MIT Innovation Roundtable – March 1, 2010, 2:00-5:00PM

Introductions (approx total of 20 minutes) 2:00pm:

Susan Hockfield – Introduction to the Process - 5 minutes **Robert Solow** – Policy Introduction: the Next Phase of the Innovation Economy – 15 minutes

Panel I – 2:20pm - Potential for Accelerating Emerging Growth Sectors

(approximately 1 hour 10 min.; short summaries of policy proposals from each (8 minutes), mostly open discussion among panelists, Q&A):

Moderator: Suzanne Berger

- Panelists:
 - <u>Energy</u> **Richard Lester** (based on IPC's upcoming report on the energy innovation system)
 - <u>Robotics</u> **Rod Brooks,** and <u>Next Gen IT / AI</u> **Daniela Rus** (based on priority research at CSAIL)
 - <u>Life Sciences / Convergence</u> Phil Sharp
 - <u>New Materials</u> Angela Belcher

[5 minute break]

Panel II – 3:35 pm - Improving the Innovation System: R&D Support/Tech <u>Transfer/Entrepreneurship</u> (approx. 1 hour 10 min.; short summaries (8 minutes) of policy proposals from each, then open discussion between panelists, Q&A):

Moderator: **Fiona Murray** Panelists:

> Role of Public R&D Investment - **Darron Acemoglu** Support for Innovation from Private Investment? – **Andrew Lo** Encouraging Entrepreneurship – emerging models – **Ed Roberts** Encouraging Clusters - **Scott Stern**

Summary of Workshop / Outline of Major Points - 4:45pm - **Charles Cooney** (approximately 10-15 minutes)

Closing Comments – Susan Hockfield

Room 3-270

Summary of MIT Roundtable on Developing National Innovation Policies March 1, 2010

Introduction

Susan Hockfield, Ph.D. MIT President

The United States (U.S.) is currently facing a structural recession, in which the jobs that are lost are lost permanently; therefore, completely new industries will be required to replace these lost jobs. There are fewer jobs in the U.S. today than there were in 2000, but there are 11 million more workers. Approximately, 8 million jobs have been lost, many of which will not return in their prior form. The U.S. must innovate its way out of this recession.

The last time that the country faced such a recession was during the 1980s. At that time, MIT took a leadership role and promoted economic policies that led to the substantial growth enjoyed in the 1990s. A similar effort is necessary today to move the country forward. This faculty roundtable has been assembled to answer the question of where will the next wave of economic growth come from, and what can be done to promote the such growth?

Overview of the Challenge

Robert Solow, Ph.D. Professor Emeritus of Economics and Nobel Laureate

The U.S. must improve the productivity of the national economy. The U.S. currently possesses an enormous current account deficit, and increasing productivity is the only way to reduce it without decreasing purchasing power. Being more productive does not merely mean being more efficient, but importantly, being more innovative. Technological innovation is necessary to increase a country's standard of living, even without a current account deficit, and the most important determinant of a country's standard of living is its productivity. Given the need to innovate, what polices should the U.S. adopt to foster innovation? What areas should be targeted for innovation?

The U.S. should target areas that hold promise relative to the U.S. economic position. Encouraging innovation in sectors with large and growing markets, such as energy, is logically more appealing than focusing on those with small and shrinking markets. Another useful area for innovation could be finding substitutes for goods that are becoming scarce, such as some metals.

It should be noted that the U.S. economic structure is well suited to these sorts of problems, but it cannot compete with emerging economies that can easily create domestic production capabilities for low-level goods. Once an object becomes a commodity, a high wage country no longer holds a comparative advantage in its production. There is, however, "always a constituency for last decade's industry," which funnels money that could be used for innovation into areas in which the U.S. no longer holds a comparative advantage. Of 130 million employees in the United States, only 20 million produce material goods, with the rest providing services. These services range from day care to information technology

support, and consume two thirds of all consumer expenditures. Useful innovations in service industries represent an undeveloped area in which the U.S. holds a comparative advantage.

Innovation requires support through resources – money and training – and support. Significant funding is often directed to established industries and results in marginal efficiencies, but these increases will not lead to the widespread innovation necessary to drive significant economic growth. The U.S. needs sharp business incentives to do **<u>new</u>** things. Government funding should be used to support work that would not be done otherwise; subsidizing work that would happen without government intervention is merely substituting for private investment.

Panel 1: Accelerating Emerging Growth Sectors

IntroductionSuzanne BergerRaphael Dorman and Helen Starbuck Professor of Political Science

Currently, the nation is in the middle of an economic crisis that has destroyed millions of jobs, many of which may never return. Approximately fifteen million people in the United States are unemployed and many of these people are too discouraged to even look for work. Prior to this economic crisis, the U.S. was very good at creating new jobs; however, high paying jobs such as those at companies like General Motors (GM), are quickly disappearing and are being replaced by jobs at places such as Wal-Mart that pay much lower wages. It is clear that societies that are more productive and innovative can pay everyone more. Moving innovation rapidly into the economy is advantageous to everybody, as is the surge of growth and productivity that would pull everybody up.

MIT can contribute to reconstructing an economy in which innovation would promote growth, and, above all, a surge of new jobs. More resources must be devoted to innovation. There are numerous scientific and technological possibilities already present that must be brought to bear in the economy. The flow of these innovations into the economy must be accelerated in order to promote new growth in the creation of new jobs. The U.S. also needs to develop new policies, beyond simply spending more money on R&D. MIT can play a pivotal role as an institution to bring these visions to fruition.

Energy

Richard Lester, Ph.D.

Department Head of Nuclear Science and Engineering Founding Director of the MIT Industrial Performance Center

The threat of climate change requires us to shift as quickly as possible away from an economy based on fossil fuels and towards low-carbon energy supplies and more efficient energy use. This transition must be completed on the time scale of a few decades in order to avoid a range of dangerous outcomes that today seem increasingly more likely. In the energy sector, a transition of this scale has never happened so quickly and this will have serious implications for the U.S.

Innovation will be essential to these actions, because most of the low-carbon energy technologies available today are too expensive or otherwise unable to compete against today's incumbent

fossil fuel technologies. Government could conceivably mandate the use of these technologies, but such policies would impose heavy costs on energy users and taxpayers. Ultimately, our ability to negotiate the energy transition will hinge on how quickly we can bring down the costs of low-carbon energy technologies.

Three separate waves of innovation could facilitate this transition. First, the U.S. should achieve improvements in energy efficiency through business models that can be implemented quickly. Second, the U.S. must deploy large-scale low carbon energy supply technologies and drive down their costs through continual advances, especially after 2020. Third and finally, the U.S. must draw on entirely new concepts, processes, and materials that are being pursued by basic researchers. These breakthroughs will likely not make major contributions until mid-century because of the long timescales for technology development and turnover of energy capital stock.

These waves of innovation must be pursued aggressively; unfortunately, the innovation system of today cannot meet these needs. True energy innovation will require hundreds of billions of dollars a year of mostly private investment in cost competitive, scalable, and environmentally benign new technologies. It will make thousands of new sites available for the construction of controversial energy facilities and infrastructure, and every year train tens of thousands of young people from craft workers to Ph.D. scientists and engineers. All in all, these demands are far greater than anything previously seen.

The challenge of energy innovation is different from other kinds of innovation because the major impetus for it comes from outside the marketplace. If left solely to market forces, the pace of innovation will be too slow. Two prescriptions could augment these forces. One prescription is for the government to fund R&D on a large scale. However, even if scaled up several-fold, government support for early stage research will not be sufficient to induce the required rate of innovation over the next several decades. Another prescription is to use price adjustments to achieve the desired results. Pricing carbon emissions is the most efficient way to stimulate demand for low-carbon energy technologies. This alone will not suffice, however, partly because of the many other distortions and rigidities in energy and technology markets. In addition, politicians are unlikely to let energy prices rise high enough to induce innovation at the necessary rate.

The energy innovation problem encompasses multiple and often conflicting goals. The U.S. must reduce carbon emissions, increase energy security and push for affordable energy prices while simultaneously safely developing of new industries and jobs that go with them. This system includes many different kinds of customers and multiple timescales. Success will only come if the technology is adopted by an enormous number of users. Cost competiveness will be essential because while users may care about the services energy provides, they care less about where it comes from and mainly about cost. Three major obstacles must be overcome.

1) A more realistic view of the scale of the problem is needed. The innovation challenge is much larger than most people think, and it will require a more comprehensive strategy than anything that has gone before.

- 2) A strategy of the necessary size and scope will not be sustainable without a durable base of political support. In the history of defense technology, the combination of a potent external threat, substantial opportunities for business growth and local job creation, and a politically powerful industrial base with Congressional supporters in every part of the country fueled 60 years of essentially unbroken political support for advanced defense research and innovation. Today there is no equivalent broad-based, political coalition to support a national low-carbon energy innovation strategy. Rather, there are disparate and often competing regional advocacies, narrowly defined corporate interests, separate and competing technology and fuel factions, single-issue environmental lobbies, and a public that appears less eager for the government to act on climate policy than in most other societies.
- 3) The current organization and structure of government energy innovation institutions is also not up to the task. For example, the Department of Energy (DOE) still struggles to find a coherent mission more than 30 years after its creation. While more public support for early stage research is certainly needed, it will not be enough for existing institutions simply to do more of what they are already doing. New strategies and institutions will be necessary, especially to address the crucial downstream activities of demonstration, commercialization, and the early stages of large-scale technology take-up.

Robotics

Rodney Brooks, Ph.D.	Panasonic Professor of Robotics in Electrical Engineering and
	Computer Science
	Co-Founder, Chairman, and Chief Technical Officer of Heartland
	Robotics

Over the last decade, The U.S. has seen a great deal of robotics innovation and successful marketplace entry of surgical robotics, home cleaning robots, and military robots. The growth is spectacular—more than 10,000 ground robots in the US military and over five million robots in people's homes, both up from zero in June 2002. Robotics has taken off for three primary reasons. First, computation and sensors have become exponentially cheaper in the last fifty years. Second, research in computer vision and in simultaneous localization and mapping has made major strides in the last ten years. Third and finally, for certain tasks, robots have passed the usability threshold that makes them useful to untrained people. Overall, we have seen exponential growth in the capabilities of robots.

The first robots in manufacturing were invented in the U.S. in 1961. At that time, there were no computers, no sensors, limited motions capability, and the cost of systems integration was approximately ten times the cost of the robot. Unfortunately, today's industrial robots are much the same, as their creators have not yet exploited the information technology revolution of microprocessors and networks. Current manufacturing robots re engineered to be precise and repeatable, but not adaptable, and they are often unsafe for people to be around. These expensive robots can only operate in very structured environments with limited application. A new vision for American manufacturing encompasses skilled workers producing both high-value and mass-market products. Robots could empower workers by giving them new tools and taking over simple tasks, freeing workers to work smarter. In addition, robotics and Science, Technology, Engineering, Math (STEM) education could support each other.

One barrier to robotics innovation is the long time (~ 10 years) it takes to move from lab to product. Four recommendations could accelerate robotics innovation at MIT.

- 1) Develop a professional masters program in robotics. This program would bridge electrical engineering, mechanical engineering, and business, providing a good source of workers for local industries as they grow.
- Develop co-ops at very small pre-revenue companies without asking them to pay MIT tuition could accelerate growth. A pre-money equity percentage could quality the company.
- 3) Increase support to robotics companies and incubators, particularly for robotics faculty interested in starting a company.
- 4) Create an MIT Robotics Lab with graduate education and an undergraduate robotics major to help supply robotics manufacturing with educated workers.

Beyond MIT, the government could also play a role in accelerating robotics innovation. DARPA-like funding could be applied to manufacturing R&D, but it should not simply be focused on high-end high value processes. These resources should also be provided to lower end and smaller enterprises, similar to the European Union's Small/Medium Enterprise Robotics Program. Government should also demand and encourage more low-end manufacturing, and push harder on labor and other standards for manufacturing of imported goods.

Next Generation Information Technology and Artificial Intelligence

Daniela Rus, Ph.D.Professor in Electrical Engineering and Computer ScienceAssociate Director of CSAIL at MIT

Computation has deeply affected our economy and how we live, work, learn, and play. The earliest computers were invented to compute trajectories; mainframe computers sped up billing and insurance, desktop computers increased personal productivity, and, more recently, networked computers with sensors enable real-time monitoring and surveillance applications. This trend is moving toward more interactions in the physical world through robots that can act in the world for us. Ordinary objects amongst us will start to become programmable so that we can adjust their properties to enable functionality. The next level of innovation will occur at the convergence between computation and other disciplines. At MIT, these interactions will likely be a major source of mutual innovation and transformation.

For example, computation and biology will transform each other. Computation has already caused breakthroughs in biology, like genome sequencing and behavior modeling. In turn, biology is transforming computation and providing new challenges that force computer scientists to revisit how they represent data and computation, and organize their priorities. Some goals for representation include experimental design, predictive modeling, automated reasoning, and query processing. Some examples of biology transforming computation include personalized medicine,

drug design, the understanding of evolution, and development of new devices and algorithms to discover the detailed mechanisms of development.

In another example, computation and chemistry have intersected, enabling a combinatorial approach to materials discovery and cell and tissue engineering. At the same time, the challenges of chemistry are pushing for new innovation and computation, for example, in the area of creating smarter materials and power sources. Computation has also enabled a revolution in social interactions that is creating new opportunities and capabilities. Examples can be found in location-based computing, privacy-based computing, computing for the developing world, and computing to automatically infer professional connections. It is anticipated that adding new capabilities to social networks that do location-based computing, taking into account privacy issues, will be an extremely powerful and active area of computing.

Finally, computation is blending with environmental studies and sustainability. Computing has enabled the simulation and prediction of weather patterns and climate change, and has increased the accuracy and scope of data collection with sensor networks. In turn, the need to address environmental problems requires new computational paradigms to enable more sustainable living. This could include observation, modeling, and providing damage control and repair solutions, which will likely be found at the interaction of computation, engineering, and environmental studies.

Three primary innovative themes emerge from these four examples.

- There is a need for richer knowledge capture and representation, such that we can move from textual information to ways of capturing and representing meaning and relationships, and in turn making this knowledge accessible for all. It is anticipated this transition from "WWW text" to "WWW computing" to be a large generator of jobs.
- 2) There is a need to encourage better human-machine collaboration. By building combined human computer systems that let humans do what they do best, and machines do what they do best, we will achieve more capability and ultimately create a different class of jobs.
- 3) Computation is becoming more about interacting and extending our sensing capabilities into the physical world. A wide rage of physical phenomena could be predicted through augmented reality and personalized activity with software avatars.

In order to achieve this, computation and artificial intelligence must be brought to bear on the economy. Many ideas coming out of MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL) could become products immediately that create jobs. MIT should encourage the capitalization of computation by simplifying the creation of startups and expanding on existing organizations, such as the Deshpande Center. Also, MIT should promote the idea of incubation, access to venture capital, and guidelines that make it easier for faculty and students to start companies. Innovation will ultimately be accelerated by providing better bridges and opportunities for people in different departments to interact with each other.

Convergence of the Life Sciences with Engineering and the Physical Sciences

Institute Professor of Biology MIT Koch Institute for Integrative Cancer Research

The convergence of computational, engineering, and physical sciences with life sciences will be a major source of innovation for the coming decades. In fact, this convergence is likely to represent the most important area of innovation of the early part of the 21st Century as it addresses many of the major challenges facing society: advancing the quality of healthcare at lower cost, providing new sources of energy for transportation and materials, increasing the availability of food by increasing productivity of plants, and furthering monitoring and engineering of environmental systems to enhance their protection and management.

The basis for these statements can be found in a report recently issued by the National Academy of Science entitled "*The New Biology for the 21st Century*" that was produced by a distinguished committee co-chaired by Tom Connelly, chief technology officer of Dupont, and Dr. Sharp. This report calls for an increase in funding of the convergence of life sciences and computational, physical and engineering sciences in an interagency fashion that takes advantage of the expertise of different agencies such as the National Science Foundation (NSF), the Department of Energy (DOE), the Department of Agriculture, and the National Institutes of Health (NIH). There has been some recognition of these recommendations in the NSF budget for 2011.

Such a convergence is particularly relevant to MIT because of its location in one of the most innovative centers in the world for biomedical research. This includes the surrounding biotech and pharmaceutical companies as well as the neighboring hospitals and universities. Much of the future economy of New England is dependent upon innovations in medicine and healthcare delivery. The newly emerging convergence of life sciences and engineering is pictured as a "third revolution" that has its origins in two earlier revolutions. The first revolution occurred in the 1950s and 1960s with the discovery of the structure of DNA and the development of science and technology in molecular biology that gave rise to biotechnology in the 1970s. During this period, biotech companies such as Biogen, Genzyme, and Millennium were established in Cambridge, Massachusetts. Later, several international pharmaceutical companies such as Novartis, Merck, and Amgen followed.

Science advanced with a second revolution at the turn of the century - the integration of early advances of bioinformatics and engineering with molecular biology that allowed the sequencing of the human genome. Through these and other advances we have begun to elucidate the working parts of cells and to learn how small sets of these parts function in systems in normal and disease processes. As we have seen in the human genome project, interdisciplinary teams need to work together to develop the technology and computationally address the complexity of data in many areas of research in life sciences. This will only increase as even more powerful high throughput methods are used to explore cellular systems. There are several impediments to realization of the innovations promised by convergence that could be partially addressed through the recommendations listed below.

1) Expand funding within NIH and other agencies to support interdisciplinary research in life sciences.

- 2) Assign interagency working groups to lead project supported by a significant portion of the funding. These projects would benefit from different expertise housed in each agency.
- 3) Examine both academic structures and peer review to insure that interdisciplinary research is appropriately valued.
- 4) Develop educational programs to train students for interdisciplinary research in biology, computation, physical sciences, and engineering.

New Materials

Angela Belcher, Ph.D.

Germeshausen Professor of Biological Engineering Department of Material Sciences and Engineering

Major global issues, including energy, healthcare, and the environment, provide great challenges and opportunities for material sciences. MIT is on the forefront of materials innovation. One example is work by Yet-Ming Chiang, a co-founder of the company A123. He published a paper on a new battery material in 2000. This work was funded by DOE and took 33 months to go from paper to product. The ability to develop his idea on his own, rather than feed it into an already existing battery company with preconceived notions, was key to this rapid commercialization.

The following recommendations could result in similar successes:

- 1) Continue to invest in basic science innovation, since it is impossible to predict where the next breakthrough technology will come from.
- 2) Increase the number of interdisciplinary scientists and engineers.
- 3) Invest in K-12 education to get kids excited about science and engineering early.
- 4) Decrease the time to move from scientific discovery to commercial product. It currently takes approximately 18 years for the average new material discovery to reach commercialization. This is far too long to wait for a product or an important solution to major challenges especially during the current economic crisis.

Panel 2: Improving the Innovation System

Introduction

Fiona Murray, Ph.D.

Sarofim Family Career Development Associate Professor of Management

Dr. Murray opened the panel with brief comments about the importance of an innovationpromoting policy agenda. Academia needs to improve its understanding of how innovation happens - both on the macro and micro scales. Such an understanding will be critical to creating an innovation policy agenda.

The Logic and Role of Public Support for R&D

Daron Acemoglu, Ph.D. Charles P. Kindleberger Professor of Economics

It is important to consider both the positive and negative impacts of public support for research and development: what can the country get out of it, and what are the dangers? Primary justifications for government intervention include the redistribution and correction of externalities, and decisions made in the political economy. Externalities are any kind of activities that create either benefits or costs to another that the people undertaking the activities don't internalize. Mediating socially relevant externalities are a legitimate reason for government intervention in innovation and invention in academic matters. But of course the reality is that many government interventions are motivated by political economy, which is not for the good of the society but the good of the politicians and their constituencies.

Academics in particular have to be careful in advocating money being poured into universities because they are the beneficiaries of that money. It is quite important to actually understand what the case is for the government's continued and increased support for academia and innovation.

What are the key externalities that would actually justify government intervention? There is a widespread belief that there are major externalities in education, e.g., if you have more educated workers, they increase the productivity of other workers and ultimately justify additional investment into education. The economic reasoning for this is not very solid, since most workers create interactions with other workers in the same firm as themselves. The data also indicate that for K-12 education that there is no evidence of any type of major productivity externality (not taking into account education's contribution to creation of civil society).

The economic case for externalities in R&D is much stronger. First, R&D has a "spillover effect" in that knowledge spreads beyond the company that pays for the research. For example, patents have finite length and narrow breadth, allowing others to ultimately take advantage of the advances. Second, some types of R&D will be neglected - for example, basic science that has an unclear path to market and R&D directed at public goods. Third, when R&D is directed at reducing other harmful externalities—for example R&D targeted at new environmentally friendly technologies—there may be strong "free riding" incentives on the part of the private sector, resulting in serious private underinvestment.

What should be done if there are externalities in R&D and the private sector under invests? It is not necessarily true that the government should step in. All government interventions come with various inefficiencies and cost tax dollars that could have alternative uses. Second, public and private R&D funding may be substitutes in some situations, causing public R&D dollars to crowd out private spending. Third, government may also encourage suboptimal lines of research because it has different priorities or a conflicting organizational approach than the government. For example, could Darwin have written *The Origin of Species* if he were required to demonstrate short terms results like an MIT faculty member may be required to do today?

In order to create positive externalities, government support of innovation should target three specific areas:

1) Exploit areas where public and private research offer compliments instead of substitutes. A classic example is development of the ARPANET (high public investment), which led to the Internet (heavy private investment). Other examples can be found within the aviation industry and the nuclear power industry – sectors where private investment alone would not have resulted in breakthrough technologies.

2) Avoid multiple objectives. Short-term job creation cannot, and should not, be the objective of government support for R&D. Do not confuse commercialization of existing technologies and public-private research partnerships. The former is a profit-making enterprise that should not be subsidizes by government.

3) Avoid short-run accountability. While researchers funded by public funds must demonstrate some accountability in the form of deliverables, emphasis on short run accountability seriously distorts the process of science. When there are multiple objectives, but incentives are only designed on the basis of some of them (i.e., those that are easy to measure), significant distortions result. The hard to measure objectives without accompanying incentives will see underinvestment. Likewise, if a publicly funded project can deliver a product in six months, it would likely have been undertaken by a private company anyway, which violates the goal of public funds being *complimentary* to private money.

Innovation and Financial Infrastructure

Andrew Lo, Ph.D. Harris & Harris Group Professor of Management

Innovation requires financial infrastructure. With good infrastructure, large-scale innovation is possible; without it, it is not possible. Indeed, well-designed financial infrastructure might not only be necessary, but also *sufficient* for strong innovation. The infrastructure required includes private investment; well-functioning capital markets; proper design of securities; effective accounting, legal, and regulatory structure; and systemic stability.

The financial crisis provides an example of the power of capital markets. The crisis was precipitated in part by financial innovation, but even more important was the emergence of true "global capital markets" in the last 15 years. The skyrocketing home prices showed the staggering sums of money out there that could be tapped. The question then becomes, how can we use this money for spurring innovation instead of asset bubbles?

An example of this would be applying a portfolio approach to curing cancer. Drug discovery is expensive, slow, and risky. In this field, it typically takes \$500 million and 10 years to develop a drug with a 5% chance of success. There are also many possible mechanisms for fighting cancer, so it would be ideal to pursue many very different paths, whereas big pharma only pursues a few. What if a \$20 billion fund could be raised and solely targeted at funding cancer drug development? If each drug's chance of success is independent, the fund would have an 87% chance of success, with an expected return on investment of about 10% per year. This "mega-fund" technique is not limited to drugs; it could also be a mechanism for solving many of society's biggest challenges, such as climate change and energy independence.

Is such a portfolio approach realistic? It could be, if it used a solid financial structure. One way would be to securitize it – for example, 10 million households investing \$2000 each would cover an entire \$20 billion fund. The returns would depend on experimental results and would be uncorrelated with the performance of the S&P 500. This kind of diversification with uncorrelated risk could be very attractive to investors, and innovation depends on the ability to design programs such that it is in companies' self interest to innovate. This kind of financial engineering could also simultaneously demonstrate genuine social value.

Financial structure can greatly enhance or inhibit innovation. Government and university policy could help by supporting financing of innovation, using tax policies strategically, and launching targeted public/private partnerships. The government could also play a critical role in launching these "mega-funds," just as it did in launching Fannie Mae and Freddie Mac. The potential for solving the world's biggest challenges could be enormous if the science and financial engineering could be properly combined to create sustainable vehicles for supporting large-scale innovation.

Encouraging Entrepreneurship

Ed Roberts, Ph.D.

David Sarnoff Professor of Management of Technology Chair of the MIT Entrepreneurship Center

Dr. Roberts presented several key findings of the Kaufmann Foundation-supported report "*Entrepreneurial Impact: The Role of MIT*" by Roberts and Eesley. If taken together, the companies founded by MIT alumni would constitute the 11th largest economy in the world. Many of these companies are extremely high tech and innovative. Interestingly, the impact of university alumni is more important than direct tech transfer, and lessons drawn from these alumni could be very enlightening for charting the future of innovation policy.

The most striking result is that the largest 2% of MIT alumni-founded companies created 70% of all the jobs created by MIT companies, i.e. big companies make a big impact. This means the U.S. must rethink the Small Business Administration. In order to impact economic growth and job creation, it should be remade as the *New* Business Administration with a focus on high-growth businesses. The New Business Administration should also revamp the Small Business Innovation Research (SBIR) program. Currently, SBIR grant winners are mostly small companies that stay small and focus only on R&D that looks good to SBIR program administrators. The federal government could also provide tax credits granted "per new domestic employee," as is done in many countries worldwide, and offer five year post-degree visas with easy paths to green cards or citizenship for all foreign students in science, technology, and management programs. Foreign students are much more entrepreneurial than U.S. students: 30% of foreign MIT graduates form companies, and half of these remain in the U.S. with their companies.

Tax policy could also play a key role in spurring innovation at U.S. companies. The U.S. should reduce capital gains tax rates for long term (> 5 years) investments in U.S.-headquartered startup companies. It is also crucial to make corporate R&D tax credits permanent, to reduce the uncertainty firms face when budgeting for R&D. Further, tax credits should be increased for firms that grow their domestic R&D funding.

Universities should also be encouraged to foster science and technology entrepreneurial leadership. One way to do this would be to fund ten "model" entrepreneurship centers across the U.S. at science and technology-based universities to develop, document, and assist in nationwide dissemination of best practices. Universities should also make entrepreneurship programs university-wide, to integrate management students with science and technology students. Universities should remove rules and regulations that form barriers to faculty and staff entrepreneurship.

Encouraging Innovation Clusters

Scott Stern, Ph.D.

Joseph and Carole Levy Professor at the Kellogg Graduate School of Management at Northwestern University

For more than 60 years, U.S. leadership in science, innovation, and entrepreneurship has served as a foundation for economic growth and as a means of addressing pressing social challenges. This leadership stemmed not only from effective innovation policy, but also from a significant commitment of human and financial resources to train scientists and engineers, build research infrastructure, and sustain public and private support for fundamental science and engineering research. While a host of nations have followed the U.S. example, R&D leadership in this country has lagged, most notably in terms of science and engineering workforce growth. Recent crises such as the great recession and addressing climate change have highlighted the disconnect between our historical innovation leadership and our ability to deploy these resources to meet current challenges.

Productivity growth and prosperity depend on *national innovative capacity*, which is the ability to develop and commercialize new-to-the-world technologies, products, and organizations. National innovative capacity generates increased productivity; increased productivity then gives rise to greater prosperity. There are several key ingredients required for an effective innovation infrastructure. Innovation *resources* include a skilled science and engineering workforce, access to higher and postgraduate education, availability of risk capital, and quality information infrastructure. Innovation *policies* include effective subsidy and grant programs, consistent R&D tax policy, strong education policy and funding, intellectual property protection, and openness to international trade and investment. Another key component is having a national *knowledge stock* consisting of basic research investments, a strong cumulative innovation record, and overall technical sophistication.

This national innovative capacity provides the environment in which dynamic private companies do the innovating. The two most important linking mechanisms between national innovation capacity and private industries are universities and venture capital markets. Universities do not just produce students and knowledge; they produce the ability to build cumulative innovation systems within their local environments that form innovation clusters. See "*Entrepreneurial Impact: The Role of MIT*" by Roberts and Eesley for the example of the Kendall Square biotech cluster around MIT. Universities have the commitment to openness and the ability to catalyze innovation within the university and externally. This ability may in fact be more important than the papers they produce. Even in this age of the Internet and easy mobility, strong local innovation clusters see significantly increased industry growth rates. Clusters spawn related and

supporting industries; open and vigorous local competition around innovation; sophisticated and demanding local customers that anticipate the needs of future customers elsewhere; and strong inputs of skilled workers, basic research infrastructure, risk capital, and information infrastructure.

It is important to realize that there are no short-term magic bullets to creating long term-growth through innovation. In 2007, General Motors employed approximately 40 times as many employees as biotech success story Genentech. This is just one illustration of the fact that innovation is not a reliable *short-term* job creation engine. But investing in and reinforcing the comparative advantage of regions is linked to *long-term* economic performance. The development of a coherent innovation clusters takes time. Over time, effective innovation policy serves as the foundation for sustainable economic growth and the capacity to effectively address pressing social challenges. The ability to address emerging crises depends on the ability to exploit long-term investments in the national innovation system.

Question and Answer Session

How should the nation connect broad-based public support for innovation to the reality of building a strong innovation system?

Professor Stern pointed out that there is a large disconnect between the strong support for investment in scientific research, and very, very low support for increasing taxes or cutting other programs to pay for it. There once was a bipartisan group in Congress that was well informed on these issues, but that group has fallen apart in the last several years for a variety of reasons, leaving something of a gap in leadership. Prof. Lo went on to say that the best way to encourage firms to do anything is through appealing to their self-interest. If we want innovation, we must make it in their interest to do so. The real estate bubble did not happen overnight; it happened because at every step of the food chain, someone profited from moving it along to the next step. We must start designing social programs with that kind of self-interest in mind. With the proper financial structure, we can do that, and then literally trillions of dollars are available to pour into these kinds of objectives, but this requires very careful structuring.

In the light of the GM vs. Genentech employment example, then should MIT be reaching out to very large firms to support their innovation?

Professor Stern noted that many large corporations spend most of their R&D money on incremental improvements to their existing technologies. He cited the oil industry as an example of an industry that spends orders of magnitude more on making minor improvements to petroleum deposit detection than is spent on anything in green energy.

Only one of the roughly 14 corporate sponsors of MIT's Energy Initiative are U.S. based, despite MIT's efforts to reach out to large U.S. companies in this area. Professor Lo said that these large American firms often focus on protecting their franchise and bottom line. This is why it is important to fund startups. Startups do not already have "skin in the game" and are unafraid of

disruptive new technologies. A large number of startups means many different approaches to developing technologies, and we can pick the best ones.

Summary StatementCharles Cooney, Ph.D.Robert T. Haslam (1911) Professor of Chemical Engineering

Dr. Cooney providing the following summary points to wrap up the discussion.

- The U.S. currently faces extraordinary challenges. Now is the right time to bring together the best thinkers from science, engineering, business, and the social sciences to define the problems and create novel strategies to address them. The MIT community needs to recognize the unprecedented urgency and scale of these challenges, and that the nation's problems will require extended focus of effort. Dealing with these issues will require upwards of 20 years of concerted effort.
- 2) Not surprisingly, there is widespread belief that the government should fund more research, but the country should focus this money towards the problems facing society. In general, the MIT community should be thinking about how to translate their research into solutions for society. Likewise the MIT community should be thinking about be thinking about how to do research that will have an impact at a scale relevant to the needs of society.
- 3) The MIT community should recognize that solutions often come from the interface between disciplines, and not from traditional departmental silos. For example, the convergence of biology and engineering shows tremendous promise, as does the convergence of computation and robotics. Unfortunately, much of the incentives in the current system are geared towards these silos. The U.S. needs to encourage its students to pursue progress at the interfaces between fields.
- 4) As MIT moves forward, it should adhere to the following guidelines
 - MIT should address issues at the interface of government, industry and academia.
 - Innovation policy should avoid multiple objectives. For example, innovation policy should focus on long-term growth of a sector and not short-term jobs creation.
 - MIT should encourage the growth of its "innovation culture."
 - MIT should recognize that it is part of a regional and national community, and should continue its work to develop an innovation cluster in the greater Boston area.

This summary of the March 1st, 2010 MIT Innovation Roundtable was written by the following members of the MIT Science Policy Initiative:

Dina Faddah Mike Henninger Josh Wolf Gerard J. Ostheimer Graduate Student Graduate Student Graduate Student Ph.D. Postdoctoral Fellow