 institutions, universities, and government agencies. An additional ~40 workshop attendees contributed to the discussions and content of the report, from dozens of academic, industrial, philanthropic, and federal institutions. The report outlined the need for convergence investments in several illustrative areas: brain disorders; infection and immunity; cancer; and other unmet health needs. It also highlighted advances in convergence technologies: imaging in the body; nanotechnology for drug delivery; regenerative engineering and medicine; and big data & health information technology. The report concluded with policy recommendations to advance convergence research and health outcomes within the university, federal government, and industrial sectors.

Philip Sharp and Susan Hockfield published a letter in the February 10, 2017 issue of *Science*, which was co-signed by over 100 scientists and leaders. The letter urged the new administration to embrace the potential of Convergence to develop new therapies, advance science, and foster health innovations. Additional information on the convergence research model, including a copy of the 2016 report and videos of its release, are available online at http://www.convergencerevolution.net/.

Digital Health

As part of the Convergence Initiative, MIT is building an effort to use digital technologies to transform healthcare. The key question is: *How can the digital revolution and the evolution of health systems converge to optimally prevent, detect, understand, and treat disease in order to improve health outcomes and lower cost?*

The opportunities in digital health are far reaching. The challenge is to develop approaches to optimally acquire, curate, and interpret vast amounts of data in a way that can be acted upon by a health system operated by humans. Continuous monitoring of patients with chronic disease will detect disease progression and predict dangerous episodes like heart attacks or seizures sooner, leading to prevention, faster treatment, better recovery and lower costs. Early detection will prevent or ameliorate the onset of acute disease, and facilitate early intervention. Real-time updates to standardized, interoperable electronic health records will ensure that medical histories are available to healthcare practitioners at a moment's notice in an emergent situation, while protecting patient privacy. This could be a key tool to combat the opioid epidemic, by reducing prescription abuse and helping first responders identify overdose victims. Personalized medicine will offer widespread benefits as we develop the tools to collect, analyze, interpret and act on vast amounts of genomic, molecular, and environmental data specific to an individual.

MIT is uniquely positioned to confront this national and global grand challenge. The Institute has a long history of providing systems-level engineering and management solutions to complex societal problems, based on superb engineering and science. Many students are excited by opportunities to innovate the future of health. Departments from across the university offer expertise in big data analytics, computer science, modeling, device design and manufacturing, life sciences and engineering (including systems biology and genetics), systems engineering, and economics. A critical mass of faculty members is passionate about health and healthcare and understand its unique challenges. MIT has formed strategic partnerships with leading organizations in the industry, hospitals and healthcare deliverers, to medical device and pharmaceutical

companies. And we are located in a region served by world-class hospitals and home to leading companies at the intersection of life sciences and information technology, including Kendall Square, a major hub of the biotech industry.

Over the past year, the Provost has engaged in several collaborative activities with local hospitals and academic institutions and the Commonwealth of Massachusetts with a focus on Digital Health. He has also charged a faculty group to consider what contributions MIT could make in digital health that would integrate MIT's expertise across campus to transform health care and lower costs.

Advanced Manufacturing

MIT leaders have played a major role in the design of national efforts to confront structural problems in the U.S. manufacturing sector, starting in 2011 with the MIT Production in the Innovation Economy (PIE) study project. Building on PIE research, national policy work continued with MIT taking a leadership role in the President's Advanced Manufacturing Partnership (AMP). Two major reports (AMP1.0, 2012, and AMP2.0, 2014) were issued, and led to federal support for a network of regional institutes to promote manufacturing innovation, which became the Obama Administration's largest new technology initiative and focus. These competitively selected partnerships between federal research agencies and state governments, academia, and private companies seek to integrate new technologies and processes into the U.S. manufacturing industry and ensure that workers have the knowledge and skills needed to implement these innovations domestically. On campus, this focus on advanced manufacturing has led to new research and educational activities while stimulating regional outreach to and partnerships with manufacturers and other educational institutions. It has also helped define the campus-wide innovation initiative.

Campus leaders in manufacturing, including President L. Rafael Reif, Provost Martin A. Schmidt, and Professor Krystyn J. Van Vliet, who were the technical co-leads of AMP, continue to engage with key federal officials and business leaders to help pave a robust path for the utilization of advanced technologies by U.S. manufacturers. Further details follow below.

Advanced Manufacturing Partnership

MIT Presidents Susan Hockfield and Rafael Reif were named by President Obama as successive co-chairs of the steering committee for his industry-university Advanced Manufacturing Partnership (AMP) in its two phases, from 2012 through 2014. MIT Provost Martin Schmidt and Professor Krystyn Van Vliet served as successive technical co-leads for AMP1.0 and AMP2.0.

The AMP1.0 report in 2012 proposed the establishment of a new network of advanced manufacturing institutes, modeled on the German Fraunhofer institutes. The AMP2.0 report, released in October 2014, refined the recommendations for what is now known as ManufacturingUSA. It also proposed strategies for collaborative R&D efforts across leading federal agencies, best practices for apprenticeship and training programs, and policies to support financing of production scale-up for advanced manufacturing processes and technologies. President Reif and Provost Schmidt led the AMP2.0 Steering Committee, along with Dow CEO Andrew Liveris, and the President's National Economic Council Director, Science Advisor, and Commerce Secretary, in 2013–2014. Professor Van Vliet co-chaired the AMP2.0 technology development workgroup, which prepared model technology strategies on digital manufacturing, advanced materials for manufacturing, and sensors/measurement/process control areas. Van Vliet, now serving as Associate Provost, continues to help set the path for the ManufacturingUSA as a member of the Leadership Council for the MForesight advisory group (see http://www.mforesight.org).

Manufacturing Innovation Institutes

Fourteen Manufacturing Innovation Institutes (MIIs) have been stood up, with lead sponsorship from the Departments of Commerce, Energy, and Defense. Combined federal, state, and industry funding for these institutes is expected to exceed a half billion dollars annually.

MIT participates in many of the 14 MIIs, and has leadership roles in two. MIT faculty members Michael Watts and Lionel Kimerling lead the technology development and workforce education teams, respectively, for the AIM Photonics Institute. AIM Photonics, a regional consortium including New York and Massachusetts firms and universities, was

established by the Department of Defense in July 2015 to develop integrated photonic devices. In April 2016, Secretary of Defense Ash Carter visited the MIT campus to announce the creation of the Advanced Functional Fabrics of America (AFFOA). AFFOA's national headquarters in Cambridge, Massachusetts opened on June 19, 2017 with an event featuring Under Secretary of Defense for Acquisition, Technology, and Logistics James MacStravic, Governor Charlie Baker, members of the Massachusetts Delegation, industry leaders, and MIT President Rafael Reif. MIT Professor Yoel Fink serves as CEO of the institute, which is managed by an independent nonprofit organization founded by MIT. Regional and national partners are participating in the institute, which integrates revolutionary fibers into textiles to make new capabilities available to U.S. clothing and soft goods manufacturers.

The "Future Postponed"–addressing the Innovation Deficit

Federal support is the primary mainstay of U.S. basic research. As federal R&D funding has stagnated, the strategy to maintain the U.S. edge in science and technology must include new ways of explaining the central societal need for science to policy makers. The MIT report *The Future Postponed: Why Declining Investment in Basic Research Threatens a U.S. Innovation Deficit*, released in April 2015, is one such effort. The science community has often told the story of how past investments in research paid off in now-ubiquitous technologies like the Global Positioning System, Magnetic Resonance Imaging, and the Google search engine. But it has not adequately communicated how research cutbacks today will affect the science of tomorrow. *The Future Postponed* explains the critical importance of federal investment in science research to grow the economy, stay competitive internationally, and solve global challenges in health, energy, security, food supply, and other areas through the development of better therapies, cures, tools, and technologies.

The MIT Committee to Evaluate the Innovation Deficit, named in October 2014 and comprising 30 MIT faculty and researchers from across all schools at MIT, selected, wrote, and vetted case studies of 15 vital areas of science and engineering from infectious disease, to batteries, Alzheimer's, cybersecurity, catalysis, economics and plant science. The report is not a list of priorities in science research, but rather a short set of illustrative examples from a much longer list of critical fields worthy of investment. It's a vision of the future of innovation in America and a call for sustained support for research.

The report gained national press attention in such forums as the Wall Street Journal, the New York Times, Reuters, the Los Angeles Times, and others. A group from the faculty committee, led by Professor Marc Kastner, former MIT Dean of Science and currently President of the Science Philanthropy Alliance, held a forum hosted by AAAS and briefed Congressional staff, White House staff, and other national stakeholders during a Washington DC visit on April 27, 2015.

A second volume of the report, *The Future Postponed 2.0*, was released on February 22, 2017. The report was led by Marc Kastner, and vetted by an advisory committee of nine noted experts from outside MIT. Working with researchers across the country, thirteen additional case studies were published beyond the first volume. The newest case studies were written by experts at 15 institutions around the country, and covered diverse topics such as protein design, circadian rhythms, forest ecology, dark matter, clean energy technology, arctic oceanography, and more. All individual case studies and volume two of the *Future Postponed* report can be found online at http://www.futurepostponed.org/.

On the same day as the report release, an op-ed was published in *The Hill*, co-authored by Maria Zuber, Vice President for Research at MIT, and Rush Holt, CEO of AAAS. The op-ed titled, *Neglecting Research Today Threatens US Innovation Tomorrow*, discussed the *Future Postponed 2.0* report and the importance of investing in basic research.

Innovation

In October 2013, President Reif announced an "innovation initiative" at MIT, which was followed by a report on the proposed project in December 2014, http://innovation.mit.edu/sites/default/files/images/MIT_Innovation_Initiative_PreliminaryReport_12-03-14.pdf. The initiative has primarily focused on MIT itself. As summarized on its website (http://innovation.mit.edu/about) the report emphasizes:

- Capability-building Programs: Growing existing education opportunities while creating a select few new programs of interest to MIT students and faculty
- Convening Infrastructure: Expanding maker and collaborative spaces across campus and creating digital tools that connect them into a unified campus
- Communities: Linking the MIT community more deeply with corporations, governments, and innovation hubs in Cambridge and around the world
- Lab for Innovation Science and Policy: an organized effort to develop the 'science of innovation' and evidence-base to inform both internal and external program design

In May 2015, President Rafael Reif announced a new innovation programmatic focus in a Washington Post op-ed (http://newsoffice.mit.edu/2015/reif-op-ed-washington-post-0524). President Reif emphasized the need for regional and national policy elements to fill a gap he identified in the national innovation system. Following his words with action, President Reif announced the creation of a new kind of accelerator on October 26, 2016. Called The Engine, the new Cambridge-based accelerator supports startup companies working on "tough technologies" with potential for societal impact. It provides funding, space, tools, resources, and expertise to companies pursuing capital- and time-intensive technologies with "great potential for positive impact for humanity" as described by President Reif. By April 2017, The Engine had raised over $150 million for its first fund. A formal opening event highlighting some of The Engine's first investments was held on September 19, 2017.

Online Education

Educational innovation has been a central component of the Institute's mission throughout its history. Many curricular and organizational innovations developed at MIT have had national impact, as have educational technologies developed and pioneered on campus. In his September 2012 inaugural address, Rafael Reif announced that continued educational innovation would be a major focus of his presidency. In 2013, he established an Institute-wide Task Force on the Future of MIT Education to envision how new capabilities and instructional models can spark innovation in higher education on campus and beyond. MIT is now a national leader in the growing effort to utilize online technology to enhance learning while providing new educational opportunities both on campus and beyond. MIT's Office of Digital Learning (ODL) and edX, an online learning destination co-founded by MIT and Harvard University in 2012, spearhead these activities.

edX currently offers open online courses from over 130 partner institutions to students from every country in the world, serving almost 13 million unique learners to date. The founding partners alone offered 290 courses in edX's first four years. edX continues to offer free, open enrollment for most courses, while expanding its verified certificate program and new micromasters program, which offer enhanced options for earning course credit at low cost. ODL manages the Institute's course contributions to edX, known as MITx, and provides leadership for on-campus innovations in teaching and learning. It also manages MIT's OpenCourseWare initiative (OCW), which has made instructional materials from MIT courses freely available since 2001. OCW has now delivered material from over 2,400 MIT courses to 200 million learners and educators worldwide.

In August 2014, Professor Sanjay Sarma and Professor Karen Wilcox, who had co-chaired the Task Force on the Future of MIT Education, assumed the leadership of a study of the national policy aspects and implications of online education, with support from the Carnegie Foundation. This Online Education Policy Initiative (OEPI) explored teaching pedagogy and efficacy, institutional business models, and global educational engagement strategies. Important input was also obtained through a May 2015 workshop, sponsored

by the National Science Foundation, which brought the learning science and online learning technology communities together to discuss emerging ideas about online pedagogy. OEPI released its final report, *Online Education: A Catalyst for Higher Education Reform*, on April 1st, 2016 at the National Academy of Sciences (see https://oepi.mit.edu/final-report).

edX and the Office of Digital Learning continue to explore the frontiers of education through research into pedagogy, student motivation and behavior, assessment methods, and the science of learning itself, through studies of online learning experiences and outcomes, and through continued development of learning platforms. See https://www.edx.org/about/research-pedagogy and https://openlearning.mit.edu/value-digital-learning/research.

Internet Policy Research Initiative

The Internet Policy Research Initiative (IPRI) works with policy makers and technologists to increase the trustworthiness and effectiveness of interconnected digital systems that support our economy and society. As global interconnectedness increases there is a need to bridge the gap between the technical and policy communities who are trying to neutralize threats and seize opportunities that a more interconnected world creates.

Under the umbrella of IPRI, MIT has taken a focused interdisciplinary research approach that draws on the best of MIT's expertise in engineering, social science, and management to tackle these grand challenges. Its goal is to help guide governments and private sector institutions around the world in framing sustainable, effective Internet and cybersecurity policies.

Research

IPRI produces research across five main areas: cybersecurity, privacy, networks, critical infrastructure, and the Internet experience. IPRI research has already impacted the national debate on encryption policy and the security of new electronic surveillance proposals. Developed with colleagues from around the world, IPRI's Keys Under Doormats paper has been widely cited at several legislative hearings and IPRI members have testified to Congress and been featured in the world press.

Education

In addition to research, the initiative focuses on training a new generation of technology policy leaders who can move effectively between technology and policy roles. As an example, the initiative has developed a joint course with Georgetown Law School on privacy technology and legislation that combines MIT and Georgetown students in teams of lawyers and engineers to develop draft legislation related to current technology issues. IPRI also partnered with a leading Chinese university to teach Chinese engineering, law and business students a comparative perspective of the Foundations of Internet Policy course in Shanghai, China. Other courses taught by IPRI researchers focus on privacy legislation and technology, cybersecurity policy, information policy, and app development.

Engagement

The third pillar of the initiative is engaging with policy makers throughout the world and helping inform policymaking from a solid technological foundation. IPRI has hosted a range of high-level policymakers at MIT including Vice President Ansip of the European Commission, Secretary Penny Pritzker of the U.S. Department of Commerce, Director Robert Hannigan of GCHQ in the UK, and the European Data Protection Supervisor Giovanni Buttarelli. IPRI engagement also extends to the business community in areas such as the protection of critical infrastructure from cyberattacks (oil, gas, financial, electricity and communication networks). IPRI held five expert workshops with industry, governments and academia in each of the sectors to understand the needs and challenges, and develop a research agenda to address the most pressing issues and published a report of its findings.

Research Initiatives

Cybersecurity Initiatives

In 2015, MIT launched three campus-wide cybersecurity efforts aimed at addressing the technical, regulatory, and managerial aspects of cybersecurity. The three initiatives: Internet Policy Research Initiative (described above), Cybersecurity@CSAIL, and MIT Sloan's Interdisciplinary Consortium for Improving Critical Infrastructure Cybersecurity $(IC)^3$, are intended to provide a cohesive, cross-disciplinary strategy to tackling the complex problems involved in keeping digital information safe.

Cybersecurity@CSAIL

Cybersecurity@CSAIL launched in 2015 with 5 founding industrial partners. The goal of CyberSecurity@CSAIL is to identify and develop technologies to address the most significant security issues confronting organizations in the next decade. Presently, approaches to system security do not give overall security guarantees, but rather attacks are fought individually—"patch and pray" style. CyberSecurity@CSAIL aims to provide an integrated and formal approach to the security of systems, combining design and analysis methods from cryptography, software and hardware. Cybersecurity@CSAIL's approach includes three key elements: collaborate closely with industry for input to shape real-world applications and drive impact; approach the problem from a multidisciplinary perspective; and create a test-bed for our industry partners to implement and test our tools as well as have our researchers test tools developed by our partners.

MIT Sloan's Interdisciplinary Consortium for Improving Critical Infrastructure Cybersecurity $(IC)^3$

It is not a question as to whether you will have a cyber attack, only when and how. $(IC)^3$ addresses the important strategic, managerial and operational issues related to the cybersecurity of the nation's critical infrastructure, ranging from energy and healthcare to financial services. An MIT interdisciplinary team, lead by Sloan, along with industry partners (such as: ExxonMobil, Schneider Electric, State Street Bank), looks to address issues, such as cyber risk analysis, return on cybersecurity investment, cybersafety models, more effective information sharing, better organizational cybersecurity culture, disrupting the cybercrime ecosystem, and metrics and models to better protect organizations.

Environmental Solutions Initiative

Launched in 2014, the Environmental Solutions Initiative (ESI) advances science, engineering, policy and social science, design, the humanities, and the arts toward a people-centric and planet-positive future. ESI pursues this mission by mobilizing students, faculty, and staff across MIT in partnerships for interdisciplinary education, research, and convening.

ESI's educational mission is to prepare and equip MIT's extraordinary students to steward a healthy planet in every career path. In September 2017, ESI launches a new, multidisciplinary minor in Environment and Sustainability open to undergraduates from all majors. ESI works closely with faculty who teach required undergraduate classes (GIRs) to incorporate problem sets and material on climate and environment.

ESI's agenda for advancing research and expanding work toward environmental solutions focuses in three key domains: climate science and earth systems, cities and infrastructure, and sustainable production and consumption. These domains are multidisciplinary and promote collaboration across MIT's five schools. ESI's research seed grant program has supported 15 projects spanning these domains with field sites across the globe.

ESI's core forum for convening, ESI's People and the Planet series of invited lectures brings fresh and sometimes provocative points of view into contact with the MIT and Cambridge communities.

ESI is guided by a Faculty Advisory Committee and a Student Advisory Council, and is building an External Advisory Board with broad representation.

http://environmentalsolutions.mit.edu/

Abdul Latif Jameel World Water and Food Security Lab

The Abdul Latif Jameel World Water and Food Security Lab (J-WAFS) serves to organize and promote food and water research around campus, emphasizing innovation and deployment of effective technologies, programs, and policies in order to have measurable impact as humankind adapts to a rapidly changing planet and combats water and food-supply scarcity. The lab addresses the collective pressures of population growth, urbanization, development, and climate change—factors that endanger food and water systems in developing and developed countries alike. To accomplish this, the lab develops broad-based approaches employing MIT's interdisciplinary strengths and expertise in science, engineering and technology, climate and hydrology, energy and urban design, business, social science, and policy. J-WAFS, as an interdepartmental lab reporting to the Vice President for Research, spearheads the efforts of MIT's faculty, labs, and centers to work towards solutions for water and food security that are environmentally benign and energy-efficient, including the development of transformative water and food technologies. These efforts are supported in part through seed grants distributed competitively to MIT researchers from J-WAFS' endowment, established in 2014 through a generous gift by alumnus Mohammed Abdul Latif Jameel '78.

J-WAFS also seeks to partner with other institutions, foundations, industry, philanthropists, and governments to develop regionally appropriate solutions and innovations, whether for fast-growing megacities or for the rural developing world. Water supply in urban settings, for example, may benefit from conservation policies and infrastructure-scale systems, whereas rural populations may need small-scale, locally powered water purifiers. Ensuring stable food supplies requires a similarly varied approach that engages technology, biological and environment science, policy, and business innovation. J-WAFS also supports graduate student-driven food and water research and business communities on campus, through fellowships, conference sponsorship, and other mentoring and assistance.

http://jwafs.mit.edu/

MIT Energy Initiative

The MIT Energy Initiative (MITEI) plays an important catalytic role in accelerating responses to the many challenges facing our global energy system through energy research, education, and outreach efforts.

MITEI brings together researchers from across the Institute and facilitates collaborations with government and industry to analyze challenges, develop solutions, and bring new technologies to the marketplace. Member companies and organizations have supported more than 900 projects to date. Nearly 30 percent of the MIT faculty is engaged with MITEI's programs. The Initiative delivers comprehensive analyses for policy makers and regulators, such as the "Future of" study series, including *The Future of Solar Energy* (2015), and a study currently underway, *The Future of Nuclear Energy in a Carbon-Constrained World*, with the Nuclear Science and Engineering Department. Other studies include systems-level research such as the 2016 *Utility of the Future* study and report, and a new study under development: *Mobility of the Future*.

As a vital component of MIT's Plan for Action on Climate Change, MITEI's eight Low-Carbon Energy Centers present opportunities for faculty, students, industry, and government to advance research and development in key technology areas for addressing climate change, from solar energy to electric power systems, fusion, and other areas. (See http://energy.mit.edu/lcec.)

The MITEI Seed Fund Program supports innovative early-stage research projects that address energy and related environmental issues. Including 2017 grants, the program has supported a total of 161 energy-focused research projects representing $21.4 million in funding over the past nine years. The program encourages researchers from throughout MIT's five schools to collaborate in exploring new energy-related ideas, and attracts a mix of established energy faculty as well as many who have just begun approaching energy in their research or are new to MIT.

MITEI leads Institute energy education efforts and has engaged thousands of undergraduate, graduate, and postdoctoral students through sponsored research opportunities and other programs. Energy education programs include the Energy Studies Minor, Undergraduate Research Opportunities Program (UROP) in energy, short modules during the Independent Activities Period, Discover Energy: Learn, Think, Apply (DELTA) Freshman Pre-orientation Program, graduate Society of Energy Fellows, and other initiatives. Faculty associated with MITEI help shape energy education at both the undergraduate and graduate levels, by teaching, advising, and developing new curricula.

In addition to informing public policy through research reports, MITEI fosters dialogue within the academic research community and provides the public with context on current energy issues. Convening events throughout the year, MITEI hosts thought leaders from across the energy value chain. MITEI staff, faculty affiliates, and graduate students share their research and perspectives at domestic and international events. Staff members also participate in Institute-wide efforts focused on addressing climate change. MITEI highlights the research and achievements of faculty and students through articles, media outreach, social media, and other digital and print platforms to reach diverse audiences.

http://energy.mit.edu

MIT.nano — Toolset for Innovation

With nano-scale advancements, we are reimagining Health and Life Sciences, Energy, Computing, Information Technology, Manufacturing, Quantum Science, and other fields. That is because nano is not a specific technology. It does not belong to a particular industry or discipline. It is, rather, a revolutionary way of understanding and working with matter, and it is the key to launching the next Innovation Age, the Nano Age. In the words of MIT President L. Rafael Reif, "[B]ecause nanoscience and nanotechnology are omnipresent in innovation today, a state-of-the-art nano facility is the highest priority for MIT, the School of Science, and the School of Engineering."

Tools to build the Nano Age will be available within MIT.nano, the new nanoscience and technology center at the heart of the MIT campus. Opening in the summer of 2018, MIT.nano is a comprehensive, 200,000-sq ft shared facility for nano-scale advancements. It is designed to give our researchers and innovators, as well as our partners, access to a broad and versatile toolsets that can do more—from imaging to synthesis, fabrication and prototyping—entirely within the facility's protective envelope.

The opening of MIT.nano will also mark the beginning of a new era of nano-education at MIT, with hands-on learning spaces and advanced teaching tools integrated throughout the facility. The top floor of MIT.nano houses the new undergraduate chemistry labs teaching complex. Also on the top floor is the set of prototyping laboratories, designed to provide tools that could translate basic advances into hand-held technologies. There, inventors can translate nano-scale advancements into hand-held systems, transitioning academic pursuits into prototypes for a better World.

Quantifying and analyzing technology translations from MIT.nano will give insights into the steps comprising the innovation process, which we expect will enable us to transform the mere art of innovation into a systematic science. Knowledge and insights that we gain we are committed to share broadly in order to accelerate the advancements of the Nano Age, through both act and deed.

Clinical and Transformational Research in Health and Life Sciences

A series of related initiatives from the Institute of Medical Engineering and Science (IMES) have propelled MIT into the forefront of transformational research in health and life sciences. These initiatives are specifically designed to shift the fulcrum which in the past has been positioned to early-on propel emerging concepts from the academic laboratories at MIT to clinical domains of hospitals. Such a paradigm provides early feedback as to the function and efficacy of a putative medical device, diagnostic or drug but often times ideas get "lost in the translation". With the notion that technology development requires iterative interactions and refinement best performed where technology is developed, they chose to move the fulcrum to balance the flow from MIT to hospitals and to shift from a translational or translocational paradigm which simply moves projects from one place to another to one which allows for ideas to be transformed while be moved.

The expectation and goal is to use these initiatives to formally change how technology is developed and evaluated and to bring MIT from the periphery of this space to the center, to make MIT the place that collaborators, local, regional, national and internationally come to for idea transformation rather than seek ideas for clinical testing.

American Heart Association One Brave Idea and BWH-MIT Initiative

The "One Brave Idea" (OBI) was a competition sponsored by the American Heart Association (AHA), Verily, and AstraZeneca, for a single award of $75M to address coronary heart disease (CHD), the most prevalent cause of morbidity and mortality in the developed world. The winning project, submitted jointly by Brigham and Women's Hospital (BWH) and MIT, and headed by Drs. Calum MacRae (Chief of Cardiology, BWH) and Elazer Edelman (Director MIT Biomedical Engineering Center and Clinical Research Center) focuses on developing novel tools to increase the information content in coronary heart disease assessment to allow much earlier and more definitive characterization of the disease, thus improving immediately preventative strategies, but also efficiently laying the groundwork for the discovery of new disease pathways and interventions. The basic premise is to provide better matching of the 1069 level of discrimination on a genetic level with the now 104 scale of disease phenotypes.

Exploiting the capabilities of MIT and BWH, OBI proposes to discover, through innovative phenotyping of early preclinical stages in those with definitive CHD genotypes or definitive premature CHD, upstream biologic traits, or endophenotypes, that are broadly applicable and would allow, in tiered combination, high sensitivity screening, then high specificity confirmation across the entire population at an early age.

OBI has set ambitious goals to accelerate discovery and intervention through the iterative forging and re-forging of partnerships necessary to achieve. Working with the AHA, AstraZeneca, and Google leadership, MIT and BWH can engage entire areas of activity that to date have not exploited in the study of chronic common disease. The projects started will not be the end result of the award, but rather learning examples of what can be achieved together, a means by which to bring together the greater communities of clinicians, scientists, investigators, engineers and policy makers, and a venue from which to grow an ever impactful array of like programs and a repository for greater and greater support of this nature.

MIT Clinical Research Center and Tufts-MIT CTSI

MIT has had a Clinical Research Center (CRC) since 1962 and remains one of two non-hospital institutions with such resources. The CRC has worked closely with internal MIT resources like Committee on the Use of Humans as Experimental Subjects—MIT's Institutional Review Board (IRB)—to ensure the safety of human subjects in the over 700 protocols run by MIT investigators and with external agencies and institutions. The latter involved MIT assuming a role in the National Institute of Health (NIH) network of clinical translational science through National Center for Advancing Translational Sciences program. Indeed, MIT was a key partner in creating a national agreement on IRBs. In 2016, MIT through the leadership of the CRC Director Elazer Edeman joined the Tufts Clinical and Translational Science Institute (CTSI) to renew Tufts' application for funding of the NIH as one of three national hubs supporting all of the 64 programs with the Clinical and Translational Science Awards (CTSA) program. The Tufts CTSI is comprised of a robust partnership of more than 40 organizations, with a unique identity within the CTSA Consortium and nationally recognized strengths in emergency medicine, large effectiveness trials, clinical trials methods innovations, and translational science education. From bench to bedside, to clinical practice, to care delivery and public health, to public policy and beyond, Tufts CTSI is committed to fostering collaboration and innovation across the translational spectrum.

The MIT CRC joins the Tufts CTSI with a specific focus on medical device innovation and prototyping. Translating a research idea into a medical device or diagnostic tool is a challenging process that requires multiple design improvements during the early stages of prototype development, before human testing in clinical research. As user needs and clinical effects grow clearer during the design and prototyping process, this can prompt iterative changes in design and materials. The CRC seeks to create a research environment that bridges critical translation from preclinical development to initial human studies. They aim to facilitate research teams at this early stage to efficiently turn device concepts into testable prototypes, and effectively incorporate clinical insights into the full span of preliminary research and development (R&D). Successfully traversing this translational process requires specialized facilities and tools, as well as close collaboration between large and diverse groups of scientists, engineers, biomedical researchers, and clinical care providers.

These initiatives will allow MIT to not only address issues MIT must confront to continue active research in health and life sciences research including HIPAA adherence and human subjects safety but to also assume its rightful position as an international leader in technology development and evaluation, to set the tone for public policy debates and to remain as critical thought leader and advisor of federal agencies like the FDA and political leaders.