

**FROM THE LAB BENCH TO THE MARKETPLACE:
IMPROVING TECHNOLOGY TRANSFER**

HEARING
BEFORE THE
SUBCOMMITTEE ON RESEARCH AND SCIENCE
EDUCATION
COMMITTEE ON SCIENCE AND
TECHNOLOGY
HOUSE OF REPRESENTATIVES
ONE HUNDRED ELEVENTH CONGRESS

SECOND SESSION

JUNE 10, 2010

Serial No. 111-99

Printed for the use of the Committee on Science and Technology



Available via the World Wide Web: <http://www.science.house.gov>

U.S. GOVERNMENT PRINTING OFFICE

57-177PDF

WASHINGTON : 2010

For sale by the Superintendent of Documents, U.S. Government Printing Office
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**FROM THE LAB BENCH TO THE MARKET-
PLACE: IMPROVING TECHNOLOGY TRANS-
FER**

THURSDAY, JUNE 10, 2010

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION
COMMITTEE ON SCIENCE AND TECHNOLOGY
Washington, DC.

The Subcommittee met, pursuant to call, at 10:11 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Daniel Lipinski [Chairman of the Subcommittee] presiding.

BART GORDON, TENNESSEE
CHAIRMAN

RALPH M. HALL, TEXAS
RANKING MEMBER

U.S. HOUSE OF REPRESENTATIVES
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Hearing on

*From the Lab Bench to the Marketplace:
Improving Technology Transfer*

June 10, 2010
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Witness List

Dr. Thomas W. Peterson
Assistant Director
Directorate for Engineering
National Science Foundation

Ms. Lesa Mitchell
Vice President of Advancing Innovation
Ewing Marion Kauffman Foundation

Mr. W. Mark Crowell
Executive Director & Associate Vice President
Innovation Partnerships and Commercialization
University of Virginia

Mr. Wayne Watkins
Associate Vice President for Research
University of Akron

Mr. Keith L. Crandell
Co-founder and Managing Director
ARCH Venture Partners

Mr. Neil D. Kane
President and Co-founder
Advanced Diamond Technologies, Inc.

HEARING CHARTER

**COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND SCIENCE
EDUCATION
U.S. HOUSE OF REPRESENTATIVES**

**From the Lab Bench to
the Marketplace: Improving
Technology Transfer**

JUNE 10, 2010
10:00 A.M.—12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

1. Purpose:

The purpose of the hearing is to examine the process by which knowledge and technology are transferred from academic researchers to the private sector, and to identify best practices, policies, and other activities that can facilitate the commercialization of federally funded research for the benefit of society and the economic competitiveness of the United States.

2. Witnesses:

- **Dr. Thomas W. Peterson**, Assistant Director, Directorate for Engineering, National Science Foundation
- **Ms. Lesa Mitchell**, Vice President of Advancing Innovation, Ewing Marion Kauffman Foundation
- **Mr. W. Mark Crowell**, Executive Director & Associate Vice President for Innovation Partnerships and Commercialization, University of Virginia
- **Mr. Wayne Watkins**, Associate Vice President for Research, University of Akron
- **Mr. Keith L. Crandell**, Co-founder and Managing Director, ARCH Venture Partners
- **Mr. Neil D. Kane**, President and Co-founder, Advanced Diamond Technologies, Inc.

3. Overarching Questions:

- What are the challenges to increasing the transfer of knowledge and technology from university researchers to the private sector? Are there best practices, training, or policies that should be put in place at universities, Federal agencies, and industry to facilitate the commercialization of federally funded research?
- How does the National Science Foundation (NSF) foster the transfer of knowledge and technology from U.S. universities to the private sector? What is the appropriate role of NSF beyond its role of supporting basic research in the “innovation ecosystem”? What changes, if any, should NSF make to its portfolio of programs?
- What are the key elements of successful university-industry commercialization collaborations? How do university technology transfer programs vary across institution type? What type of education, training, and support are universities offering professors, postdoctoral fellows, and graduate students interested in the commercialization of their research discoveries? How are universities engaged in local, state, and regional innovation initiatives?

4. Background:

While there is no single agreed upon definition, innovation is generally considered to describe the process by which new scientific and technical knowledge is converted into a useful product or service that generates economic growth and job creation and/or that improves individual and societal well being. Whether or not one includes basic research, from which new knowledge is generated, as part of the definition of innovation, it is often the necessary first step in the process of commercialization of products.

U.S. economic strength has long been attributed, at least in part, to investments in research and development (R&D) by both the Federal Government and the private sector, and to its nearly unparalleled research universities. In recent years, an increasing number of countries have begun to adapt their R&D activities to the U.S. innovation model. For example, China increased their investment in R&D by 500 percent between 1991 and 2002, from \$14 billion to \$65 billion. Similarly, European Union leaders have urged their members to increase their investment in R&D to three percent of their GDP by 2010. In addition to significantly increasing funding for R&D activities directly, U.S. competitors have also started to invest heavily in improving their higher education systems and have begun supplying the funds for startup companies and incubation centers for product development¹. In recognition of the critical role that venture capital plays in supplementing investments in R&D and in the technology transfer process, emerging economies have also made great efforts to attract and stimulate venture capital activity in their countries.

This hearing is largely focused on one part of the entire “innovation ecosystem”: the process by which the results of academic research are transferred out of the university and into the hands of companies, including start-up companies, which seek to turn those results into useful products.

Federal Research Investments

According to the National Science Board’s 2010 Science and Engineering Indicators report, academic performers are estimated to account for 55 percent of U.S. basic research, and 31 percent of total (basic plus applied) research. The Federal Government provided 60 percent of funding for academic R&D expenditures in 2008, the universities provide approximately 20 percent with institutional funds, and the remainder comes from state and local government funds (7 percent), industry (6 percent) and a mix of other sources (8 percent), such as charitable foundations. The Federal share has actually been declining from a peak of nearly 70 percent in the early 1970s, with colleges and universities making up for the difference using their institutional funds. Nevertheless, as has been the case since the 1950s, the Federal Government is the largest source of support for basic research, and universities and colleges remain the largest performing sector, with Federal laboratories and the private sector nearly tied for a distant second.

Measuring Technology Transfer

Currently, the effectiveness of any single university’s ability to transfer knowledge and technology is often measured against a set of metrics that include: the number of research articles published and cited, the number of invention disclosures filed, the number of patents issued, the number of licenses offered, formation of startup companies, and the number of products released. A survey by the Association of University Technology Managers (AUTM)² indicates that invention disclosures filed with university technology transfer offices grew from 15,510 in 2003 to 19,827 in 2007 and the number of new U.S. patent applications filed increased from 7,921 to 11,797 over the same period of time. Additionally, AUTM reported a growth in the formation of startup companies from 348 in 2003 to 555 in 2007, with a cumulative total of 3,388 startup firms associated with university patents and licenses. Although a number of factors are evaluated in the AUTM survey, many consider the money generated as a result of licensing income to be an adequate indicator of a university’s technology transfer success. According to the 2007 survey, the license income for select institutions ranged from \$0 to almost \$800 million with the total license income reported for the 194 institutions at \$2.7 billion. These data highlight the wide range of success in technology transfer occurring at institutions across the

¹*Rising Above The Gathering Storm*; The National Academies Press 2006

²AUTM® U.S. Licensing Activity Survey 2007: http://www.autm.net/AM/Template.cfm?Section=Licensing_Surveys_AUTM&CONTENTID=4518&TEMPLATE=/CM/ContentDisplay.cfm

country and suggest that perhaps the successes of some institutions could serve as useful models for other institutions.

These results may also suggest that a more comprehensive set of metrics should be established in order to accurately determine the success of knowledge and technology transferred from colleges and universities and to quantify the return on Federal investment in academic research. The National Science Foundation and the National Institutes of Health are currently collaborating on a project known as STAR METRICS (Science and Technology for America's Reinvestment: Measuring the Effect of Research on Innovation, Competitiveness and Science), which is the first national Federal and university partnership to document the outcomes of science investments for the public. This project is in its initial proof of concept phase in partnership with a handful of regionally and otherwise diverse institutions. The National Academy of Sciences is also in the early stages of a study to outline a framework by which research impact can be quantified.

The Role of NSF in Fostering University-Industry Partnerships

NSF generally promotes knowledge and technology transfer from universities to the private sector by increasing the number of university-industry partnerships and collaborations. The primary agency-wide programs are *Grant Opportunities for Academic Liaison with Industry (GOALI)*, *Partnerships for Innovation (PFI)*, and *Small Business Innovation Research & Small Business Technology Transfer (SBIR/STTR)*. The *GOALI* program (\$18.6 million in FY 2011) seeks to improve industry-university research linkages in the design and implementation of products and processes and funds fundamental research and novel collaborations between universities and industry that focus on education and knowledge transfer between the two entities. The *PFI* program (\$19.2 million in FY 2011) establishes collaborations between the private sector, state and local governments, and colleges and universities in order to support innovation in regional communities and to develop innovation infrastructure for economic growth. In the FY 2011 budget, NSF has requested \$12 million to implement a new "innovation ecosystem" component within the program; to date the details of the new component have not been outlined.

NSF also supports a number of research center programs that focus specifically on increasing university-industry collaboration and transferring university developed ideas, research results, and technology to U.S. industry. For example, the *Industry/University Cooperative Research Centers Program (I/UCRC)* supports partnerships between universities and industry that feature industry-relevant research and leverages Federal investments by requiring strong industrial support of and collaboration in research and education. Additionally, the goal of the *Engineering Research Centers (ERC)* program (\$65.7 million in FY 2011) is to train engineering graduates in an intensive research setting that focuses on fundamental engineering systems research to create the country's future innovations and innovators.

The Division of Industrial Innovation and Partnerships within NSF's Engineering Directorate houses the SBIR/STTR programs, which seek to support regional innovation and economic growth by funding translational research at small businesses; SBIR/STTR has a requested budget of \$142.9 million in FY 2011, a 14 percent increase over FY 2010. The SBIR program, created by the Small Business Innovation Development Act of 1982, requires that any Federal agency that supports extramural R&D activities over \$100 million allocate 2.5 percent of its R&D obligations for projects with small businesses. The STTR program was established in 1992 to promote collaborations between small businesses and nonprofit organizations such as colleges and universities or other federally funded research and development centers. Federal agencies that have extramural R&D budgets over \$1 billion are required to participate in the STTR program and must allocate 0.3 percent to the program activities. The SBIR/STTR program is split into three phases that progress from determining whether an innovation has sufficient technical and commercial merit, to conducting research to develop the innovation, to the formulation and the implementation of a commercialization plan. The Technology and Innovation Subcommittee has held numerous hearings on the SBIR and STTR programs in recent years.

In May 2010 the *i6* prize program was announced to bring innovative ideas to the marketplace. The \$12 million challenge is sponsored by the U.S. Economic Development Administration, the National Institutes of Health (NIH), and NSF. In the first step of the challenge, six teams that determine the most creative ways to spark entrepreneurship, innovation and technology commercialization in their regions will be awarded \$1 million. In the second phase, NIH and NSF will use SBIR funds to award a total of up to \$6 million in supplemental funding to the phase I winners.

Current Law Related to Technology Transfer

In the late 1970s, Congress began to examine ways in which to foster technological advancement and commercialization in industry of Federal R&D activities, resulting in the enactment of two major laws in the 1980s, the Stevenson-Wydler Technology Innovation Act (P.L. 96-418) and the Government Patent Policy Act of 1980 or the “Bayh-Dole Act” (P.L. 96-517). Both of these laws were intended to encourage increased innovation-related activities in the business community and to remove barriers to technology development, allowing market forces to operate. The Stevenson-Wydler Act outlines the assignment of patent rights to inventions resulting from collaborative work between Federal laboratories and outside entities where direct Federal funds are not involved. The Bayh-Dole Act addresses the distribution of patent rights resulting from federally-funded R&D performed by outside organizations, primarily U.S. universities, stating:

“It is the policy and objective of the Congress to use the patent system to promote the utilization of inventions arising from federally-supported research and development; . . . to promote collaboration between commercial concerns and nonprofit organizations, including universities; . . . to promote the commercialization and public availability of inventions made in the United States by United States industry and labor; [and] to ensure that the Government obtains sufficient rights in federally-supported inventions to meet the needs of the Government and protect the public against nonuse or unreasonable use of inventions. . . .”³

The Technology and Innovation Subcommittee intends to carry out a comprehensive review of the Bayh-Dole and Stevenson-Wydler Technology Innovation Acts later this year. For the purposes of today’s hearing, witnesses have been asked to testify on the infrastructure, policies and practices that promote successful knowledge and technology transfer from universities, and the role of the National Science Foundation in helping to support the innovation ecosystem.

5. Questions for Witnesses:

Dr. Thomas W. Peterson

- Please describe how the National Science Foundation fosters the transfer of knowledge and technology from U.S. universities to the private sector. What specific programs include knowledge transfer either as an explicit goal or as a regular outcome of the program? Has NSF identified best practices for achieving knowledge transfer based on those programs? If so, how is NSF applying those best practices across its broader portfolio of research programs?
- How is NSF planning to implement the new “innovation ecosystem” component of the Partnerships for Innovation (PFI) program proposed in the FY 2011 budget? Please describe any outcomes or recommendations that resulted from the recent workshop on the PFI program.
- How is NSF supporting knowledge transfer through its education and training programs? Which programs, if any, provide an opportunity for students and faculty to build the knowledge and skills necessary to participate successfully in knowledge transfer, including through entrepreneurship?
- Beyond NSF’s traditional role of supporting basic research, what is the unique role of the agency relative to universities and to the private sector in promoting regional innovation and strengthening U.S. economic competitiveness?
- How does the NSF assess the long-term economic impact of both its knowledge and technology transfer programs and of its basic research programs?

Ms. Lesa Mitchell

- Please provide an overview of the Ewing Marion Kauffman Foundation efforts to advance innovation and promote entrepreneurship. What are the challenges to increasing the transfer of knowledge and technology from university researchers to the private sector? Are there best practices, training, or policies that should be put in place at universities, Federal agencies, and industry to facilitate the commercialization of federally funded research?

³35 U.S.C. § 200

- What are the key components of a successful university-industry collaboration? How can Federal investments in basic research be more fully leveraged to promote regional innovation and economic growth?
- Do you believe the National Science Foundation (NSF) has a role to play in the “innovation ecosystem” beyond its traditional role of supporting basic research? If so, what is that role? What changes or recommendations, if any, do you have regarding NSF’s portfolio of technology transfer and university-industry collaboration related programs, including its process for evaluating the potential for technology transfer through those programs?

Mr. W. Mark Crowell

- Based on your experience at both the University of North Carolina and the University of Virginia, what are the challenges to increasing the transfer of knowledge and technology from university researchers to the private sector? What type of education, training, and services are offered by the University of Virginia to professors, postdoctoral fellows, and graduate students interested in the commercialization of their research discoveries?
- Are there best practices or policies implemented by the institutions that you have been affiliated with that could serve as a model for other universities interested in increasing the commercialization of federally funded research?
- What are the key elements of a successful university-industry collaboration? To what extent does the University of Virginia rely on university-industry research partnerships to facilitate knowledge and technology transfer? What other aspects of university-industry collaboration are most critical to enhancing technology transfer? Is the University of Virginia engaged in local, state, and/or regional innovation initiatives?
- Do you believe the National Science Foundation (NSF) has a role to play in the “innovation ecosystem” beyond its traditional role of supporting basic research? If so, what is that role? What changes or recommendations, if any, do you have regarding NSF’s portfolio of technology transfer and university-industry collaboration related programs?

Mr. Wayne Watkins

- What type of education, training, and services are offered by the University of Akron to professors, postdoctoral fellows, and graduate students interested in the commercialization of their research discoveries? What are the challenges to increasing the transfer of knowledge and technology from university researchers to the private sector? Are there unique challenges faced by mid-sized universities such as yours in the commercialization of federally funded research?
- What are the key elements of a successful university-industry collaboration? Are there best practices or policies implemented by the University of Akron that could serve as a model for other universities interested in increasing the commercialization of federally funded research? Specifically, what is the role the University of Akron’s Research Foundation? How is the University of Akron engaged in local, state, and regional innovation initiatives?
- Do you believe the National Science Foundation (NSF) has a role to play in the “innovation ecosystem” beyond its traditional role of supporting basic research? If so, what is that role? What changes or recommendations, if any, do you have regarding NSF’s portfolio of technology transfer and university-industry collaboration related programs?

Mr. Keith L. Crandell

- Please provide a brief overview of ARCH Venture Partners, including a description of how the company interacts with researchers and identifies investment opportunities, the stage within the “innovation ecosystem” at which the company becomes engaged, and the company’s role in the development and commercialization of a research discovery.
- What are the challenges to increasing the transfer of knowledge and technology from university researchers to the private sector? How do the barriers to commercialization vary across geographic region?
- Are there best practices, training, or policies that should be put in place at universities, Federal agencies, and industry to facilitate the commercialization of federally funded research? What recommendations, if any, would you

offer to university technology transfer offices to improve the commercialization of their researchers' discoveries? Are there training and/or educational opportunities that are missing at universities that would benefit entrepreneurial minded scientists and increase commercialization?

- Do you believe the National Science Foundation (NSF) has a role to play in the "innovation ecosystem" beyond its traditional role of supporting basic research? If so, what is that role? What changes or recommendations, if any, do you have regarding NSF's portfolio of programs that promote knowledge and technology transfer through university-industry collaboration or other means?

Mr. Neil D. Kane

- Please provide a brief description of Advanced Diamond Technologies, Inc., including a description of the research and activities supported by the National Science Foundation. Based on your experience forming start-up companies around university developed technologies, what are the challenges to increasing the transfer of knowledge and technology from university researchers to the private sector?
- Are there best practices, training, or policies that should be put in place at universities, Federal agencies, and industry to facilitate the commercialization of federally funded research? What recommendations, if any, would you offer to university technology transfer offices to improve the commercialization of their researchers' discoveries? Are there training and/or educational opportunities that are missing at universities that would benefit entrepreneurial minded scientists and increase commercialization, including access to mentors and advisors from the private sector?
- Do you believe the National Science Foundation (NSF) has a role to play in the "innovation ecosystem" beyond its traditional role of supporting basic research? If so, what is that role? What changes or recommendations, if any, do you have regarding NSF's portfolio of programs that promote knowledge and technology transfer through university-industry collaboration or other means, including NSF's Small Business Innovation Research & Small Business Technology Transfer programs?

Chairman LIPINSKI. This hearing will now come to order.

Good morning and welcome to today's Research and Science Education Subcommittee hearing. The big smile you may see on my face this morning is not only because I am passionate about this issue but because the Chicago Blackhawks won the Stanley Cup last night for the first time in my lifetime, so I am very happy about that. But I didn't get as much sleep as I would usually like to, but here we are this morning. It is going to be a very good hearing and so there are going to be no problems at all keeping me awake and attentive.

This morning we are taking an in-depth look at how we turn new knowledge and technologies created at our universities and colleges into products, companies and jobs. I am particularly excited about this topic because of my experience as a university professor and my recognition that America's international competitiveness and economic growth will increasingly depend on successful technology transfer from lab to marketplace. At a time when we are increasingly asking the question, where will new American jobs come from, we need to be looking more closely at how we can best help our universities, filled with the world's best researchers, how we can best help them continue to be economic engines that power America's future.

Let me begin by making one point clear: Our competitors have noticed how well our system works, and many are trying to imitate it. Countries like China and members of the European Union are now investing heavily in their own R&D programs. Combined business and government spending on R&D in China, for example, has been increasing by almost 20 percent a year over the past decade, and China has already overtaken Japan as the number two publisher of scientific articles. They are determined to move up the value chain, and we need sustained investments and smart policies if we want to remain the world leader in science and technology.

Two weeks ago we took a big step forward when the House passed the *America COMPETES Reauthorization Act*. This bill includes substantial new investments in basic and applied research, a skilled STEM workforce, the kind of public-private partnerships that facilitate technology transfer, and in research infrastructure, including mid-scale research instrumentation and university infrastructure, which was a special focus of mine in developing the bill. Included in the COMPETES Act is my five-year reauthorization of the National Science Foundation [NSF], whose primary mission is supporting fundamental research and developing STEM professionals across almost all disciplines of science and engineering. This bill would double NSF funding, much of which would go to our colleges and universities.

In discussing technology transfer programs, it is important to remember that although innovations often begin with these kinds of Federal investments, the path from the lab bench to the marketplace is anything but straightforward. It depends on a complicated network of private companies, scientists, universities, venture capitalists, startups and entrepreneurs. It also depends on luck, timing and, to some extent, location.

Some universities have more successful tech transfer offices. Some scientists are better prepared or more inclined to engage with

the business community. And some parts of the country have cultivated networks of entrepreneurs and venture capitalists who know how to turn an idea into a product that can transform our everyday lives.

According to a survey by the Association of University Technology Managers, the number of academic invention disclosures filed, the number of U.S. patent applications filed, and the number of university spin-off companies formed have all grown significantly over the past few years. But the survey also indicates a wide range of success across our academic institutions, with licensing income varying from nearly nothing to almost \$800 million. In order to strengthen the current system and improve the return on Federal research spending, it is imperative that we gain a better understanding of this process from multiple perspectives.

I am interested in hearing from today's witnesses about best practices or policies that can improve the technology transfer process, and the appropriate role of the National Science Foundation in supporting such efforts. I also hope to hear your thoughts on the role of regional networks, how we can improve collaboration between scientists, entrepreneurs and venture capitalists, and how we can better track and quantify the impact of both technology transfer activities and research spending. Finally, I would like to learn what impact the recession is having on the creation of new startups, and to hear the witnesses' ideas on how we can make sure that American discoveries turn into American companies and American jobs.

I thank all the witnesses for being here and look forward to your testimony.

[The prepared statement of Chairman Lipinski follows:]

PREPARED STATEMENT OF CHAIRMAN DANIEL LIPINSKI

Good morning and welcome to today's Research and Science Education Subcommittee hearing. This morning we are taking an in-depth look at how we turn the new knowledge and technologies created at our universities and colleges into products, companies, and jobs. I am particularly excited about this topic because of my experience as a university professor and my recognition that America's international competitiveness and economic growth will increasingly depend on successful technology transfer from lab to marketplace. At a time when we are increasingly asking the question "where will new American jobs come from?", we need to be looking more closely at how we can best help our universities—filled with the world's best researchers—continue to be economic engines that power America's future.

Let me begin by making one point clear: Our competitors have noticed how well our system works, and many are trying to imitate it. Countries like China and members of the European Union are now investing heavily in their own R&D programs. Combined business and government spending on R&D in China, for instance, has been increasing by almost 20% a year over the past decade, and China has already overtaken Japan as the number 2 publisher of scientific articles. They are determined to move up the value chain, and we need sustained investments and smart policies if we want to remain the world leader in science and technology.

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According to a survey by the Association of University Technology Managers, the number of academic invention disclosures filed, the number of U.S. patent applications filed, and the number of university spin-off companies formed have all grown significantly over the past few years. But the survey also indicates a wide range of success across our academic institutions, with licensing income varying from nearly nothing to almost \$800 million. In order to strengthen the current system and improve the return on Federal research spending, it is imperative that we gain a better understanding of this process from multiple perspectives.

I'm interested in hearing from today's witnesses about best practices or policies that can improve the technology transfer process, and the appropriate role of the National Science Foundation in supporting such efforts. I also hope to hear their thoughts on the role of regional networks, how we can improve collaboration between scientists, entrepreneurs, and venture capitalists, and how we can better track and quantify the impact of both technology transfer activities and research spending. Finally, I'd like to learn what impact the recession is having on the creation of new startups, and to hear the witnesses' ideas on how we can make sure that American discoveries turn into American companies and jobs.

I thank all the witnesses for being here and look forward to your testimony.

Chairman LIPINSKI. The Chair will now recognize Dr. Ehlers for an opening statement.

Mr. EHLERS. Thank you, Mr. Chairman, and I apologize to you and the audience for being a bit late. I was in a meeting which much to my surprise turned out to be related to this issue. I was meeting with David Brooks, the columnist for the New York Times, and one of the brightest lights, I think, not only at the New York Times but in the American press, and he was discussing issues related to this and how the research is done and uncovered the educated but not highly educated individuals in America do not see the need for doing research for really trying to develop ideas that are found that way, it just should sort of happen naturally with the economic system we have, and failing to recognize the need for everyone to participate in those ideas. And that has direct bearing on what we are talking about today.

In today's hearing, I am very anxious to learn about partnerships between universities and industry and how the National Science Foundation is supporting these relationships. I have also been an advocate ever since I got here of the research and development tax credit to encourage industries to engage in research, and I find it a travesty that the best I have been able to obtain is year-by-year increases or tax rates. Most bean counters and corporate executives cannot make long-term decisions or judgments based on an annual phenomenon and so we really should work on that as well.

I understand that the Technology and Innovation Subcommittee of this committee will be undertaking a comprehensive review of both the Bayh-Dole Act and the Stevenson-Wydler Technology Innovation Act later this year, and I hope that this subcommittee will work closely with the other subcommittee on this series of hearings since we should always be considering the value of commercializa-

tion to comprehensive STEM education provided at our universities. It may even be appropriate to consider some joint Subcommittee hearings dependent on context.

I suspect that most university partnerships are overwhelmingly fruitful relationships, but I think we need to be mindful of some of the unintended consequences as well. While they are in school, students should be able to explore the scientific process, and universities must establish standards for these partnerships that protect students from being transformed into cheap labor for industry. It is my hope that the witnesses testifying before us today, and I am pleased to have such a distinguished panel here, that the witnesses will offer this Committee insight into ways to improve university-industry technology transfer partnerships and to explore the appropriate Federal role.

I look forward to the testimony of each of the members of our panel. I thank all of you for being here.

But I also want to add a comment of former Speaker Newt Gingrich, who is always a strong supporter of scientific research and technology, and he has repeatedly said in his speeches during the last few years that his greatest mistake as Speaker of the House was doubling NIH allocation for research while not also doubling the NSF allocation, and I totally agree with him. I fought for it at the time. I am sorry that I did not succeed. But I hope that in the future we will adequately improve the National Science Foundation budget so that the partnerships we are examining today have a greater chance of success.

With that, Mr. Chairman, I yield back. Thank you.

[The prepared statement of Mr. Ehlert follows:]

PREPARED STATEMENT OF REPRESENTATIVE VERNON J. EHLERS

In today's hearing I hope to learn about partnerships between universities and industry, and how the National Science Foundation is supporting these relationships.

I understand that the Technology and Innovation Subcommittee will be undertaking a comprehensive review of both the Bayh-Dole Act and the Stevenson-Wydler Technology Innovation Act later this year. I hope that the Research and Science Education Subcommittee will work closely with the other subcommittee on this series of hearings, since we should always be considering the value of commercialization to comprehensive STEM education provided at our universities. It may even be appropriate to consider some joint subcommittee hearings depending on context.

I suspect that most university-partnerships are overwhelmingly fruitful relationships, but I think we need to be mindful of some of the unintended consequences as well. While they are in school, students should be able explore the scientific process, and universities must establish standards for these partnerships that protect students from being transformed into cheap labor for industry.

It is my hope that the witnesses testifying today will offer this Committee insight into ways to improve university-industry technology transfer partnerships and to explore the appropriate Federal role. I look forward to the testimony of our distinguished panel, and I thank them for being here.

Chairman LIPINSKI. Thank you, Dr. Ehlert.

If there are Members who wish to submit additional opening statements, your statements will be added to the record at this point.

[The prepared statement of Mr. Carnahan follows:]

PREPARED STATEMENT OF REPRESENTATIVE RUSS CARNAHAN

Mr. Chairman, thank you for holding today's hearing on improving technology transfer. While the focus of today's hearing is technology transfer from universities,

another important part of this discussion is the role that non-profits play in this process.

In my home state of Missouri, we have a medical research facility that illustrates the critical role organizations can play in advancing medical findings and driving success in a community. The Stowers Institute for Medical Research is a state-of-the-art research facility, which has been located in Missouri since November 2000. Stowers was founded by a former WWII veteran and has grown to a \$1.7 billion facility, which employs over 200 scientists, researchers, technicians and support staff – all dedicated to preventing and curing diseases. And, I believe it's fair to say we would all like to see Stowers—and organizations like Stowers—be more successful in their pursuits.

With this in mind I'm pleased to report that Rep. Clever has taken a role in helping organizations find a new and improved path to finding cures. This important legislation, H.R. 3443, would correct inconsistencies in the tax code so organizations can take steps beyond scientific discovery, without threatening their non-profit status or business models.

In closing, I'd like to thank the members of the panel for their participation in today's hearing. I hope that we can continue our efforts to improve tech transfer and by doing so, promote innovation and ensure U.S. economic competitiveness in the future.

At this time I would like to introduce our witnesses. Dr. Tom Peterson is the Assistant Director for the Directorate of Engineering at the National Science Foundation. Ms. Lesa Mitchell is the Vice President of Advancing Innovation at the Ewing Marion Kauffman Foundation. Mr. Mark Crowell is the Executive Director and Associate Vice President for Innovation Partnerships and Commercialization at the University of Virginia. Mr. Wayne Watkins is Associate Vice President for Research at the University of Akron. Mr. Keith Crandell is the Co-founder and Managing Director of ARCH Venture Partners. ARCH Venture Partners is unique in the Midwest for really going in and finding those who are doing exactly what we are talking about today, going from the university bench and bringing those products to the market. And finally we have Mr. Neil Kane, who is the President and Co-founder of Advanced Diamond Technologies, Inc. [ADT]. ADT is the world leader in development of diamonds for industrial electronics, energy and medical applications, and Mr. Kane is also former Executive Director of the Illinois Technology Enterprise Center at Argonne National Lab, an entrepreneur in residence with Illinois Ventures.

I welcome our witnesses, and as you should know, you will each have five minutes for your spoken testimony. Your written testimony will be included in the record for the hearing. When you all have completed your spoken testimony, we will begin with questions. Each Member will have five minutes to question the panel.

So we will start right now with Dr. Peterson.

STATEMENTS OF THOMAS W. PETERSON, ASSISTANT DIRECTOR, DIRECTORATE FOR ENGINEERING, NATIONAL SCIENCE FOUNDATION

Dr. PETERSON. Thank you, Chairman Lipinski, Ranking Member Ehlers and distinguished Members of the Subcommittee. Thank you for the opportunity to testify on the process by which knowledge and technology are transferred from the academic institutions to the private sector. I am Tom Peterson, the Assistant Director for the Engineering Directorate at the National Science Foundation.

As NSF's investments in basic research and education bear fruit, we support the translational research as part of our investment portfolio to show the best stewardship of the funds with which we

are entrusted. In a recent survey conducted by the independent Science Coalition, fully one-third of the companies they studied started with the help of federally funded research depended on research supported by the National Science Foundation. Our success stories in improving tech transfer, then, are built both on programs with long histories at NSF as well as through new programs designed to expand our capabilities to contribute to the innovation ecosystem.

In my written testimony, I provide in some detail descriptions of a wide range of NSF programs focusing on the important task of facilitating the commercialization of NSF-funded research. In the short time I have with you this morning, I will give you a sampling of those programs and some specific examples of successful transfer of research discovery to the marketplace.

The Engineering Research Centers, established in 1985, or the ERCs, constitute the flagship engineering centers program at NSF. From 1985 through 2009, ERCs have produced 1,700 invention disclosures, 625 patents, 2,100 patent and software licenses, and have spun off 142 firms. Most importantly, they have produced more than 10,000 graduates at all levels who are truly the best means for tech transfer.

In the 1990s, the Engineering Research Center on Data Storage Systems at Carnegie Mellon developed a nickel aluminum underlayer that is the primary technology behind high-capacity storage devices in laptops, MP3 players and other consumer electronics. More recently, the ERC for Collaborative Adaptive Sensing in the Atmosphere at U. Mass Amherst developed a more sensitive radar network for detecting low-altitude weather phenomena, thereby adding valuable minutes to the warning time at the onset of tornadoes.

The Industry/University Cooperative Research Centers, or I/UCRCs, is the oldest centers program and it consists of small interdisciplinary groups of faculty and students focusing on industry-relevant research. Currently, there are 52 active I/UCRCs and this highly leveraged program has established over 1,000 industry connections to about 150 different universities. The I/UCRC for Engineering Logistics and Distribution at the University of Arkansas, for example, works with Walmart and has developed logistics software that has resulted in a more than four percent reduction in inventory costs.

NSF's Small Business Innovation Research [SBIR] and Small Business Tech Transfer [STTR] programs, designed to increase the commercial application of federally supported research results, has produced over 1,000 high-tech small businesses since the Congressional legislation that began the program in 1982.

I conclude my testimony this morning with one final example of NSF basic research which has found its way into the marketplace. In the early 1990s, we supported an Engineering Research Center on Optical Electronic Computing Systems at the University of Colorado and Colorado State University. That center was led by a brilliant and energetic professor named Kristina Johnson, who developed a line of 3D imaging components for scientific and industrial applications, and with colleagues, spun out some of the ERC's innovations with support from NSF's STTR program into a company

called ColorLink in Boulder, Colorado. In 2007, that company was acquired by RealD Cinema out of Beverly Hills, and in the hands of filmmakers, the ERC technology was the basis for the blockbuster film “Avatar,” which introduced to a worldwide audience a new generation of 3D cinematic experience. In fact, the film won a 2009 Academy Award for visual effects based in part on this innovative 3D technology. By the way, that Professor Johnson, who helped develop the technology, now serves as the Under Secretary for Energy in the Department of Energy.

In summary, the Engineering Directorate takes very seriously its responsibility to show leadership within the NSF in bridging basic research discovery to market commercialization. Our research portfolio is a balance of support for basic research as well as these translational research areas which constitute and contribute vitally to innovation. Equally important, by maintaining a healthy connection with business and industry through translational research activities, we further enhance our basic research portfolio through new ideas generated by our industry partners. In short, it is beneficial to both our academic researchers and to the marketplace that we continue to foster these strong ties between NSF and the real world.

Mr. Chairman, that concludes my remarks and I will be happy to answer any questions.

[The prepared statement of Dr. Peterson follows:]

PREPARED STATEMENT OF THOMAS W. PETERSON

Chairman Lipinski, Ranking Member Ehlers, and distinguished members of the Subcommittee, I am Tom Peterson, Assistant Director for the Engineering Directorate (ENG) at the National Science Foundation (NSF). Thank you for the opportunity to testify on NSF’s perspective of the process by which knowledge and technology are transferred from academic institutions to the private sector and on the best practices and policies to facilitate the commercialization of federally funded research.

The National Science Foundation is the Nation’s premier mission agency for promoting fundamental research and education in science and engineering across the board. Additionally, however, programs within the National Science Foundation help to foster and encourage the translation of new knowledge generated through basic research into processes, products and methodologies with significant economic or societal impact. Programs with an innovation component are supported across the Foundation, which plans to invest more than \$400 million in center and partnership programs in fiscal year (FY) 2011. Within NSF, the Directorate for Engineering is the natural focus of innovation-related efforts. Engineering research in general focuses on discovering how basic scientific and engineering principles work as well as how they can be harnessed for practical ends.

The term “innovation” can often be subject to innovative definitions, but for our purposes we define innovation as the conversion of fundamental discoveries into new commercial products and processes. It has long been recognized that there is a gap between “discovery” (produced by fundamental and applied research in universities) and the design/development work in industry that yields new products. This gap is often referred to as “the Valley of Death”. If there is a long research pathway needed to translate academic discoveries into industrial products, and if industry is not willing to invest in that pathway, the academic discoveries sit on the shelf and the opportunity for new products and new industries is lost. While other countries have not had the United States’ capacity to produce new discovery through fundamental research, many are better at translating and implementing those discoveries (whether their own or “imported”) into commercial products. This “translational” phase of research is where the U.S. has an opportunity to improve.

1. Describe how the National Science Foundation fosters the transfer of knowledge and technology from U.S. universities to the private sector.

The NSF has developed a strategy utilizing a combination of the Foundation's experience, existing programs and new initiatives to speed the generation of useful discoveries and their effective penetration into industry. By so doing, these discoveries can yield high-value products and processes, new businesses and even new industries, greatly expanded employment opportunities, and a more technologically advanced workforce widely distributed across the U.S.

Successful innovation demands research that is most often characterized by several distinct features:

- It is technology- and often engineered-systems motivated
- It requires the integration of multiple disciplines
- It is developed in collaboration with industry or other practitioners.

Several large, ENG-funded programs existing within the NSF embody these features and are already successfully producing translational research that results in innovation in industry.

Existing ENG Resources

Engineering Research Centers (ERCs)—Engineering Education & Centers (EEC) Division: Established in 1985, this is the flagship engineering centers program at NSF, with more than \$67 million planned for FY 2011. The 54 ERCs formed to date have literally changed the culture of academic engineering by supporting cross-disciplinary teams, strategically focused on joining discovery with research that advances enabling and engineered systems technology, in partnership with industry. Currently, 15 ERCs are within the ten-year window of NSF support, and the majority of ERCs who have 'graduated' are still in operation. Their education programs start with pre-college students and teachers and continue through practicing engineers.

A primary driver for the establishment of the ERCs program by the NSF was to facilitate the transfer of knowledge and technology developed out of the ERCs' research on next-generation engineered systems to U.S. industry. This focus on innovation was and still is at the heart of the ERC-industry partnership. That partnership has yielded rich dividends.

The third generation of ERCs (Gen-3), funded since 2008, are even more directly focused on bridging the innovation gap through partnerships with small firms and groups dedicated to entrepreneurship. The very structure of the Gen-3 ERCs establishes a culture of discovery and innovation by requiring from each ERC:

- **Guiding strategic vision** for transforming engineered systems and the development of an innovative, globally competitive and diverse engineering workforce
- **Strategic plans** for research, education, and diversity to realize the vision
- **Cross-cultural, global research/education experiences** through partnerships with foreign universities
- Strategic, discovery & systems motivated cross-disciplinary research program, including **small firms engaged in translational research**
- Education program **strategically designed to produce creative, innovative engineers** by engaging students in all phases of the innovation process
- **Long-term, focused pre-college partnerships** to bring engineering concepts to classroom & increase enrollment in engineering
- **Innovation partnerships** with member firms and organizations dedicated to stimulating entrepreneurship and speeding technological innovation
- **Cohesive and diverse** cross-disciplinary leaders and team, management systems
- Multi-university configuration, cross-institutional commitment to facilitate and foster the cross-disciplinary culture, diversity, and **mentoring**

Funded jointly by NSF, universities, and industry, collectively these large centers have resulted in commercialized products and processes whose value is estimated to significantly exceed ten billion dollars; and they have produced more than 10,000 graduates at all levels who are in great demand by industry.

The story of ERC innovations is updated periodically and posted at <http://show-case.erc-assoc.org>.

Industry/University Cooperative Research Centers (I/UCRCs)—Industrial Innovation & Partnerships (IIP) Division: Formed in 1972, the I/UCRC program is the oldest centers program at NSF. It has survived because it is a model that works: small interdisciplinary groups of faculty and students focusing on industry-relevant and mutually agreed-upon research. Industry and other agencies provide the majority of the support—7 to 8 times the NSF investment, which is planned at \$10 million for FY 2011. Currently there are 43 I/UCRCs. They can be funded by NSF for three five-year periods, with a reduced level in the second and third periods. I/UCRCs also have a long history of producing technological advances with billions of dollars of economic value and some 4000 MS and Ph.D. graduates who are highly sought by industry because of their industry-relevant experiences.

Emerging Frontiers in Research and Innovation (EFRI)—The EFRI Office was established in 2006 to provide ENG with a rapid-response capability for focusing on important emerging areas of research. Each year, interdisciplinary initiatives are funded in areas that represent transformative opportunities, potentially leading to new research areas for NSF, ENG, and other agencies; new industries or capabilities that result in a leadership position for the Nation; and/or significant progress on a recognized national need or grand challenge. EFRI awards support small teams of interdisciplinary investigators for four years. Focus areas for FY 2009 are BioSensing & BioActuation: Interface of Living and Engineering Systems; and Hydrocarbons from Biomass. The topics for FY 2010 are Science in Energy and Environmental Design; Engineering Sustainable Buildings; and Renewable Energy Storage. EFRI plans to invest \$31 million in FY 2011 research areas.

Partnerships for Innovation (PFI)—IIP Division: Begun in 2000, the PFI program promotes innovation by forming partnerships between academe, the private sector, and local, regional, or Federal Government. The program activities include generation of new ideas through research; transformation of new ideas into new goods, businesses, or services to society; building infrastructure to enable innovation; and education/training of people to enable/promote innovation. More than a thousand partnerships have been formed since the beginning of the PFI program. To date, 157 PFI grants have been awarded; currently there are 51 PFI projects. These are funded for 2 to three years, after which they are sustained by the partners or other stakeholders. Their outputs include innovation in all its forms: knowledge and technology transfer, product commercialization, start-up formation, workforce development, and education in the innovation enterprise in academia at all levels and in industry. NSF has requested \$7 million for PFI in FY 2011.

Various NSF-wide programs, in which ENG participates, also explicitly and effectively foster this kind of industry-collaborative research. They include:

- **Grant Opportunities for Academic Liaison with Industry (GOALI)**—this proposed \$4-million FY 11 investment promotes university-industry collaboration by supporting academic fellowships/traineeships in industry, industrial practitioners on campus, and industry-university team research.
- **Small Business Innovation Research (SBIR)/Small Business Technology Transfer (STTR)**—this proposed \$143-million FY 11 investment stimulates technological innovation by strengthening the role of small business in meeting Federal R&D needs, increasing the commercial application of federally supported research results, and fostering participation by socially and economically disadvantaged and women-owned small businesses.
- **National Nanotechnology Initiative (NNI)**—a government-wide program established in 2001 to coordinate Federal nanotechnology R&D; the NSF investment in NNI for FY 2011 is planned at \$399 million. One of its goals is to foster the transfer of new nanotechnologies into products for commercial and public benefit through academic researcher collaboration with industry. The ENG Senior Advisor for Nanotechnology is one of the key architects and leaders of NNI.

These illustrate the extent of participation by ENG in university industry partnerships. There are a few other such programs distributed at other parts of NSF that are referenced in the next section.

2. How is NSF planning to implement the new “innovation ecosystem” component of the Partnerships for Innovation (PFI) program proposed for the FY 2011 budget?

The ENG directorate at NSF is fortunate to have, in its FY 2011 budget, proposed increases in support for partnership programs contributing to innovation. These proposed increases are most welcomed. In developing plans that demonstrate good stewardship of these anticipated additional funds, and mindful that the total re-

quested increase in FY 2011 is \$12 million, we have studied means by which we can build on the existing strengths of NSF support, rather than trying to ‘start from scratch’ with new programs. This is *not* meant to represent a ‘business as usual’ approach, and as can be seen from our proposed plans, new and unique initiatives are proposed. Rather, we are trying support concepts that will provide the most rapid evidence of success, and that means building on programs in the community that have already demonstrated propensity and talent towards market innovation. That is, we intend to support those members of the community who have shown an interest and an ability to take the fruits of basic research and translate those fruits into societal benefit. Our investment is designed to engage more faculty and students in innovation, to increase the commercial impact of innovative technologies, and to build regional connections for the innovation ecosystem.

New and Emerging Initiatives

Focused additional effort for the innovation ecosystem is being directed by the ENG directorate using both reallocated dollars from our base budget as well as the proposed additional support in FY 2011 budget for partnerships for innovation.

At a recent workshop held to elicit input from experienced PFI grantees and other members of the community, NSF was encouraged to consider investments in:

- Undergraduates as inventors and innovators
- Open participation in innovation and entrepreneurship from community colleges through the four-year universities and on into Graduate institutions
- Leveraging of existing small business strengths over and above the spin-off model
- Supporting innovation process models that create small groups of collaborators across diverse sectors
- Incentivizing universities to support an innovation culture and its role on societal impact

In response to the clear need to improve American innovation and speed the translation of discovery into industrial products, a number of new initiatives are already being developed or planned that will integrate the efforts of the EEC Division, the IIP Division, and/or the EFRI Office.

Innovation Fellows: Planned by the EEC Division for FY 2011, this program will support cohorts of engineering undergraduates to pursue an innovation-focused Ph.D. graduate program that includes summer internships in industry.

Industry Postdoctoral Fellows: In partnership with The American Society for Engineering Education, the EEC Division plans to expand the Innovation Fellows program to include 40 grants per year to postdoctoral students for innovation-focused work in industry, the costs of which are shared between industry and NSF. EEC piloted this activity in FY 2010.

Industry-defined Fundamental Research: This pilot initiative, begun in FY 2010, is being developed within the IIP Division in response to a proposal from The Industrial Research Institute (IRI). IRI will invite its members, other professional society members, and university partners to examine possible research thrusts that are fundamental and that could have a transformative economic impact on an industry or sector. These research areas will then feed into the research programs of the other divisions of ENG.

University-Industry Collaboration to Advance Discovery: This initiative, under study by the EFRI Office, will accelerate innovation based on the transformational research already funded by EFRI by providing incentives to industry researchers to partner with EFRI grantees. It is envisioned as a GOALI-like exchange between the academic researchers and potential industrial adopters and refiners of the technologies developed. As a first attempt to implement this idea, the FY 2010 EFRI Solicitation allows industry researchers to serve as co-PIs on a research project defined as a GOALI project.

SBIR/STTR and ERC Supplement Opportunity for Collaborations (SECO): This collaboration opportunity, piloted in FY 2010, seeks to form partnerships between small businesses and ERCs that will leverage NSF’s investments in SBIR/STTRs and ERCs to speed innovation. The SBIR/STTR program stimulates entrepreneurship in this country through government support for research in small business. These small firms often need additional research to commercialize their products. The agility of small companies to respond to market conditions and opportunities has the potential of providing substantial commercialization advantages. The Engineering Research Centers program creates a culture in engineering research and education that links discovery to technological innovation through transformational fundamental and engineered systems research in order to advance tech-

nology and produce engineering graduates who will be creative U.S. innovators in a globally competitive economy.

These partnerships are expected to lead to one or both of the following outcomes:

- ERC generated research will be more quickly translated into the marketplace through collaboration with an SBIR/STTR awardee or small R&D firm.
- The capability of an SBIR/STTR awardee or small R&D firm to achieve its product goals will be strengthened through the research capacity of an ERC.

Assembling an “Innovation Ecosystem” in NSF

These current and prospective programs constitute a portfolio of innovation-oriented programs within ENG that, together, address: (1) large research universities as well as smaller teaching-oriented institutions serving diverse populations; (2) large groups and small groups of faculty as well as individual researchers, at one or multiple institutions; (3) multidisciplinary research foci from fundamental through proof-of-concept; and (4) education of engineering students in an industry-oriented, systems-research-focused environment.

The elements of this portfolio thus comprise a collective ecosystem for generating innovation in U.S. industry through NSF support. Other programs within ENG and throughout NSF also comprise natural elements of this “innovation ecosystem” and bring resources explicitly to bear in the effort to complete the building of this ecosystem. Among the largest of these programs are:

- **Science and Technology Centers** (Office of Integrative Activities)
- **Materials Research Science and Engineering Centers** (Division of Materials Research)
- **Nanoscale Science and Engineering Centers** (Foundation-wide)
- **Expeditions in Computing** (Directorate for Computer & Information Science & Engineering).

The key characteristics of the ecosystem and each of its component elements must be:

1. The university research is explicitly driven by industrial needs (not near-term but clearly defined mid- to longer-term needs), ranging across the full spectrum of industrial sectors and company sizes from start-ups to Fortune 500 companies.
2. Faculty are involved along a continuum from fundamental discovery-oriented research to beyond the proof-of-concept phase, working with industry at all stages, and with faculty at all points along the continuum aware of how their work contributes to the whole. (System-wide communications and annual grantee conferences will be needed.)
3. Through a concerted focus on NSF-funded translational research in collaboration with industry, the handoff of technology to industry moving into industrial development will be smoother—the “Valley of Death” is bridged—resulting in rapid, efficient innovation.

Numerous options are still under consideration for support in order to better translate basic research discoveries into marketable products and processes. The 2011 Budget Request provides \$12 million for two proposed “innovation partnerships”. One will focus on supporting the individual entrepreneur, through a “Technology Translation” plan. The other will focus on supporting entrepreneurial—and typically interdisciplinary—teams and building regional innovation communities through a “Center Connection” plan. While details of each plan continue to be addressed, Table I below provides a comparative summary of both approaches.

	Technology Translation Plan	Center Connection Plan
Technology Source	Technology derived from Individual PIs with current or prior NSF research support.	Technology derived from currently active Centers, such as ERCs, I/UCRCs, STCs, MRSECs, NSECs.

Goal	Rapid conversion of research discoveries into new commercial products or processes.	Translate Center-developed research and/or technology into new start-up business (es) or existing firms. Develop a network of connections between university researchers and local/regional business community.
Expected Accomplishments	A Final Technology Translation Plan (FTTP), suitable for review by potential third-party funders. IP protection obtained in preparation for disclosure of the FTTP to potential third-party funders	Development of a network of connections between university researchers and local/regional business community. Faster translation of research into existing firms and/or new start-up firms. Evidence of developing local and/or regional innovation ecosystem and creation of jobs. Preparation of students with entrepreneurial experience.

Table I. Proposed New Innovation Ecosystem Models: FY11 Partnership for Innovation Support

3. How is NSF supporting knowledge transfer through its education and training programs?

Since the mid-1980s, when concerns about U.S. industrial competitiveness were widespread, it has been widely believed that baccalaureate programs in the Nation's engineering schools have tended to produce engineers who, while well prepared in engineering science, need more experience with technological advancement and interdisciplinary teamwork; who need more training before they can meet the basic needs of industry. Many large corporations find that they must provide significant training beyond on-the-job experience. Traditional engineering students obtain little practical experience in their educations. Furthermore, although industrial employers place high value on teamwork, most graduating engineers traditionally have had limited experience in working in teams. ERCs are designed to produce graduates who excel in these areas, where traditional graduates fall short. The centers try to bring to engineering education a new culture based on goal-oriented values, complementing the theoretical science-based education long predominant in academic engineering. Those involved in the ERCs have come to recognize that education may actually be the centers' most important means of contributing to the Nation's global competitiveness. ERCs devote much energy and resources to "spreading the culture" through education, and to creating an environment conducive to this new kind of education. ERC education programs are a primary means of achieving the overall goal of culture change in engineering education, and in academic engineering generally. They encourage that change by articulating the ERC ideals, making opportunities available to implement the ideals, and facilitating the use of those opportunities.

This is particularly important in engineering, where discoveries made at universities have the potential for a more direct realization in the form of commercially useful products and processes. One of the three "guiding goals" of the Engineering Research Centers, for example, is "to educate a globally competitive and diverse engineering workforce from K-12 on." This goal is pursued in several ways: by making education a core part of the center's strategic plan; by integrating fundamental research with engineering practice and incorporating it in the curriculum; by involving industry directly in the education process; by including students at all levels, from undergraduate through postdoctoral, on research teams; and by encouraging innovation and entrepreneurship.

Engineering Research Centers have proven their capacity to produce graduates who are more effective in industry as innovators and leaders of cross-disciplinary teams. The Gen-3 ERCs have an additional challenge: to develop education programs in which students learn how to be even more creative and innovative through

explicit training in product design, entrepreneurship, and working in collaboration with start-up firms carrying out translational research. The ERC pre-college programs engage both teachers and students in engineering research projects carried out in an innovation ecosystem (an ERC) in partnership with industry. Overall, it represents an effort on the part of the ERC program to establish a comprehensive system of engineering education that produces a large and diverse cadre of engineers primed for global leadership in innovation.

The PFI program has spawned several innovation-enabling education and training models. Precollege programs at tribal colleges attract and train high school students in hands-on engineering problem solving skills. The program offers a combined engineering and business bachelor's degree tailored to industry needs, providing mentorships to budding entrepreneurs and helping assess market potential. It also serves to cross-fertilize collaboration across engineering, business, medicine, law and other colleges, thereby fostering a true innovation culture.

4. Beyond NSF's traditional role of supporting basic research, what is the unique role of the agency relative to universities and to the private sector in promoting regional innovation and strengthening U.S. economic competitiveness?

In a study conducted by the Pennsylvania State University under NSF support⁽³⁾, leaders from government, industry, and universities convened to consider issues and develop alternatives for action aimed at more effectively leveraging university research for United States industrial competitiveness and economic growth. More than 120 leaders from government, industry, and universities explored problems and proposed solutions from the perspective of five key industry sectors. As might be imagined the five focus groups discussed a wide range of issues and identified a multitude of problems and potential solutions. At the same time, a limited number of common issue areas were identified across the groups. Specifically, four major issue areas were consistently identified representing fundamental barriers to more effective leveraging of university research for industrial competitiveness and growth:

- Insufficient industry engagement in university research
- Restrictive intellectual property management policies
- Inadequate resources for technology commercialization
- Low flow of talent across industry-university boundaries

Many potential solutions to these and other issues were suggested and strenuously debated in the focus groups. A number of the solutions suggested to address the above four core issue areas stand out, either because of the consistency with which they were advocated or because they represent especially unique and creative approaches. These stand-out solutions for each of the above core issues are highlighted below.

Issue Area	Proposed Solutions
Insufficient Industry engagement in university research	Increase federal support for industry-university research partnerships Expand support for sector-focused industry-university research consortia
University Intellectual Property Management Policies	Create an industry-university panel to develop amendments to Bayh-Dole 1980. Incentivize university tech transfer offices to support industrial competitiveness and economic growth objectives.
Inadequate resources for technology development	Strengthen SBIR and broaden and refocus STTR Create new program for development of commercially promising university discoveries
Talent Flow across university-industry boundaries	Better prepare scientists and engineers for careers in industry Expand interaction between university faculty and industrial counterparts

Table II. Mechanisms for Leveraging University Research for Industrial Competitiveness and Growth

NSF involvement in support of innovation and industry-university partnerships goes beyond programs exclusive to the NSF. We have partnered with many govern-

mental agencies in a number of activities focused specifically on the support of innovation.

For example, the NSF has been an active participant in the inter-agency working groups focusing on the development of regional innovation clusters (RICs). It is one of the partnering agencies participating in the “Energy Efficient Building Systems Regional Innovation Cluster” initiative, also called an Energy-RIC or E-RIC, an effort involving the Departments of Energy, Commerce and Labor, NIST, EDA and SBA as well as NSF in an interagency working group focusing on the stimulation of Regional Innovation Clusters. NSF has had representation on this working group since its inception.

Additionally, in March of 2010, the Office of Science and Technology Policy (OSTP) and the National Economic Council (NEC) issued a Request for Information (RFI) about ideas and best practices for Proof of Concept Centers (POCCs). POCCs have seen some success in supporting early stage technologies by providing seed funding and expert assistance in the path toward commercialization. This RFI resulted in well over one hundred responses from entrepreneurs, industry and universities. Important issues about how to measure success and lessons learned are now being assembled and reviewed. These “voices from the field” will serve as the basis for a set of recommendations for how the Federal Government can help spur a culture of innovation among the various stakeholders.

And, NSF along with NIH is partnering with EDA/DOC in the “i6 Challenge”, which is designed to encourage and reward innovative ideas that will accelerate technology commercialization in a regional innovation ecosystem. Through supplemental funding NSF SBIR/STTR grantees will participate in this innovation ecosystem.

The requested FY 2011 budget for NSF will enable the innovation ecosystem to leverage the strengths of American universities through connections with industry, and these connections may then foster regional “engines of innovation” in any arena of advanced technology—whether it be new approaches to energy generation and use, advanced information technologies, cyber security, or bioengineering. By encouraging and accelerating knowledge transfer from universities to industrial partners, NSF programs (such as the Engineering Research Center program) can help bring the technology to the marketplace. The ultimate goal is to extend America’s historical reputation for “Yankee ingenuity” to a new recognition as “a nation of innovators.” The economic benefits of this enhanced innovation will be distributed more evenly across companies of all sizes, types, and geographic locations in the U.S. as well as a broader spectrum of Americans. And it will produce graduates who are capable of continuing the “Innovation for Prosperity” envisioned here out into the future to sustain our Nation’s technological leadership and economic vitality for generations to come.

5. How does the NSF assess the long-term economic impact of both its knowledge and technology transfer programs and of its basic research programs?

Perhaps the most challenging aspect of supporting the translation of basic research ideas and concepts into the market place is assessing, specifically, how relevant and productive our investments have been. The reasons for this are manifold and include:

- Often the ‘lead-time’ between the basic research discovery and the marketable product or process is significant. Commercialization rarely takes place in the early stages of support for basic research, and hence a ‘cause and effect’ between support for basic research and the subsequent development of a commercial product cannot be established by simply taking a ‘snapshot’ assessment of an individual grant or contract. The *Science of Science and Innovation Policy (SciSIP)* program in the NSF Directorate for Social, Behavioral and Economic Sciences attempts to study this very complex question.
- The development of new product areas (for example, cell phones, or iPods) result not from one single research discovery but from an entire portfolio of research projects. Hence, the relationship is less a relationship between a product and one individual project and much more a relationship between a product and support for a research portfolio, distributed over both time and university principal investigator.

All that being said, however, our partnership portfolio (which includes the Engineering Research Centers (ERC), the Industry/University Cooperative Research Centers (IUCRC), the Partnerships for Innovation (PFI) program, the Grant Opportunities for Academic Liaison with Industry (GOALI) program, and the small busi-

ness (SBIR/STTR) program) is the most heavily assessed portfolio in the ENG directorate and, with the possible exception of education programs in the EHR directorate, the most heavily assessed portfolio in the entire NSF. Those assessment instruments include examining the breadth and depth, and specificity, of industry partnerships, the numbers of start-ups and small businesses spun out, the numbers of invention disclosures, patents generated and jobs created by NSF supported work. While those analyses are not necessarily conducted annually, they are conducted with regularity, often involving outside contractors. Even the National Academies have been involved, for example, in the evaluation of our SBIR program. Example statistics from those analyses include:

- From 1985 through 2009, ERCs have produced 1,701 invention disclosures, had 624 patents awarded, granted 2,097 patent and software licenses, spun off 142 firms, and have produced more than 10,500 graduates at all levels.
- The highly leveraged IUCRC program has established over one thousand industry connections to about 150 universities. In addition to millions of dollars in direct investment by these industries to support university research, they have invested significantly to move translational research into the market place. One of the most effective means of technology transfer has been through undergraduate, graduate and postgraduate students who are then hired by industry from these centers. Industry finds these students to be 'industry ready' to make early contribution and in fact many of them come back to become the industry sponsors at these centers.
- Over one thousand high tech small businesses have been supported by the NSF SBIR/STTR program since the congressional legislation in 1982. In-depth analysis has shown that these firms create jobs at the rate of approximately eight percent and impact the economy with revenue growth at approximately 18 percent. About 40 percent of firms have strong collaboration with universities with half of their technologies coming directly from universities.
- Since the inception of the GOALI program in early 1980s, about one hundred university-industry collaborations are established each year. The PFI program started in 2000 and has contributed thousands of public and private innovation partnerships for universities ranging from Foundations, K-12 school systems, technical professional organizations, small businesses and Fortune 500 industries.

Summary

The Engineering directorate takes very seriously its responsibility to show leadership within the NSF in translational research, bridging the important step from basic research discovery to market commercialization. Our research portfolio is a balance of support for basic research as well as these translational research areas, which contribute vitally to innovation. And, importantly, in maintaining a healthy connection with the business and industry community through translational research activities, we further enhance our basic research portfolio with new ideas generated by our industry partners. In short, it is a benefit to both our academic researchers and to the marketplace that we continue to foster these strong ties between ENG and the real world.

Mr. Chairman, this concludes my remarks. I would be happy to answer any questions.

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BIOGRAPHY FOR THOMAS W. PETERSON

Dr. Thomas W. Peterson is assistant director for Engineering at the National Science Foundation (NSF). Prior to joining NSF, he was dean of the College of Engineering at the University of Arizona. He received his Bachelor of Science from Tufts

University, his Master of Science from the University of Arizona and his doctorate from the California Institute of Technology, all in Chemical Engineering. He has served on the faculty of the University of Arizona since 1977, as head of the chemical and environmental engineering department from 1990 to 1998, and as dean from 1998 until January 2009.

During his service as dean, Peterson was a member of the Executive Board for the Engineering Deans' Council of ASEE and was vice-chair of EDC from 2007 to 2008. He has served on the board of directors of the Council for Chemical Research and on the Engineering Accreditation Commission (EAC) of the Accreditation Board for Engineering and Technology (ABET). He was one of the founding members of the Global Engineering Deans' Council, and at Arizona made global education experiences a high priority for his engineering students. He is a fellow of the American Institute of Chemical Engineers and a recipient of the Kenneth T. Whitby Award from the American Association for Aerosol Research.

The ENG Directorate at NSF provides critical support for the nation's engineering research and education activities, and is a driving force behind the education and development of the nation's engineering workforce. With a budget of approximately \$640 million, the directorate supports fundamental and transformative research, the creation of cutting-edge facilities and tools, broad interdisciplinary collaborations, and through its Centers and Small Business Innovation Research programs, enhances the competitiveness of U.S. companies.

Chairman LIPINSKI. Thank you, Dr. Peterson.
Ms. Mitchell.

STATEMENTS OF LESA MITCHELL, VICE PRESIDENT OF ADVANCING INNOVATION, EWING MARION KAUFFMAN FOUNDATION

Ms. MITCHELL. Chairman Lipinski and Members of the Subcommittee, thank you for this opportunity to testify before the Subcommittee focused on the role of improving technology commercialization of government-funded research and how it can play as a driver in economic growth and job creation.

If there is a silver lining to the economic crisis our country now faces, it is that policymakers and academics, as well as citizens, are now paying tremendous attention to job creation and economic growth. For far too long, the sources of job creation have been taken for granted. The Ewing Marion Kauffman Foundation is one of the largest funders of economic research focused on innovation and entrepreneurship, and we welcome the renewed focus on these issues generally, as well as the more narrowly focused conversation we will be having today on technology commercialization.

In my testimony today, I will highlight three main policy proposals and can review the Kauffman Foundation's current thinking on best practices in technology commercialization. First, we call for an increase in the transparency of research resulting from federally funding through the creation of an "innovation exchange." Secondly, we encourage Federal agencies funding research to become more involved with driving university-specific improvements in technology commercialization. While we would agree that we have done well and other countries are following our lead, we also believe that we could do better. While we are very supportive of Bayh-Dole as good policy, we believe it has not been consistently implemented and that we need to look at opportunities for market forces to help that process. Thirdly, we call for an increase in funding allocations for proof-of-concept centers and commercialization education programs through Federal agencies funding research.

It has long been known that universities play an important role in economic growth, dating back to the 1800s when land-grant uni-

versities were created to provide skilled people and new research knowledge for a growing economy. The way we perceive and manage this role has changed, however. Universities now are expected to generate growth, rather than merely sustain or support it. They accomplish this through generating new knowledge, producing graduates, and licensing innovations, or actually in many cases creating new companies. Federal funding of research provides a critical base for most of these applications. Most federally funded university research is already supported precisely because it promises to contribute to a government mission such as health, national defense, energy production or environmental protection. In the life sciences in particular, most research is conducted squarely in what Princeton University political science Professor Donald Stokes termed "Pasteur's Quadrant," where research is both scientifically valuable and also immensely practical. We would argue that most efforts to increase commercialization can be achieved at relatively small marginal cost and can occur in ways that benefit both science and society. There is no single model for success.

We have highlighted in my remarks and in my detailed testimony some basic elements, but they may need to be applied in different ways, as the Chairman alluded to previously. What works best at each university may depend on its research strengths, the nature of the related industries, the nature of the regions, big cities, rural communities, et cetera, and other variables. The only common thread is the need for a well-developed ecosystem of innovation. In high-growth regions with highly entrepreneurial universities, the following tend to be true of the faculty: they have frequent and extensive contact with private industry, which attunes them to thinking in terms of practical value creation while enabling them to share their expertise. High-growth regions operate with university policies that encourage such activities, rather than laboring against policies that draw barriers between the academic and commercial realms. Magic bullets may score occasional hits, but ecosystems flourish with many pathways to the commercialization market.

We call on you to increase the transparency of research resulting from Federal funding through the creation of an "innovation exchange," to encourage Federal agencies funding research to become involved in institution-specific technology commercialization effectiveness reviews, and lastly to increase funding allocations for proof-of-concept centers and commercialization education programs.

Thank you for your invitation to present to the Committee today.
[The prepared statement of Ms. Mitchell follows:]

PREPARED STATEMENT OF LESA MITCHELL

Chairman Lipinski and Members of the Subcommittee:

Thank you for this opportunity to testify before the Subcommittee focused on the role that improving technology commercialization of government-funded research can play in driving economic growth and job creation. If there is a silver lining to the economic crisis our country now faces, it is that policymakers and academics, as well as citizens, are now paying tremendous attention to job creation and economic growth. For far too long, the sources of job creation have been taken for granted. The Ewing Marion Kauffman Foundation has been interested in economic growth through the mechanisms of innovation and firm formation, and we welcome the renewed focus on these issues generally, as well as the more narrowly focused conversation we will have today on technology commercialization.

In my testimony today, I will highlight three main policy proposals and review the Kauffman Foundation's current thinking on best practices in technology commercialization. First, we call for an increase in the transparency of research resulting from Federal funding through the creation of an "Innovation Exchange." Second, we encourage Federal agencies funding research to become more involved with driving university-specific improvements in technology commercialization. Third, we call for an increase in funding allocations for proof-of-concept centers and commercialization education programs through Federal agencies funding research.

The Role of Universities

It has long been known that universities play an important role in economic growth, dating back to the 1800s when land-grant universities were created to provide skilled people and new research knowledge for a growing economy. The way we perceive and manage this role has changed, however. Universities now are expected to generate growth, rather than merely sustain or support it. They accomplish this through generating new knowledge, producing graduates, and licensing innovations—or actually creating new companies. Federal funding of research provides a critical base for most of these activities.

Universities' primary goals are, and should continue to be, the discovery and dissemination of new knowledge. But at the same time, universities are not monasteries. New knowledge for its own sake does not benefit human beings; it must be applied to real-world problems and challenges, and when this is done, the results must be disseminated to society. In market economies, dissemination often is best accomplished when innovations are commercialized, for it is the commercial infusion of human and financial capital that enables innovations to "scale," and thereby encourage economic growth.

Federal funding of university research has resulted in numerous and important commercial applications. For example, consider the list of the fifty most important innovations and discoveries funded by the National Science Foundation in its first fifty years, according to the NSF itself in 2000. Although this "Nifty Fifty" list includes some huge basic advances—such as the discovery that the universe is expanding at an accelerating rate—much of the list consists of innovations that have been commercialized, or that have become platforms for many commercial products and services that are widely used today: barcodes, CAD/CAM software, data compression technology used in compact discs, and perhaps most significant of all, the Internet (which the NSF funded along with DARPA, the Department of Defense research agency). A recent Information Technology and Innovation Foundation report found that universities and Federal laboratories have become more important sources of the top 100 innovations over the last thirty-five years. In 1975, private firms accounted for more than 70 percent of the R&D 100 (*R&D Magazine's* annual list of the 100 most significant, newly introduced research and development advances in multiple disciplines), but by 2006, academia was responsible for more than 70 percent of the top 100 innovations.

Despite the significant social and economic contributions of university commercialization, there has been much discussion about polluting the waters of basic research with market principles, saying that an increased commercialization focus will negatively impact funding of basic research. Most of this concern comes out of a mythical view of the linearity of the innovation process. It is nearly impossible to draw lines around research activities and to predict which of them are "basic" and which "applied." But regardless of this enduring myth, I am not here today to advocate for a shift of research dollars out of basic research and into applied activities. Most federally funded university research is already supported precisely because it promises to contribute to a government mission, such as health, national defense, energy production, or environmental protection. In the life sciences, in particular, most research is conducted squarely in what Princeton University political science professor Donald Stokes termed "Pasteur's Quadrant," where research is both scientifically valuable and also immensely practical. We would argue that most efforts to increase commercialization can be achieved at relatively small marginal costs and can occur in ways that benefit both science and society.

In Search of Improved Pathways

The Kauffman Foundation has funded research focused on understanding the multiple pathways in which innovations are most effectively created and disseminated to the market, and we are not alone in recognizing the significance of this issue. In February 2010, Department of Commerce Secretary Gary Locke convened a meeting at the National Academies to open a dialogue with university and industry leaders focused on improving commercialization practices. On May 6 of this year,

the Kauffman Foundation co-hosted the White House Energy Innovation Summit, which also focused on developing and accelerating new pathways to market—in this case, for energy innovation. And it is not just the Administration speaking out on this issue; university presidents and industry leaders are calling for new models and a review of practices in this arena. According to Arizona State University President Michael Crow, we must first design and implement new models of higher education to achieve the levels of connectivity, transparency, and speed of technology commercialization necessary to accelerate the innovation pipeline.¹

There is much to applaud in the current system of Federal research support and commercialization, but like any system or process, it can be improved. Indeed, the innovative process itself requires a constant lookout for ways to do better. We must remember that most technology commercialization programs on university campuses are relatively young in their tenure and, as such, can learn from the dissemination of best practices and the curtailment of operations that have inefficient scale potential. But before we get to best practices and issues of scale, I want to discuss several Federal policy steps that could be taken to support improvement efforts on individual campuses.

First, federally funded research results must become more transparent and accessible. Open dissemination of research can significantly break down barriers that exist between public and private researchers. Many existing academic and intellectual property protection norms do not support sharing the knowledge gained through federally funded research; this should be revisited. We need more efforts like the Public Library of Science (PLOS), which is a nonprofit organization of scientists and physicians committed to making the world's scientific and medical literature a freely available public resource, and the recent Yale Law School roundtable on "Reproducible Research: Data and Code Sharing in Computational Science." It is critically important to bring together legal, computational, life sciences, and scholars of other disciplines to propose frameworks and action steps that will enable access to future research, commercialization, and replicability.

As we move from discussing research to what could be considered innovations resulting from the research, separate platforms and standards for openness should be considered. The Federal Government should create an "Innovation Exchange" mechanism in the United States. Specifically, we believe the Federal Government should implement policy that requires all universities receiving Federal funding to allow the outcomes of their research to become immediately accessible through a centralized clearinghouse. With experience, the Innovation Exchange platform can become a strategic advantage for entrepreneurs and companies, and therefore, support an accelerated economic recovery and growth.

Foundations are unique in that we pilot projects than can better humankind. Indeed, the Kauffman Foundation has studied and funded potential models of the Innovation Exchange like the iBridge Network (www.ibridgenetwork.org), which is currently a host site for more than 100 universities and 12,000 innovations. The iBridge Network was created to reduce the transaction barriers of commercialization and facilitate sharing across researchers, institutions, and non-profit and for-profit entities, while also shortening cycle time for commercialization transactions. The iBridge Network is an example of how pooling the pockets of knowledge that are currently held at individual campuses and creating transaction marketplaces that span traditional geographic boundaries can lead to more social benefit. The iBridge Network was not intended as a final solution; as such, the Kauffman Foundation would be willing to provide all previous knowledge and intellectual property available to an appropriate not-for-profit or government entity that would be assigned the responsibility of managing an Innovation Exchange.

Second, we need to encourage the engagement of Federal agencies funding research in university-specific evaluations of the effectiveness of the technology commercialization processes and policies as it relates to the disciplines and departments that receive Federal funding. This review will be helpful in determining if departments and professors are advocates of institutional-specific changes to current technology commercialization practices. While university ownership of innovations, as specified in the Bayh-Dole Act, is a starting point for commercialization, to-date it has been an unfunded mandate and one specifically focused on licensing. Bayh-Dole does not specify the entire ecosystem required for commercialization. Elsewhere we have conceptualized some changes that could occur at the individual institution level such as allowing a free and competitive market in technology licensing. While allowing individual faculty or departments to choose their commercialization agents may not be a necessary requirement at every institution, like other free markets, an open system could dramatically speed up the commercialization of new tech-

¹Summary Report of the White House Energy Innovation Conference, May 7, 2010.

nologies, ultimately benefiting consumers—in the United States and around the world—more rapidly. A free market directive also would likely lead university technology licensing offices (TLOs) to specialize or turn to outside agents with the appropriate expertise. A university might drop its TLO altogether, but continue to earn licensing revenues—less the fees charged by outside TLOs or agents. Federal agencies funding research need to be active in reviewing institution-specific technology commercialization practices from a discipline-specific perspective and driving adoption of new, more radical approaches at underperforming institutions. Performance should first be measured by innovations moved to the market, not revenue generated.

Increased funding to proof-of-concept centers and commercialization training/mentoring programs is the third area of policy relevance we see before the Committee. We know from individual-level studies of how technology commercialization practices change, that adoption of new practices is a person-to-person endeavor in most successful cases. If your mentor was good at technology commercialization, your graduate school advisor, or your current chair, then you are much more likely to engage in commercialization activities yourself. Unfortunately, most commercialization education programming is not systematic and hinges on the quality of “mentoring” received, or more accurately, how successful the mentors have been in building out commercial social networks. MIT Professor Robert Langer is the classic case study here, having mentored hundreds of graduate students and junior faculty who have been associated with his lab and gone on to significant commercial success.

The National Science Foundation has been the main Federal agency to-date to provide commercialization education funding. While we applaud NSF’s efforts, commercialization education needs to be ubiquitous (which it is not). The Department of Energy and the National Institutes of Health should require all principal investigators and graduate students who receive Clinical & Translational Science Awards (CTSA) or ARPA-E grants to participate in an approved commercialization program that would provide grantees access to detailed knowledge about intellectual property, market analysis, funding, and firm formation models.

Best Practices and Scale

Now that I have covered some of our specific policy recommendations, let me turn to the topic of best practices and scale. I bring up scale because I think one of the emerging understandings of the technology commercialization process is that individual institutions face enormous hurdles in recognizing and supporting commercialization efforts across all academic disciplines. Indeed, this is a challenge that I would argue can be addressed by developing industry-specialized or discipline-specific TLOs, which will enable the TLOs to gain scales of efficiency in licensing. It also could mean that smaller research institutions would be best suited to consider regional or technology commercialization consortia rather than the maintenance of their own TLOs. Wisconsin implemented a similar statewide model a number of years ago, and both California and North Carolina have experimented with a variety of cross-university collaborations through their public university systems.

At many universities, a TLO becomes the de facto control center for the innovation strategy of *the whole university*. Faculty, who make inventions or discoveries, work through the licensing office, which is charged with a multitude of tasks—from determining commercial viability to patenting, licensing, and earning revenue. Many, but not all, of these offices are under-resourced for such a large agenda, and are in a constant push-pull based upon competing university priorities. In working with universities to address these topics, we learned of an underlying issue that may pose a greater concern: a tendency to focus on patenting and licensing to the neglect of other modes of innovation due to the competing concerns.

High-profile success stories have led us all to think of patentable technologies as the universities’ primary form of innovative “output” to the economy, and of licensing as the main means of commercial diffusion. In fact, as innovation scholars have pointed out, universities have a range of valuable outputs—from “information,” or knowledge, to human capital—and there are many possible pathways for diffusing them into the market: through consulting engagements, through non-patent-based startups, or simply through networking entrepreneurial students and faculty.

We see evidence that these outputs and pathways, if well-cultivated, can provide a significant new source of entrepreneurial outcomes in addition to patenting and licensing. For instance, many MIT students and alumni are prolific entrepreneurs and, in a program that serves them called MIT Venture Mentoring, the majority of the mentored companies do not hold intellectual property from MIT. Most of the companies either are based on new business models to meet a need in a market, or they are software companies, which tend to rely less on patents. A replica of this model has been implemented in St. Louis, New Haven, and Toronto with some early

visible success. Other areas, such as business plan competitions and industrial affiliate programs, show great potential impact, although they have not been studied much to-date. Patenting and licensing are certainly important, but a brighter future awaits universities and regions that, supported by resources across the campus and from a local entrepreneurial community, can tap the whole spectrum of innovation. As for incubators, there are times it makes sense to bring fledgling firms together to share lab facilities and services, and there can be synergies from the interaction. But, in too many cases, the incubator also is a real estate project that has to make real estate sense. If wet labs are needed, they can drive the costs quite high, and if filling the space becomes a concern that trumps serving the entrepreneurs, much of the value is lost. There are examples of successful incubators in places like St. Louis and Madison, Wisconsin; however, there are many more examples of failures. We should continue to learn from the successful incubators, while also considering new models.

One such new model, the proof-of-concept center, is seeing success, both as an incubator of early-stage ideas and as a way to provide students and faculty an opportunity to experience commercialization in a real sense. Proof-of-concept centers do not require shared physical space, but instead provide funds and expert assistance for early-stage innovators to test commercialization potential.

Many universities will be best served in expediting the transactional part of the processes in which they are involved. Here, “express licenses” are an emerging best practice. New examples of standardized licensing agreements, such as the University of North Carolina at Chapel Hill’s Carolina Express License Agreement or the University of Hawaii’s, bypass customized negotiations with the university, which can take considerable time with unpredictable results, in favor of clear, transparent, and timely license agreements.

The Carolina Express License Agreement is an example of how universities and entrepreneurs can streamline collaborations to facilitate the formation of new companies and jobs. The Carolina Express License Agreement was developed by a committee of UNC faculty entrepreneurs, venture capitalists, attorneys, and UNC’s Office of Technology Development as a way to shorten the cycle time in which federally funded inventions move from lab to market in the form of a startup. Founders or entrepreneurs interested in starting a company can choose the Express License, which outlines provisions for company ownership, future revenue payments, and other common sticking points that can slow down commercialization. By creating a standardized licensing agreement, UNC departs from current commercialization guidelines issued by the Association of American Universities, which states that all technologies arise under unique circumstances and therefore require a customized licensing process. We must maintain universities’ intellectual property rights while recognizing that technologies, innovations, and intellectual property are a small portion of what it takes to start an entrepreneurial venture.

A Call for Commercialization Education

The critical role that federally funded research plays in our economy is compromised because faculty, graduate students, and postdoctoral researchers do not have a base-level understanding of the commercialization process. The more than 48,000 postdoctoral researchers at United States institutions are at the forefront of new discoveries, but few have an opportunity to develop the entrepreneurial skills necessary to move their innovations from the lab to the market. With the aim of cultivating entrepreneurs from among the postdoctoral community, the Kauffman Foundation developed the Entrepreneur Postdoctoral Fellowship program to educate and train scientist-founders, who will create the high-growth technology companies of tomorrow. In our initial year, thirteen of the nation’s top scientific postdoctoral scholars were selected to learn how to evaluate their research for commercial potential and the process to take promising research forward to commercialization. Each Fellow has a business mentor, a customized experience, and intensive entrepreneurship workshops at the Kauffman Foundation, where they have the opportunity to network and learn from each other and from entrepreneur experts.

This is an area where Federal agencies funding research could become involved. Indeed, NSF’s rapidly expanding Professional Science Master’s Program “prepares graduate students for careers in business, industry, nonprofit organizations, and government agencies by providing them not only with a strong foundation in science, technology, engineering, and mathematics (STEM) disciplines, but also with research experiences, internship experiences, and the skills to succeed in those careers.” Until the Professional Science Master’s programs take off and we see a reduction in the number of postdocs, the funding of more commercialization opportunities specifically aimed at postdocs would seem prudent.

The National Science Foundation has consistently expanded its efforts to encourage university and industry partnerships, and classic programs such as the Small Business Innovation Research grants. The Engineering Research Centers have been a cornerstone of the NSF portfolio and continue to be a wonderful source of basic research and corresponding commercial outcomes. Industry/University Cooperative Research Centers (I/UCRC) Program remains a relatively small but critical part of NSF's investments and is an increasingly important support mechanism linking new businesses with universities. The Kauffman Foundation and the National Academies have funded a myriad of studies to evaluate the effectiveness of the Small Business Innovation Research (SBIR) program. Simply stated, the SBIR program—specifically at the NSF—is a model program being replicated around the world. That being said, it is important to note that all SBIR programs do not have the same management infrastructure and capabilities. In the last two years the NIH has done a very good job of modifying the management of its SBIR program that today resembles the best practices of the NSF SBIR program.

The Case of Life Sciences

Thus far I have talked about technology commercialization broadly, and I now want to look specifically at one area—the life sciences—as it is an area of unique concern for me. A recent *Newsweek* cover story² summarized some of the main issues here very well, including:

- From 1996 to 1999, the U.S. Food and Drug Administration approved 157 new drugs. From 2006 to 2009—the agency approved 74.
- From 1998 to 2003, the budget of the NIH doubled, to \$27 billion, and is now \$31 billion.

The frustration around the slow pace of discovery to marketplace in biomedical research cannot all be attributed to the role of the university but, due to the significant role of the NIH in funding university research in this area, it should be considered. The “valley of death” between a basic discovery and the stage at which drug companies are willing to invest in the development of a compound is stopping many potentially high-impact innovations from reaching the marketplace. In this valley, academic scientists have few incentives to participate because academic publications and tenure processes aren't supportive of the difficult and sometimes tedious testing work that is necessary to determine toxicity of a compound in animal subjects. Indeed, even some of the more informal disincentives of academia, which bias against publishing negative results, discourage researchers from working with compounds closer to human consumption.

Another challenging factor in drug development today is the fact that large drug companies have reduced their workforces by more than 90,000 employees in the last year as they change strategies on testing and development, choosing to outsource these functions more to biotech firms. But biotech firms are often undercapitalized and the recent recession has not helped the situation. According to industry officials, the major source of funding for these activities in recent years, venture capitalists, have become much more reticent to support early-stage testing and translation service.

Getting new treatments and cures to patients more quickly is the goal of a unique life science proof-of-concept model that draws support from higher education, philanthropy, and industry experts to move medical innovations from the lab to the market. Earlier in this testimony we recommended the funding of proof-of-concept centers, two of which we evaluated in a report released in 2008. Since that time, the Kauffman Foundation sought to replicate the model with our own funding to prove the benefit of the model at a university that did not have the budget of an MIT or University of California-San Diego. The Institute for Advancing Medical Innovation, established at the University of Kansas with funding from the Kauffman Foundation, will focus on education and research that advances medical innovations, ultimately accelerating the number and quality of new drugs, medical devices, and drug-medical device combinations from the bench to the bedside. The grant earmarks funding for the Institute for Pediatric Innovation, which funnels its drug development work through a partnership with KU, Kansas City's Children's Mercy Hospital, and Beckloff Associates Inc. The Institute is guided by an advisory board of independent experts and staffed by experienced drug development and medical device leaders to create an unprecedented collaboration of resources and processes to support the Institute. The Kauffman Foundation grant includes seed funds for up to twenty-four proof-of-concept projects per year. Based upon the recommenda-

²<http://www.newsweek.com/2010/05/15/desperately-seeking-cures.html>

tions from its advisory board, the Institute may progress with a varying number of projects from year-to-year. In addition to its impact in the medical field, the Institute for Advancing Medical Innovation serves as a national model for how philanthropy, industry, and universities can collaborate to advance university innovations in life sciences.

These types of university, industry, philanthropy, and advocacy group collaborations have the potential to change the way in which basic discoveries are brought to market. I am particularly excited to see how these seeds of cooperation are being encouraged as a result of a large increase in funding in the recent healthcare legislation that will provide \$500 million to the Cures Acceleration Network at NIH for such collaborations this year. However, the *Wall Street Journal* has reported that companies that are partially owned by tax-exempt organizations (like universities) will not be eligible for funding.³ This exclusion of companies that likely have university equity seems like a counterproductive measure that will be a disadvantage to many startup firms that are based on university technologies.

Conclusion

There are no single models for success. We have highlighted some basic elements here, but they may need to be applied in different ways. What works best at each university may depend on its research strengths, the nature of the related industries, the nature of the region (big city, rural, etc.), and other variables. The only common thread is the need for a well-developed ecosystem of innovation. In high-growth regions with highly entrepreneurial universities, the following tend to be true of the faculty: They have frequent and extensive contacts with private industry, which attune them to thinking in terms of practical value creation while enabling them to share their own expertise. High-growth regions operate with university policies that encourage such activities, rather than laboring against policies that draw barriers between the academic and the commercial realms. Magic bullets may score occasional hits, but ecosystems flourish with many pathways to the commercial market.

We call on you to increase the transparency of research resulting from Federal funding through the creation of an “Innovation Exchange,” to encourage Federal agencies funding research to become involved in institution-specific technology commercialization effectiveness reviews, and, lastly, to increase funding allocations for proof-of-concept centers and commercialization education programs.

Thank you for the invitation to present to the Committee today.

Supplementary Materials

- Academics or Entrepreneurs? Entrepreneurial Identity and Invention Disclosure Behavior of University Scientists—http://www.kauffman.org/uploadedFiles/George_Gerard.pdf
- Assessing Risk and Return: Personalized Medicine Development & New Innovation Paradigm—<http://www.kauffman.org/research-and-policy/assessing-risk-and-return.aspx>
- A Critical Role for the Modern Research University—<http://portal.acm.org/citation.cfm?id=1017754&dl=GUIDE&coll=GUIDE&CFID=93187681&CFTOKEN=74979519>
- Commercializing University Innovations: Alternative Approaches—<http://ssrn.com/abstract=976005>
- Developing University-Industry Relations: Pathways to Innovation from the West Coast—<http://books.google.com/books?id=N-jM0Au4HgC>
- Entrepreneurial Impact: The Role of MIT—<http://www.kauffman.org/newsroom/mit-entrepreneurs.aspx>
- Finding Business Idols: A New Model to Accelerate Start-Ups—<http://www.kauffman.org/entrepreneurship/finding-business-idols.aspx>
- The Future of the Research University: Meeting the Global Challenges of the 21st Century—<http://www.kauffman.org/Details.aspx?id=5758>
- The HBR List: 10 Breakthrough Ideas for 2010—A Faster Path from Lab to Market: Removing the technology licensing Obstacle.—<http://hbr.org/2010/01/the-hbr-list-breakthrough-ideas-for-2010/ar/1> (not a complete article, must subscribe)
- The Impact of Academic Patenting on the Rate, Quality, and Direction of (Public) Research Output—<http://www.nber.org/papers/w11917>

³<http://online.wsj.com/article/SB20001424052748703559004575256303965700876.html>

- In tough times, personalized medicine needs specific partners—<http://www.nature.com/nm/journal/v14/n12/full/nm1208-1294.html> Newton
- The Knowledge Filter and Economic Growth: The Role of Scientist Entrepreneurship—http://www.kauffman.org/uploadedfiles/scientist_entrepreneurs_audretsch.pdf
- Measuring Knowledge Spillovers: What Patents, Licenses and Publications Reveal About Innovation Diffusion—<http://ssrn.com/abstract=id=1598495>
- Measuring the Social Value of Innovation: A Link in the University Technology Transfer and Entrepreneurship Equation—<http://books.google.com/books?id=jEU5YwGSU4C>
- Moving Innovations to Market—<http://www.kauffman.org/advancing-innovation/moving-innovations-to-market.aspx>
- New Standard Licensing Agreement Expedites University Startups, According to Kauffman Foundation Paper—<http://www.kauffman.org/advancing-innovation/new-standard-licensing-agreement-expedites-university-startups.aspx>
- Proof of Concept Centers: Accelerating the Commercialization of University Innovation—<http://www.kauffman.org/advancing-innovation/accelerating-commercialization-of-university-innovation.aspx>
- Should Universities Be Agents of Economic Development?—<http://www.usinnovation.org/files/ASTRABriefsSummer08.pdf>
- Technological innovation: generating economic results—<http://books.google.com/books?id=zHHUrOTzZlC>
- University entrepreneurship and technology transfer: process, design, and intellectual property—<http://books.google.com/books?id=nhAxMRjUELgC>
- University entrepreneurship: a taxonomy of the literature—<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.121.7880&rep=rep1&type=pdf>

BIOGRAPHY FOR LESA MITCHELL



Lesla Mitchell is a vice president with the Kauffman Foundation.

She has been responsible for the Foundation's frontier work in understanding the policy levers that influence the advancement of innovation from universities into the commercial market and the new relationships between philanthropy and for profit companies. Under Mitchell's leadership, the Foundation is defining and codifying alternative commercialization pathways, and identifying new models to foster innovation. Mitchell was instrumental in the founding of the Kauffman Innovation Network/ iBridge Network, the Translational Medicine Alliance, the National Academies-based University-Industry Partnership and leader in the replication of innovator-based mentor programs across the U.S. In addition, Mitchell serves on the boards of the Regenerative Medicine Foundation and the University of Kansas Institute for Commercialization.

Prior to joining Kauffman, Mitchell spent twenty years of her career in global executive roles at Aventis, Quintiles, and Marion Laboratories and ran an electronic clinical trials consulting business in support of global pharmaceutical clients.

The Kauffman Foundation

The Ewing Marion Kauffman Foundation (*www.Kauffman.org*) works with partners to encourage entrepreneurship around the world. The Kauffman Foundation is working to further understand the phenomenon of entrepreneurship, to advance entrepreneurship education and training efforts, to promote entrepreneurship-friendly policies, and to better facilitate the commercialization of new technologies by entrepreneurs and others that have great promise for improving the economic welfare of the world.

The Foundation works with leading educators and researchers nationwide to create awareness of the powerful economic impact of entrepreneurship, to develop and disseminate proven programs that enhance entrepreneurial skills and abilities, and to improve the environment in which entrepreneurs start and grow businesses.

Chairman LIPINSKI. Thank you, Ms. Mitchell.
And now we will move on to Mr. Crowell.

**STATEMENTS OF W. MARK CROWELL, EXECUTIVE DIRECTOR
AND ASSOCIATE VICE PRESIDENT, INNOVATION PARTNER-
SHIPS AND COMMERCIALIZATION, UNIVERSITY OF VIRGINIA**

Mr. CROWELL. Thank you. Chairman Lipinski and Ranking Member Ehlers, thank you for the opportunity to testify before the House Science and Technology Subcommittee on Research and Science Education. My name is Mark Crowell. As of about two weeks ago, I am the Executive Director and Associate Vice President for Innovation Partnerships and Commercialization at the University of Virginia. I took this job because I believe U.Va. is at the forefront of research universities in advancing an institution-wide innovation agenda, and I intend to share and help lead U.Va.'s vision for transforming the way ideas flow from universities to the world.

I am a 23-year member of the technology transfer profession and previously led programs at the Scripps Research Institute in La Jolla and Palm Beach, at Duke, at North Carolina State University and at the University of North Carolina at Chapel Hill, and Mr. Chairman, I am a Tar Heel basketball fan, just to get that out of the way. During 2005, I also served as President of the Association of University Technology Managers, or AUTM, a global organization of more than 3,500 technology transfer professionals.

In my 23 years of experience, I have witnessed the technology transfer profession evolve from a function of secondary importance into a key component of the teaching, research, public service and engagement missions of the university. The technology transfer function of the 1980s and much of the 1990s was largely reactive, non-market driven and completely separate from concepts like regional economies and innovation ecosystems. Let me stress, I believe this is yesterday's news and that these perceptions should no longer guide public policy. Fast-forward, in fact, through the 1990s to today and the profession and practice is markedly different.

As I will outline via some best-practice examples, technology transfer offices are sophisticated business and innovation development engines, and the people who run them are highly skilled and come from a broad array of fields. Yes, we still have administrative responsibilities but most of us are nerve centers on our campuses for innovation partnerships and commercialization, and are key parts of our regional innovation economies.

The impact of these efforts is especially easy to see in regions acknowledged to be leaders in technology-based economic develop-

ment. The example I know is Research Triangle Park, but similar stories are available or are evolving in other regions where research universities are ramping up their innovation and partnership activities. My written statement contains much more detail about Research Triangle Park and the way in which it evolved during the 1990s and early 2000s as an innovation and entrepreneurial hotspot, with impressive growth in company launches, new jobs and other indicators, and it documents the parallel and dramatic investments in academic technology transfer during this period as well as the impact of a regional licensing consortium serving three of the research universities there.

As noted, the scale and focus of academic technology transfer translational research and business development initiatives have evolved in numerous ways. A partial list of best practices includes the following: one, startup company development activities. According to AUTM's most recent survey, almost 600 universities spin-offs were formed in 2008 alone.

Two, entrepreneurship training for students and faculty are now part of the academic landscape, or as the former chancellor of UNC Chapel Hill indicated, they are part of the weave and fabric of the institution. Working with partners like the Kauffman Foundation, or regional innovation partners like the Council for Entrepreneurial Development, or CONNECT, entrepreneurship education and training activities are available for post-docs, graduate students, undergrads, faculty and others.

Three, critical pre-seed and seed capital resources and networks are being launched. It is well documented that institutional venture capital has moved further downstream and that a vast gap exists between early-stage university technology and marketplace investment opportunities. At the University of Virginia, as an example, we recently held our second annual U.Va. Venture Summit. In each of its first two years, the U.Va. Venture Summit attracted venture capital funds managing more than \$15 billion. In the first year, each of the eight U.Va. companies presenting received funding.

Four, proof-of-concept and translational research programs are becoming commonplace best practices. Again, an example from the University of Virginia is the Wallace Coulter Foundation Translational Research Partnership, which funds a project manager and about eight projects per year. Results from this activity indicate that there have been 20 new patent disclosures per \$1 million invested and that 50 percent of funded projects over the first four years have moved to a commercial license within two years, all metrics that greatly exceed traditional academic research metrics. U.Va. officials attribute the success of the Coulter project to the high-touch involvement of a diverse project review board that involves industry personnel, investment capital and others.

At the University of Virginia, we strongly believe that enhanced Federal funding by NSF and others for proof-of-concept and translational research initiatives, similar to these examples, will lead to the harnessing of what economist Paul Romer calls "the countless discoveries required for economic growth" by linking the people that make them with other participants in innovation ecosystem.

I thank you for the opportunity to be here today and I look forward to answering your questions.

[The prepared statement of Mr. Crowell follows:]

PREPARED STATEMENT OF W. MARK CROWELL

Chairman Lipinski and Ranking Member Ehlers, thank you for the opportunity to testify before the House Science and Technology Subcommittee on Research and Science Education on the important topic of enhancing technology transfer in order to more effectively translate research discoveries from the lab to the market.

My name is Mark Crowell. As of about two weeks ago, I am the Executive Director and Associate Vice President for Innovation Partnerships and Commercialization at the University of Virginia. I believe that the University of Virginia is at the forefront of research universities in advancing an institution-wide innovation agenda that works across traditional silos and boundaries, that embraces outward-facing partnerships, and that is committed at every level to leveraging its innovation capacity and to translating its research discoveries for the public good and for economic development impact. Indeed, I joined U.Va. to share and help lead the university's vision for transforming the way ideas flow from universities to the world. If future generations are to enjoy peace, prosperity, and a clean and sustainable environment in this nation, there is nothing more important than long-term investments in research universities, because research universities are the innovation engines of the United States.

I am a 23-year member of the technology transfer profession. Prior to joining the University of Virginia, I was the Vice President for Business Development at The Scripps Research Institute in La Jolla, California, and Palm Beach, Florida. From 1987 until 2008, I led the technology transfer, economic development and industry research programs at Duke University (1987–1992), North Carolina State University (1992–2000), and the University of North Carolina at Chapel Hill (2000–2008). I also served as President of the Association of University Technology Managers, or AUTM, during 2005, and still serve on the Board of Directors of the AUTM Foundation, AUTM's fund-raising and business development arm. AUTM is a global organization of more than 3,500 technology transfer professionals and is dedicated to promoting and supporting technology transfer through education, advocacy, networking and communication.

In my 21+ years of experience in Research Triangle Park, North Carolina, I witnessed the technology transfer profession evolve from a function of secondary importance into a key component of the teaching, research, public service, and engagement missions of the region's universities. In the early days of my career, this activity was largely about counting invention disclosures, filing patents when the university could afford to do so, avoiding risks, and hoping for financial windfall while praying your institution and your faculty avoided making front-page news as a result of various conflicts. Concepts of market pull, entrepreneurship, translational research, proof-of-concept funding, and equity stakes were not yet part of the vernacular of the technology transfer scene. The technology transfer function of the 1980s and much of the 1990s was largely reactive, non-market driven, and completely separate from concepts like regional economies and innovation ecosystems. Let me stress, however—this description is the “old mythology” of university technology transfer and these perceptions do not reflect the current reality. Government policy today should not be guided by outdated perceptions of the past.

Fast forward through the 1990s to today and the profession—and practice—is markedly different. Technology transfer offices in research universities are sophisticated business and innovation development engines, and the people who run them are highly skilled and come from a broad array of fields. Yes, we still deal with invention reports, patent filings, conflict of interest management, and government reporting—but we also write business plans, raise and administer proof-of-concept and pre-seed capital funds, network with entrepreneurs, train faculty and students in entrepreneurship, partner with private companies and non-profits to leverage the innovation capacity of our institutions, develop research parks, and help recruit the best and brightest faculty and students to our campuses and retain them at our institutions.

As a result of the changes and evolution highlighted above, the innovation and technology transfer functions operating in research universities are an increasingly important component of regional economies. They play critical roles in developing the innovation ecosystems needed to support, nurture, grow and retain the entrepreneurial companies that will be the primary source of wealth creation and new jobs in today's knowledge economy. The impact can already be seen in regions acknowl-

edged to be leaders in technology-based economic development. The example I know best is Research Triangle Park, but similar stories are available or are evolving in other regions where research universities are ramping up their innovation and partnership activities.

Research Triangle Park was launched in 1959. In its first thirty years of life, the economic development model followed successfully by RTP's leaders was the old-fashioned "big game hunt" model—i.e., identifying and recruiting corporate headquarters, government agencies, or major divisions of existing companies. Notable successes in RTP during this time period were IBM, Glaxo, Burroughs Wellcome, and the National Institute of Environmental Health Sciences. By 1989, there were 60 firms and 30,000 employees; most of the firms were medium to large-sized companies or divisions of companies. Despite this success in company attraction, there was very little technology transfer infrastructure in the region's universities during this period—and very little in the way of a start-up pipeline or entrepreneurial culture.

From the mid 1980s through the mid 1990s, investments in the technology transfer infrastructure in RTP were increased. The three universities launched, or rejuvenated, their on-campus technology transfer operations, and in 1987 came together to operate the jointly-governed Triangle Universities Licensing Consortium to market and license technologies developed at the three institutions. Concurrently, the state launched or increased its investment in technology-based economic development agencies like the North Carolina Biotechnology Center—which then initiated programs to partner with local universities to facilitate technology transfer and business development mechanisms and resources. The Council for Entrepreneurial Development, a non-profit RTP-based organization whose mission is "to identify, enable and promote high growth, high impact companies and to accelerate the entrepreneurial culture of the Research Triangle and North Carolina," was founded during this period as well.

The investment in technology transfer infrastructure and in a regional innovation ecosystem paid enormous dividends for the region's economy. By 2002, RTP had more than 150 firms—two and a half times the number just 13 years earlier—and RTP jobs totaled more than 45,000, a 50% increase from 1989. 52% of these companies had less than 10 employees, and 86% had fewer than 250 employees. About one-third of the firms in RTP are, in fact, start-up companies. It appears that the RTP of today is actually RTP II—a second generation research park with a much more robust innovation and entrepreneurial base of economic activity than the first version of RTP, or RTP I—whose foundation was built upon a theory and practice of economic development ("big game hunting") no longer seen as viable or effective in generating jobs and investment. The growth and evolution of RTP from 1989 to 2002 from a corporate headquarters destination to a start-up hotspot was likely the result of a confluence of a number of factors—but there is no doubt that the enhanced attention on technology transfer and commercializing research discoveries contributed significantly to the park's evolution into a business model which is much more sustainable than that followed previously.

As technology transfer and innovation management within academic institutions have become more important regionally and more ingrained into the missions and role of the research university, the scale and focus of technology transfer have changed in numerous ways. As noted earlier, the practice of technology transfer still involves the basic invention management, patenting and licensing functions which have always been part of the technology transfer operation. But the following are examples of sophisticated educational, financing, and business development functions now seen in many such operations:

- 1) Start-up company formation and support—Innovation management professionals in universities increasingly participate in dynamic business development activities. According to AUTM's most recent survey, 595 new companies were formed in 2008 alone. Start-up companies often are the best means to champion the translation and commercialization of an early stage discovery, as well as to create regional economic impact. University personnel increasingly seek partnerships within their innovation ecosystem (e.g., science and engineering faculties, business and law schools, local entrepreneurial support organizations, venture capital firms, economic development agencies, regional innovation centers and incubators, and so forth) in order to form, launch, and nurture the development of start-up companies.
- 2) Translational research, entrepreneurship and innovation training (and experiential learning) for students and faculty across the institution—At the University of Virginia, we, like many universities, hold business plan competitions as well as "business concept" competitions (focusing on pre-commercial

innovation assessment and translation). We also offer a course in BioInnovation that spans engineering, business, biology, architecture, and medicine. In addition, post doctoral researchers were brought into the technology transfer offices at Scripps and at UNC for 9 month internships to begin to grow a pipeline of academic scientists who are trained in translational research, business development and transactional aspects of commercialization—and to enhance the number of well-trained scientists with business development expertise needed to sustain and grow innovation ecosystems. Similarly, monthly seminar series with networking social events are found at U.Va. and UNC and offer a venue to bring together faculty, postdocs, graduate students, and the local entrepreneurial and business development communities in ways which catalyze relationships, networks, and business development opportunities. With support from the Kauffman Foundation, an exciting course sequence called “Launch the Venture” was created in UNC’s Kenan-Flagler School of Business—co-sponsored and co-taught by personnel in the technology transfer office—to expose would-be faculty entrepreneurs to a sophisticated and highly successful course sequence designed to teach and implement the steps necessary to build investment-worthy business plans around technologies and services suitable for the development of new companies.

- 3) Pre-seed and seed capital—It is well documented that institutional venture capital has moved further downstream in the technology development continuum and that early stage ideas emerging from academic laboratories find it increasingly difficult to attract pre-Series A investment capital necessary to form a company, attract management, and conduct the early stage development necessary to advance a technology aggressively toward commercialization. At the University of Virginia, we recently held our second annual U.Va. Venture Summit. In each of its first two years, the U.Va. Venture Summit has attracted venture capital funds managing – in the aggregate – more than \$15 billion. 100% of the eight U.Va. companies presenting in year one of the Venture Summit received funding. In another approach, in the late 1990s, NC State University formed “Centennial Venture Partners” with \$10 million from the university’s endowments to invest in start-up companies affiliated with the university. Over a period of almost three years, Centennial Venture Partners invested in about 15 university-affiliated companies – and those companies leveraged Centennial’s \$10 million to bring in more than \$140 million in follow-on funding. Other institutions across the country are developing their own approaches to access, raise, partner, or bootstrap early stage sources of risk capital so critical to the creation of entrepreneurial ventures.
- 4) Proof of concept and translational research initiatives—The University of Virginia has built several very successful—and culture changing—models for proof of concept investments and scale-up for commercialization. A primary example is the Wallace H. Coulter Foundation Translational Research Partnership, which funds (for about \$1 million per year) a project manager and about eight projects per year at around \$100,000 each. Results from this activity indicate that there have been twenty new patent disclosures per \$1 million invested, and that 50% of funded projects (over the first four years) have moved to a commercial license deal within two years. Both measures far exceed the standard “metrics” for the commercialization of academic research. Several other similar initiatives are funded at U.Va. and generate similar outcomes and success. U.Va. officials attribute the success of these initiatives to the involvement of a very diverse review board, in-person reviews with the research teams, milestone driven projects, frequent reporting, the “will to kill” projects or re-direct funds if insurmountable obstacles occur, dedicated translational research project managers, and excellent networking in the venture capital and private sectors. Again, similar initiatives are increasingly seen at other institutions around the nation, including a Center for Integrative Chemical Biology and Drug Discovery at UNC—Chapel Hill that partners with basic scientists at UNC to take their drug target discoveries, seeking to de-risk and accelerate the lead identification, proof-of-concept, and optimization process, thereby enhancing licensing and commercial potential.

The areas outlined above are not an exhaustive inventory of the many sophisticated and critical core strategies implemented by university technology transfer officials in seeking to translate basic research discoveries and innovation into products and services, but they do provide a good overview of many of the key “best practices,

policies and initiatives” that are key to fueling our innovation economy. They are examples of initiatives that are critical in enabling universities to partner more effectively with industry—and in ensuring that there are pathways for the commercialization of basic research discoveries and innovations so that economic growth, job creation, and social good can occur.

At the University of Virginia, we believe that economic and social well-being in the next global era will be achieved via an evolving paradigm that causally links knowledge creation, innovation, commercialization, societal advancement, and human dignity. We agree with economist Paul Romer, who noted that “no amount of savings and investment, no policy of macroeconomic fine-tuning, no set of tax and spending initiatives can generate sustained economic growth unless it is accompanied by the countless large and small discoveries that are required to create more value from a fixed set of resources.” These principles were a focal point in the recent NSF Partnerships for Innovation (PFI) grantee conference, titled “*Innovation Ecosystems for the Creative Economy*,” organized by the University of Virginia and led by Thomas Skalak, U.Va.’s Vice President for Research.

We also believe strongly that enhanced Federal funding by NSF and others for proof-of-concept and translational research initiatives of the types described in this statement will lead to the harnessing of what Romer calls the “countless discoveries” by linking the people that make them with other participants in the innovation ecosystem to accelerate innovation, to enhance wealth creation, and to advance societal good. Given the degree to which universities are increasingly acknowledged to be the platform for innovation for America and the world, we believe that this enhanced Federal investment in proof-of-concept research is essential to our national innovation ecosystem.

To be more specific, we certainly fully support the President’s proposed FY 2011 Budget Request for \$12 million for a new “NSF Innovation Ecosystem” component within the Partnerships for Innovation program. But we believe much more investment is needed in order to ensure that proof of concept initiatives—examples of which are highlighted in this statement—are in place and accessible to capture and translate the innovations emanating from universities nationwide. We urge funding at levels much higher than that noted above—and suggest that perhaps 0.5–1.0% of the NSF budget (and other agencies as well) be allocated to this need. This funding could take the form of Translational Research Supplemental Awards, or de novo Translations Concept Grants available for good ideas even if not based on another Federal grant. This funding should be accessible to universities in all regions—because talent and innovation exists everywhere. We believe the review process for such funding should be high-touch and market focused, with corporate partner input and development milestones being key components for initial and ongoing funding. We are pleased to note that these recommendations were supported in the “wrap-up” portion of the recent PFI conference on “Innovation Ecosystems” organized by U.Va.

The University of Virginia is committed to an innovation agenda that seeks to create and leverage pathways, partnerships, resources, and strategies for translating its intellectual capital into products and services that benefit society, generate economic growth and wealth creation, and enhance the research and educational experience of its students and faculty. A key component of success in this agenda is our ability to enter into robust, outward facing, high-engagement partnerships with key industry, venture capital, and related entities. These partnerships are local, regional, commonwealth-wide, national, and global—and we seek out and engage in such partnerships in fulfillment of our mission and our commitment to our students, faculty, sponsors, and society. We also see clearly our role in the innovation ecosystem which must be sustained and grown in order to support economic development. Like other universities, we are a critical source of ideas, knowledge, and discoveries—and in a knowledge economy, this is the raw material that fuels the economy. We are good at producing ideas and innovations—and we wish to partner with companies that are good at productizing, manufacturing, marketing, and distribution.

BIOGRAPHY FOR W. MARK CROWELL

Mark Crowell is Executive Director and Associate Vice President for Innovation Partnerships and Commercialization at the University of Virginia. His university-wide responsibilities include innovation management, commercialization, new business development, industry partnerships, translational research initiatives, and venture capital relations.

Prior to joining U.Va., Mark was Vice President for Business Development at The Scripps Research Institute in La Jolla, CA, and Jupiter, FL, where he was respon-

sible for technology transfer, business development, biopharmaceutical relationships, and new venture creation. Over the past 23 years, Mark has extensive experience in technology licensing, start-up company formation, seed capital development, innovation-based economic development initiatives and planning, and research campus planning.

Earlier in his career, Mark spent 8-1/2 years as Associate Vice Chancellor for Economic Development and Technology Transfer at the University of North Carolina at Chapel Hill, after holding similar positions at North Carolina State University (1992–2000) and Duke University (1987–1992). During the past 22 years, the technology transfer programs Mark has directed—UNC, NC State, and Duke—have helped to launch more than 135 start-up companies and numerous products and services. In North Carolina, Mark served on the Boards of key economic development and entrepreneurial support agencies, including the North Carolina Biotechnology Center, the Council for Entrepreneurial Development, the Research Triangle Regional Partnership, and the Orange County Economic Development Commission.

Mark has led many public-private collaborations, including a major initiative to work with Alexandria Real Estate Equities, Inc., to launch an 85,000 square foot business accelerator—the Carolina Innovation Center—at UNC. Another highlight includes co-founding a U.S. \$10 million seed fund at NC State University (in partnership with the NC Technology Development Authority). Mark also had extensive involvement in planning and managing the widely acclaimed Centennial Campus, a 1200+ acre research campus at NC State University.

Mark was the 2005 President of the Association of University Technology Managers (AUTM) and is the founding President of the newly launched AUTM Foundation. Currently, Mark serves as Chair of BIO's Technology Transfer Committee and as a member of the Board of Directors of CONNECT in San Diego. He has extensive national and international speaking, consulting, and management experience related to technology transfer and innovation-based economic development, and has been instrumental in forging international research and innovation transfer partnerships on behalf of UNC and of Scripps. His consulting and advisory activities have included a number of U.S. and international academic and policy groups and associations, including the National Science Foundation, the American Association for the Advancement of Science (AAAS), the National Academies of Sciences, the World Intellectual Property Organization, the Los Alamos National Laboratory, and many others.

Chairman LIPINSKI. Thank you, Mr. Crowell. And even though you are a Tar Heels fan, I apologize for getting your name incorrect the first couple times.

Now I will move on to Mr. Watkins.

**STATEMENTS OF WAYNE WATKINS, ASSOCIATE VICE
PRESIDENT FOR RESEARCH, UNIVERSITY OF AKRON**

Mr. WATKINS. Chairman Lipinski, Ranking Member Ehlers, Members of the Subcommittee, I am Wayne Watkins. I am the Associate Vice President for Research at the University of Akron and Treasurer of the University of Akron Research Foundation. We very much appreciate this invitation to submit written testimony and to highlight a couple of our observations and recommendations.

Observation one: The innovation effectiveness of universities is a function of university leadership at all levels demonstrating that they are committed to innovation. It is a function of quality research. It is a function of having porous boundaries and boundary-spanning strategies between universities and industries. It is a function of providing the full range of innovation expertise and services, not just patent procurement and licensing. It is also a function of effective education and training related to innovation.

Observation number two: Technology transfer offices are increasing, providing multiple innovation services. They must be flexible for each specific situation. The model for congregating and deploying a full range of innovation expertise and services established at

the University of Akron demonstrates the capacity of a mid-sized public university to foster innovation. I might mention one of our more rewarding initiatives is that of designating and hosting passionate and savvy industry retirees as university research foundation senior fellows, who as volunteers bridge the boundaries, the cultures, the technologies between universities and industry. The senior fellows, as fully integrated members of the university technology transfer team, reach into the university and reach out to industry to train, make connections, identify challenges, find opportunities and find resources.

Observation number three: We very much appreciate the role of government in our innovation ecosystem. The government best contributes to innovation by being the major sponsor of basic and applied research, by providing an effective patent system that rewards novel inventions and provides for rapid public disclosure of inventions. The government further contributes to innovation effectiveness by supporting a business environment that encourages investment and innovation-related risk taking, and one that minimizes regulation and other burdens to only that which is essential. The government also best contributes by providing appropriate commercialization infrastructure support.

Recommendations: First, the government should fund the experimentation of, and the development of, sustainable and effective innovation expertise congregators and service providers on a multi-institutional and regional basis, and in some cases focus on specific technologies or specific markets such as energy or advanced materials.

Two: The government should expand its use of commercialization grants, particularly where the markets alone do not adequately incentivize the commercialization. The SBIR, with the concept of supplemental grants, is an excellent example and an excellent program.

Three: The government should expect the recipients of Federal research funding to promptly make public the invention disclosures after the intellectual property protection is secured, and that has to be balanced with industry's need for proprietary and for keeping things confidential. The government should also expect that recipients of Federal research funding have effective innovation and commercialization capacity. However, to be effective, we need to realize that they are situation specific and each environment has to respond to their own resources and their own situations.

As universities, however, we really need to be the ones to demonstrate our expertise and our effectiveness in translating knowledge into products and services. Notwithstanding that our research universities have served the citizens of the United States long and well, we are at risk, given the financial crises and related economic downturn, the growing international competition and our waning educational attainment performance. Thus, as a country, we must leverage all available resources, and especially our Nation's universities, in concert with industry and the government to transform our national competitiveness through innovation.

To that end, our universities need to continuously reinvent themselves to be increasingly relevant and to be primary drivers of innovation. Conventional thinking that universities are incapable of ef-

fective innovation and marketplace relevance is wrong. Likewise, any thought that universities, industry or government alone will drive innovation is wrong. All three sectors are essential. All have room for improvement and thus we must help each other. There is tremendous latent capacity for innovation in our society that needs to be unleashed, and we believe appropriate rewards from the Federal Government will help universities and businesses become innovation proficient as we seek to inspire, develop and send to the markets the innovations that improve our quality of life and our economic security. Thank you.

[The prepared statement of Mr. Watkins follows:]

PREPARED STATEMENT OF WAYNE H. WATKINS

Chairman Lipinski, Ranking Member Ehlers, Members of the Subcommittee, I am Wayne Watkins, Associate Vice President for Research at The University of Akron, and Treasurer of the University of Akron Research Foundation. Thank you for allowing me to testify and to share a perspective on university roles in our country's innovation ecosystem and specifically about university technology commercialization, university industry collaboration, and the University of Akron Research Foundation (UARF) model for improved knowledge and technology transfer from academic researchers to the private sector. Universities, across the spectrum, have the capacity to be powerful contributors to innovation and economic development through knowledge (intellectual asset) creation, transfer, and implementation. In support of the innovation mission of universities, the following testimony is provided in response to the questions of the House Subcommittee on Research and Science Education of the House Committee on Science and Technology.

University-based technology transfer, commercialization, and university-industry collaborations are generating growing interest in academia, corporations, and government. These powerful innovation processes and relationships are ways for academic institutions to disseminate knowledge and share assets, for corporations to accelerate the commercialization of innovations, and for the Nation to leverage its valuable resources to reinvigorate the economy and create jobs. The escalating interest, in part, also stems from the recognition that academic institutions play a growing central role in regional and national economic development. The scientific and technological assets, and know-how emanating from universities, Federal laboratories, medical and other research institutions, form a powerful base that can usher in a new, globally competitive era in U.S. knowledge based manufacturing and transformational technology.

As the innovation ecosystem evolves and new technologies emerge, it is prudent to consider the policies, incentives, and structures that best accelerate innovation by enhancing university-industry collaborations and by optimizing commercialization of university innovations.

If the United States is to remain a leading player in the global innovation economy, we must develop an educated workforce that is more responsive to global technological challenges, and accelerate the rate at which we translate research and intellectual assets into economic assets. The simultaneous challenges arising from the U.S. economic downturn and growing international competition demand that we leverage all economic resources available to the United States, especially the nation's research institutions and industries.

1) What types of education, training, and services are offered by The University of Akron to professors, postdoctoral fellows, and graduate students interested in the commercialization of their research discoveries?

Each year new faculty members receive instruction on research and technology transfer processes and support at an orientation session sponsored by the Vice President for Research. The University of Akron's Office of Technology Transfer team and the University of Akron Research Foundation (UARF) Senior Fellows meet with select research teams including the professors, postdoctoral fellows, and graduate students regarding their specific research programs where they discuss, and are instructed on, commercialization opportunities, strategies, processes, conflicts of interest management, industry collaboration opportunities, mentoring opportunities, new enterprise creation, access to funding opportunities, and development services/support and related topics. In addition the Office of the Vice President

for Research hosts social events for inventors throughout the year that promote valuable interdisciplinary networking. The University of Akron's Office of Technology Transfer and the UARF Senior Fellows teams also participate periodically in department faculty and staff meetings and with the university faculty senate. Courses are taught on entrepreneurship and intellectual property management for graduate students. A new experiential learning course is under development called the Akron EMS-LaB Research Experience which is an integrated multidisciplinary biomedical research experience including student team members representing engineering, medicine, sciences and supported by law and business (EMS-LaB) students, and local area hospital clinicians. Under the EMS-LaB program, graduate student teams are formed around technology opportunities and work on a project over a two year period leading to a commercial business opportunity.

2) What are the challenges to increasing the transfer of knowledge and technology from university researchers to the private sector and what are the key elements of successful university industry collaboration?

Challenge #1—As innovation outcomes are dependent on a continuing stream of world leading researchers, innovators, and scholars, the United States must continue to **improve the quality, accessibility, and performance of its higher education systems and institutions to achieve a sustainable status as the leading source and nurturer of the world's innovations. Educating, developing, identifying, recruiting, and supporting the leading innovators is the primary challenge** to increasing the knowledge and technology flowing from the universities to the private sector and *vice versa*. Thus universities and governments need to address education performance improvement as well as access and costs. Visa and immigration issues need resolution to insure the United States benefits from the top innovators globally.

Challenge #2—**Sufficient and sustained basic and applied research funding to qualified innovators to support leading edge research and development remains a continuing challenge** to driving the downstream commercialization. The majority of research funding at U.S. universities comes from Federal agencies. Such funding is the primary source for innovations that result in technology and entrepreneurial activity spinning-out of universities. Research funding is the "lifeblood" for future innovations, and accelerates advancements in knowledge-based manufacturing and technology enterprises that keep the U.S. globally competitive. We also must insure that research funding reflects national competitiveness strategies while providing sufficient funding to a range of science and technology disciplines, and reflecting emerging trends in inter-disciplinary research. **Increased Federal funding for improving the innovation processes at academic institutions should be considered.**

Challenge #3—**Innovation does not respect individual institutional or state boundaries.** Federal funding is structured to address individual institutions and states. As we clearly see in cluster development, growing clusters often involve connections between multiple institutions and multiple communities. Federal funding could be better aligned with this regional and multi-institutional approach. State funding practices also tend not to account for the regional nature of cluster development and states should be encouraged and incentivized to cooperate in research, innovation, and entrepreneurship, across state boundaries. **As we increasingly face global competition, it may be time to rethink boundaries and funding that is traditionally tied to these boundaries.**

Challenge #4—**University leadership with expertise and strategic commitment to establishing innovation supporting universities is essential and remains a continuing challenge.** The strategic perspective and leadership of the university president, in particular, is a major factor in the innovation effectiveness of an institution. My transfer to The University of Akron was a direct result of the innovation related expertise and leadership of its president, Dr. Luis Proenza. University governing boards and others that influence the hiring of university presidents, including faculty, labor representatives, and community members, need to be appropriately attuned to the need for leadership that is innovation savvy and capable of leading university culture adaptations for improved innovation performance. Likewise the collective leadership of the institution including provosts, vice presidents, deans and department chairs as well as the informal leaders, impact the innovation effectiveness of the institution. There are excellent examples of leaders that move the university's culture to be more accommodating and celebratory of innovation related activity by recognizing and rewarding innovation, commercialization, and industry collaboration as well as by encouraging entrepreneurial activity. Institutional support may be demonstrated by the institution's faculty hiring and

promotion decisions that reward work with industries and technology transfer. Some academic institutions now give credit toward tenure for entrepreneurial and commercialization activities. These incentives along with recognition and royalty sharing to the inventors, and their research programs, are effective ways to encourage faculty to engage in commercialization. **Federal policy should recognize and support these strategies.**

Challenge #5—Creating porous boundaries and effective boundary spanning strategies between universities and industry for their mutual benefit. Strategies of effective university-industry interaction and collaboration include:

- A. **Establishing flexible organizational structures that foster industry university collaboration such as university-related research foundations.** Private non-profit research foundations have been established at universities for a wide variety of reasons many of which touch on technology transfer. Such organizations typically allow decisions to be made with greater flexibility and on an accelerated industry friendly time frame. They also allow standard corporate contractual provisions, such as indemnities. They typically allow for hiring of personnel independent of university human resource policies. Foundations often hold equity in university start-up companies, which is problematic for public universities in states with constitutions that preclude state ownership of private companies. Thus, while foundations vary significantly, they provide the mechanisms to assist corporations that often do not understand how to enter or navigate inside academic institutions. Moreover, many academic institutions are not structured to interact with corporations other than attracting corporate donations and sponsored research. It may be appropriate for university legal offices to act more like a business legal office, if not deferring to a university-related research foundation, to provide the contract administration and related legal services. Some institutions have instituted corporate liaison offices as a single-point-of-contact that assist corporations navigate the relationships. It also sends a message to the corporate community that the institution is open to doing business and is “private-sector friendly”.
- B. **Securing the services of industry experienced professionals in university research administration, technology transfer, and outreach positions.** Many institutions of higher education are finding improved innovation effectiveness by hiring senior level professionals in their technology licensing and outreach positions that have successful industry experience or significant understanding and appreciation for the same and who are attuned to the nature and perspectives of the academic community. Universities need to better understand the value to companies of both technology and talent creation that results from collaboration. The Federal Government would be well-served to encourage universities through grant making to engage innovation professionals with extensive senior level industry experience.
- C. **Identifying and connecting with industry partners that have: 1) an appreciation for universities and their nature, 2) flexibility in contracting to accommodate university limitations or core characteristics; and 3) sufficient expertise, culture, capital, and commitment to support innovation and technology commercialization originating from academic institutions.**
 - i. **Corporate culture influences the extent to which corporate researchers engage with university researchers.** Corporations differ considerably regarding their interaction with external research organizations. Just as some universities view corporations as adversarial in forming research alliances, some corporations also view universities as adversarial in negotiating licensing agreements. It is essential that corporations have leaders, who understand and practice the innovation imperative. Corporate and university representatives participating in University Industry Demonstration Partnership (UIDP) workshops voiced an emerging trend among industry to work with fewer universities, primarily to reduce transaction costs and relationship development efforts. By doing so, corporations could miss commercialization opportunities from potentially valuable research being conducted at smaller institutions or from those outside of selected geographical areas.
 - ii. **Corporate identification of university intellectual property** involves a wide range of activities from internal or contracted ferreting to

personal relationships between researchers. Many universities also have established web-accessible databases populated with available technologies and there are emerging national databases that now combine individual university web databases. Marketing outreach by university technology transfer offices to match their intellectual property with known industry needs in an open innovation mode is growing in effectiveness.

- iii. **Personal relationships between researchers may still be the best source for technology transfer and commercialization.** While there are many ways for companies to identify relevant university research, many believe that no method substitutes for personal interaction. Faculty research professionals, who meet at conferences and through less formal channels, provide a natural conduit for technology transfer and commercialization.
 - iv. **University and corporate expectations frequently differ as to speed of research and development as well as the university researchers' right-to-publish.** Corporations seek accelerated commercialization and intellectual property protection, while universities focus on teaching and knowledge dissemination. Effective partnerships respect the differences and balance the inherent conflicts.
 - v. **Small businesses often encounter additional barriers in accessing university and Federal laboratory research.** Except for entrepreneurs, who are recent alumni or who have other personal connections with the university, startups and small firms often have difficulties accessing research at major universities, and even more difficulty accessing Federal laboratory research due to the costs of relationship development and costs of access. Consortia that allow graduated fees according to size are but one method that facilitates greater access to researchers by small businesses.
- D. **Corporations, universities, and other research institutions can benefit by engaging in asset sharing programs.** Value creation is based on strategic and creative use of assets available to an organization. Such assets may include human capital (leadership, technical, administrative), information sources (libraries), intellectual property (know-how, patents, copyrights, trademarks,) equipment, and facilities, among others. As corporations continue to become leaner and focus on core capabilities, academic and other research institutions are expected to increasingly perform corporate functions.
- E. **Corporate open innovation and limited open innovation.** Corporations are performing less internal R&D and increasingly sourcing innovations from outside their organization. Some are engaging in open innovation, while others are sourcing technology and expertise among a few strategically-selected partners. Corporations and innovation organizations including higher education institutions, hospitals, and others need to consider policies, programs, procedures, and organizational structures to maximize the societal benefit from open sourcing.
- F. **Enhancing corporate ability to identify and exploit growing intellectual property portfolios.** With growing intellectual property portfolios in industry, academic institutions, research organizations, and government, there is a corresponding increase in potential or existing intellectual property that has not yet been recognized or fully exploited. Some contract research organizations in the United Kingdom have been successful in commercializing innovations that are not central to the core contracted research, and they have negotiated the right-to-own and commercialize those tertiary innovations. Strategies need to be developed in the United States that more effectively identify untapped and latent innovations.
- G. **Manufacturers may not be benefitting from commercialization activities to the extent that other types of corporations benefit.** Advancing U.S. manufacturing involves incorporating the most advanced innovations and processes to be able to compete internationally. Yet manufacturers do not appear to have the same types of partnerships and interaction with academic institutions, particularly research universities. Federal programs such as the National Institute for Standards and Technology Manufacturing Extension Partnership (MEP) have focused on "the fundamentals" and are just beginning to recognize the value of technology transfer activities.

- H. **Appropriate roles for inventors in commercialization need to be established on each specific situation.** University inventors often want to play a significant role in the commercialization of their innovations. When the innovation is used to form a start-up company, the inventor may want to become the business leader or CEO, and when the inventions are licensed, the inventor often wants to play a consulting role in adapting their inventions for commercial use. But faculty inventor's often do not have the skills to be strong entrepreneurs and business leaders and, from a business commercialization standpoint, the inventor's continuing presence may not always be preferable. Further, from the stand point of an investor in a start-up, the innovator's role as CEO often is generally not advisable. Universities need to be sensitive to corporate expectations in setting up commercialization strategies relative to the roles for inventors in start-ups and licensing arrangements.
- I. A typical university receives less than 15% of its research funding from industry. Yet the innovation rewards of university-industry research are often significant. **Federal financial support for industry sponsored research would pay significant economic development and innovation dividends.** We also find that industries are increasingly entering into research agreements with universities outside of the United States. **A National Academies report cited ease of collaboration and access to faculty expertise as two reasons for increasing partnerships with international institutions over domestic institutions.** The cost and transfer of intellectual property rights are other reasons that U.S. companies frequently sponsor research at international institutions. **U.S. universities need to become the preferred providers based on their specific value proposition.** Domestic institutions, with government facilitation, need to have research and innovation services of sufficient quality to earn preferred provider status. Recently five international technology transfer groups including the Association of University Technology Managers (AUTM), based in the United States, formed the Alliance for Technology Transfer Professionals to professionalize and promote technology and knowledge transfer on a global basis. Through the alliance, internationally recognized standards and practices may help level the playing field.
- J. **Universal "master" agreements may encourage corporate engagement in university research and commercialization.** Several universities and university systems are implementing broad research agreements, and implementing simpler, standardized agreements to expedite commercialization, reduce inconsistencies, and increase clarity and transparency. There are, however, no guarantees that industry will accept such efforts. The University Industry Demonstration Partnership (UIDP) "TurboNegotiator" platform is a tool intended to reduce time and improve consistencies.
- K. **Fair value market pricing for university research services.** Universities price their industrial research services on a cost reimbursable basis that charges for the actual time of those working directly on projects, other direct costs, and an overhead (indirect cost) component for facilities and administration cost recovery. This pricing method is a carryover from Federal grants. The method may restrict the university's flexibility to price services in a way that provides fair compensation for intellectual property that may have value unrelated to the actual cost of the research. The practice causes universities to later seek the value of the intellectual property through licenses, the uncertainty of which is problematic for the industrial partner. Universities and industry should consider fair-market-value pricing of research rather than cost reimbursable methodology as an additional mechanism for flexible university industry collaboration.
- L. **Student and faculty development**
- i. University-industry collaborations provides important **experiential and cross learning opportunities** for students and post-docs that should be encouraged. **Professors should be encouraged to obtain industry experience to assist in the collaborations and in teaching the value of university-industry collaborations.**
 - ii. **Graduate science and engineering students should be trained as more than just future university faculty** since only approximately 10% of post-docs become university faculty. Students can learn how to be effective industrial scientists or entrepreneurs in graduate school particularly as they interact with private industry during their graduate

- studies. **More internship programs at the graduate level should be encouraged and incentivized.**
- iii. **Personnel exchanges and internships remain some of the strongest relationship building tools that mutually benefit research institutions and corporations.** Experiential learning through personnel exchange programs, internships, and other forms are key knowledge and technology transfer tools. Internships in startups and venture capital companies, and exchange programs between industries, universities, Federal laboratories, and research institutions, particularly in cross-discipline areas, are building blocks for accelerated commercialization of research institution innovations. Such experiences also help to fiscally support the future work force and help to minimize the student's loan debt.
 - iv. Universities can provide a **primer for faculty on understanding how to work with the private sector.** Universities can provide support for faculty collaboration with industry by encouraging faculty to make disclosures, training faculty to work with industry and encouraging industry-funded research. Universities should **consider tenure criteria** that reward industrial outreach and technology commercialization. Universities should provide **mentoring for principal investigators (PIs)** services by connecting experienced entrepreneurial PIs with inexperienced PIs.
 - v. **Many future entrepreneurs come from medicine, science, and engineering.** Thus, it is important that **entrepreneurship education**—classes, boot camps, business plan competitions, etc.—are **directed to these groups.** In addition, entrepreneurship education to students in community colleges and in the primary and secondary education programs will stimulate interest for future entrepreneurial opportunities.
- M. **Universities can facilitate the optimization of university-industry collaboration and commercialization by considering alternatives to traditional royalty agreements.** What works for one industry or university might not work for another, so flexibility is critical. **Universities should consider when appropriate, the “Fair Return Inquiry” model** wherein the university and the potential corporate partner collaboratively seek out and determine what should be a fair return to the university, if there is a successful commercialization of the intellectual property. Such a model may lead to more philanthropy and may shorten negotiation times significantly.
 - N. Universities can improve relationships with industry by pursuing **strategic on-going partnerships rather than transaction-based interactions.** Both must work on developing mutual trust and improving points of entry to the university to increase access to faculty and technology transfer offices.
 - O. Universities should **consider a buyout of faculty time to devote to outreach and innovation** when appropriate and as resources permit. Also, **leaves-of-absence may provide needed flexibility for researchers to accelerate promising commercial inventions and spawn start-ups;** however, leaves-of-absence can also sap some of the “best and brightest” researchers from teaching and other research-related duties. Thus, academic communities, Federal laboratories, and other research institutions should carefully consider and encourage, where appropriate, leave-of-absence programs.
 - P. **Metrics that capture the value of innovation, technology transfer, commercialization, and entrepreneurial activities are needed** to better understand and support effective tools and methods. Without effective metrics, it is difficult to “make the case” for funding and for selecting as well as replicating best practices. Several organizations such as the Association of Public and Land-grant Universities (APLU), are currently working on developing metrics. The Federal Government should consider sponsoring the development of metrics.
 - Q. **Innovation is increasingly multi-disciplinary and characterized by everexpanding, inter-connecting fields.** A couple of decades ago, few would have predicted the intersection between biology and computer science (bioinformatics). Fields that were once distinct are rapidly becoming integrated. Yet Federal funding has been slow to address the ever evolving face-of-research. Federal funding should effectively address and promote multi-disciplinary approaches to innovation and commercialization. At The Univer-

sity of Akron, a new Integrated BioSciences Program at the graduate level has proved particularly effective at driving cross disciplinary collaboration.

- R. **Forming start-ups, based on university innovations, requires a different set of tools than licensing innovations.** Forming startups requires entrepreneurial and business development expertise in addition to traditional patenting and licensing knowledge. Many technology transfer offices (TTOs) at academic institutions are not prepared to handle the formation of startups. For those academic institutions that have centers of entrepreneurship, TTOs may refer innovators to the centers, but too often TTOs and entrepreneurship centers operate in different departments and do not effectively coordinate. This is also true for TTO coordination with university incubators and research parks. **Where senior level individuals with business experience are part of the TTO organization, start-up support is significantly improved.**
- S. **The role of entrepreneurial infrastructure and services.** Most major research institutions have at least an affiliated incubator, and larger institutions often have research parks. While the presence of the physical infrastructure itself sends a message that the institution and community are serious about growing entrepreneurs, the physical assets are only as good as the services that they provide. Such services include validating and assessing technology, providing access to investment capital, business strategy and development assistance, mentoring, interim CEO services, networking including exposure to potential partners and customers, among others.
- T. **Both universities and industry should minimize the inconsistencies and ambiguities that hinder relationships.** In the case of universities, changing administrations, where perhaps one president has emphasized pro-business relationships—the next may say such business relationships are not important, can hamper the development of long-term university-industry partnerships. Thus, there exists a need to embed pro-business relations within the university strategy and culture. In the case of industry, corporate policy and structures often change including strategies to interact with universities, creating a similar need to embed pro-university relations within the corporate culture.
- U. Small-businesses have less capacity to sustain the transaction costs of working with universities. Thus, efforts to **level the playing field by reducing university-related transaction costs to small businesses** would enhance the innovation system. Some university equity participation in the small business may be considered.
- V. Systemic appreciation for the societal value of university-industry collaboration includes improved education of all students regarding the roles of innovation, entrepreneurship, and intellectual capital. **Universities should consider required courses** at both the graduate and undergraduate levels **with selected innovation-related modules, such as creative thinking, innovation, entrepreneurship, intangible asset management, and academic-industry collaboration, among others.**
- W. **Alumni offer a tremendous untapped resource.** Some universities have tapped alumni to serve on business advisory boards, participate in business competition panels, invest in university-based start-ups, act as CEOs-in-residence, and entrepreneurial mentors. These activities should be expanded and encouraged.

Challenge #6—Available and appropriate capital for the commercialization of university research results remains a continuing challenge, particularly through the “valley-of-death” portion of the research to commercialization continuum. The Small Business Innovation Research (SBIR) and the Small Business Technology Transfer (STTR) programs are effective and valuable, yet insufficient relative to demand and scope, in providing funding for commercialization of R&D in emerging areas. The SBIR/STTR programs are extremely important vehicles for commercializing innovations arising from research at universities and other institutions. While “commercialization” has been an increasing emphasis in the program, there have been only modest legislative changes to support actual commercialization activities. SBIR/STTR awardees are restricted in their use of funds for marketing studies, export analyses, etc. Some agencies including the Department of Defense (DoD), the National Science Foundation (NSF), and the Department of Commerce (DoC) have embarked on additional, but limited, commercialization assistance. State programs also provide assistance to SBIR applicants and gap-funding.

There are several effective models emerging in various regions of the United States. In our northeastern Ohio area, we have found success with:

- A. The UARF's angel capital network, where the costs of our hosting the events over five years was approximately \$50,000, has resulted in follow-on funding in the presenting enterprises in excess of \$55 million;
- B. The Lorain County Community College Innovation Fund, which uses donations, supplemented with state funds, to award grants of \$25,000 and \$100,000 to emerging companies; and
- C. The student run venture fund being formed at the University of Akron that will invest donations received in companies selected by the students. The fund is considered an evergreen fund as returns go back to the fund for future investments.

Acceleration funds within academic institutions provide a promising commercialization tool. There are a number of successful programs (MIT, USC, Georgia Tech) designed to accelerate university research to market, mainly through seed funding and extensive mentoring. Linkages with institutional and external resources—(such as high-functioning incubators) that take emerging technologies to the next levels of commercialization—provide an even greater chance of success.

Challenge #7—The need for government to establish and maintain business friendly policies and to sponsor programs that enable private sector commercialization of intellectual assets.

The United States government plays a significant role in the nurturing of academic innovation. The priorities for the U.S. government related to university innovation should be:

- A. **To promote innovation and competitiveness as a critical national priority and to promote the essential and recognized roles of universities and industry in the same.**
- B. **To provide strong and sustained Federal basic and applied research funding.** Research that is not market driven does produce unanticipated beneficial discoveries. Nevertheless, merely increasing basic research funding will not necessarily result in greater economic development unless there is follow-on funding for translational research.
- C. **To have a strong patent system** that rewards novel inventions and protects against patents that lack novelty or otherwise stifle innovation. Also, encourage discussion on a potentially improved patent system that rewards early disclosure as a means of accelerating and reducing the cost of innovation.
 - i. The current patent reform efforts are appreciated and needed. However, to further accelerate innovation, the **Government** should with economists, inventors, innovators and industrialists, **consider an improved intellectual property system appropriate for the 21st century** that fosters the public good **with more immediate disclosure of inventions.**
 - a) As an example, consider a patent system that rewards immediate disclosure of inventions on-line, which publication also serves as the equivalent of patent filing for determination of patent priority if the law becomes "first-to-file." Such efforts would reduce initial research and development costs by reducing duplication of efforts as well as increase and accelerate innovation. It would cause some pause in the inventor community which seeks to maintain developments confidential as long as possible for competitive purposes. The balance should be reconsidered in light of current technology that makes information instantaneously available worldwide and the need to accelerate innovation.
 - ii. A related option is to **transform the patent system** so that it functions not only as a means to obtain proprietary protection but also serves as **an on-line idea management system.** Increasingly, organizations and countries will compete based on the speed at which they can discover, develop and implement ideas for new products and services. To compete at this level, organizations must efficiently tap into the creativity of all sources. They must also be adept at focusing employees' creative energies around key societal and business issues, gathering and evaluating ideas efficiently, and quickly identifying those with the greatest bottom-line potential for implementation. **Idea management technology is an emerging type of software that** enables enterprises to solicit tar-

geted ideas from multiple groups, such as employees, gather ideas into a centralized online database, share ideas to foster further ideation and innovation and to provide structured processes for evaluating ideas for enterprise and societal impact potential. As innovation grows in importance as a competitive advantage, idea management systems are poised to become a catalyst that can help countries and companies compete at levels never before possible.

- D. **A corollary to the idea management system is to have a central location for data collection, best practices, testing, and exchange of ideas in innovation and entrepreneurship.** There is currently no one Federal agency or department that is responsible for policies and programs on innovation and entrepreneurship. The recently established Department of Commerce (DOC) Office of Innovation and Entrepreneurship is a start but lacks funding to pursue many key functions—data collection; cross-agency coordination; identification, analysis, and replication of best practices; testing of promising innovation pilots, *et cetera*.
- E. The Bayh-Dole Act, which allows university ownership of the inventions resulting from federally-funded research, has contributed to the formation of some of the nation's top technology firms. The United States government should **continue the policy of grantee ownership and control of intellectual property, funded by the Federal Government.** The Bayh-Dole Act is sound in principle as it aligns commercialization incentive and control in the institutions that create the inventions. It is problematic to separate equitable ownership interests in technology commercialization with the control of the technology.
- F. **Establish financial rewards and funding for experimental and pilot programs such as regional proof-of-concept centers, innovation centers, and multiinstitutional innovation services providers.** Not all universities have the resources nor sufficient research, technology, and related expertise to sustain an innovation services team. Also, such funding would allow for experimentation of specialized teams focused on specific technology or market areas, such as advanced materials, energy or medicine. **The University of Akron, as a midsize state university, could be an excellent case study for Federal assistance for a regional technology transfer office,** noting that each such office would have its unique set of challenges and resources, its unique regional economy, and its unique expectations for results by state and local investors and sponsors. Best practices are dependent on these local considerations.
- G. **There are effective Federal programs that support university-industry collaborative research, and technology transfer and commercialization.** Programs such as the Technology Innovation Program (TIP) at the National Institute of Standards and Technology (NIST) promote not only university-industry collaboration but also multi-institutional, inter-disciplinary R&D and commercialization. The Industry/University Cooperative Research Center (IUCRC) program at NSF is a successful, long-standing program that focuses on the development and commercialization of university-industry R&D with the provision that the industry must provide major support to the center at all times. However, these programs are limited and under-funded. Some new programs, such as Advanced Research Projects Agency-Energy, (ARPA-E) at the Department of Energy (DoE), also have the potential of promoting successful multi-institutional, university-industry collaboration. **Continuation and expansion of effective programs, particularly for technology as it progresses through the valley-of-death including SBIR, STTR, and TIP, are appropriate.**
- H. **Tax incentives, such as the corporate research and development (R&D) tax credit, may encourage corporations to invest in R&D and also may encourage them to invest in adaptive research to commercialize innovations from research institutions.** Since R&D expenditures in many corporations have been declining, and since the cost of adapting innovations stemming from research institutions can be high, the use of tax incentives to promote the full range of research may be increasingly significant. In addition tax credits could be considered for intellectual property investment, capital formation, and industry funding of university research. Also, the Tax Reform Act of 1986 limits industry-sponsored research in university facilities financed by tax-exempt bonds, thus hindering university-industry partnerships. As the tax provision does not generate revenue, reform would not reduce tax revenues.

- I. **Develop sustainable programs to assess nascent university and Federal laboratory technology and make it presentable and easily understood by investors and entrepreneurs.**
 - J. **International Traffic in Arms Regulations (ITAR) and visa reform** could ensure that inappropriate items are not on the ITAR list and would ensure that innovators are allowed entry into the United States.
 - K. **The Federal Government should establish conflict of interest policies and support state and university conflict of interest policies that permit, rather than prohibit, conflicts to the extent they foster innovation and provided the conflicts are managed to eliminate one's influence over a public asset for one's personal gain.**
 - L. The government should support efforts to **identify and disseminate metrics and best practices related to university-affiliated innovation.**
 - M. **Consider better coordination and synergy between Federal agency programs and universities.** As there are reportedly 260 Federal programs related to economic development, an increase in awareness and coordination of programs should improve effectiveness. Federal programs that address commercialization, university-industry collaboration, and innovation-related areas, are spread across multiple agencies including NSF, DoE, DoD, DC, SBA, and others. These programs historically have not been well coordinated within agencies or between agencies leading to less-the-optimal leveraging. Some programs are duplicative and, at the same time, there are gaps between programs.
 - N. **As most states have programs to promote innovation and entrepreneurship, including university-industry collaboration and technology commercialization, the government should consider awards to effective state and university innovation models.** States have a wide range of programs aimed at leveraging university and other research institutions' R&D for economic development. These programs involve investments in university research, university-industry collaborative projects, entrepreneurship, infrastructure (incubators, research parks), SBIR assistance, mentoring, etc. Many of these programs have been effective in supporting the commercialization of university technologies and spawning start-ups. Because of the economic crisis, some long-standing successful programs may be threatened. States have a wide range of programs that support commercialization and entrepreneurship. **Federal programs should be aligned in a manner that is supportive of state efforts and that effectively leverage state programs.**
- 3) **Are there unique challenges faced by mid-sized universities such as ours in the commercialization of federally funded research?**

Yes in addition to the challenges enumerated above that are generally common to all institutions of higher education, there are unique challenges faced by mid-sized universities.

Challenge #1—With a few exceptions, such as the University of Akron, many mid-sized universities often lack the economies-of-scale and thus the expertise in technology transfer, university-industry collaborations, and new enterprise developments, that allow them to be effective as true engines of innovation. Contrast that with larger universities that likely have sufficient research size to merit a qualified and effective team of innovation service providers, yet may not have the experience and the necessary wherewithal for effective innovation. **To overcome the barriers related to inter-institution relationships, the Federal Government should consider rewards for multi-institutional innovation support teams.** Such would encourage new models that otherwise may not be pursued and would improve the return on the investments, as well as link local communities. There are many possible mid-sized state universities capable of being a true economic hub for populated urban regions.

Challenge #2—A related challenge is that of being ineligible for selected Federal programs because an institution is not a prior award winner. As an example, the NSF Partnership for Innovation program required any new applying universities to co-apply with prior award winners, which effectively precluded many universities from proposing although otherwise meritorious. This seems contrary to the principle of rewarding innovation based on merit.

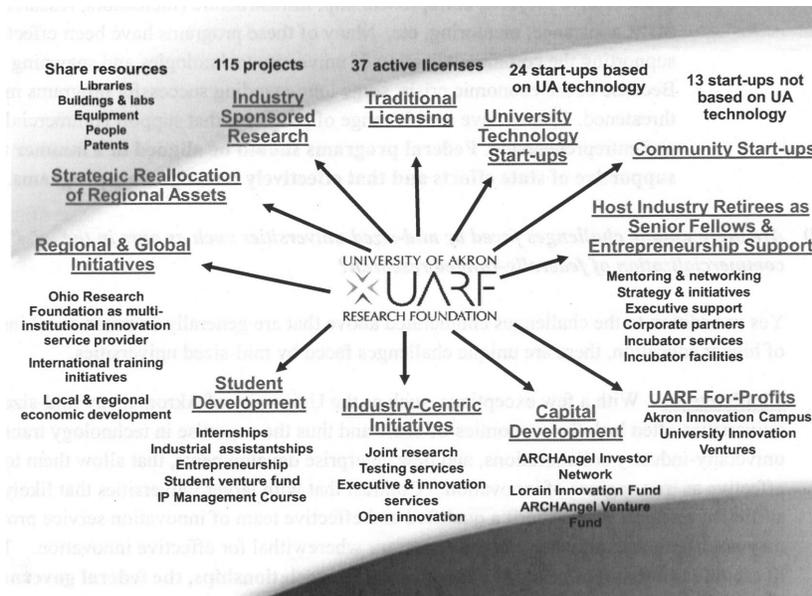
4) University of Akron Specific Questions:

a. Are there best practices or policies implemented by the University of Akron that could serve as a model for other universities interested in increasing the commercialization of federally funded research?

b. Specifically what is the role of the University of Akron Research Foundation?

c. How is The University of Akron engaged in local, state and regional innovation initiatives?

Most universities focus their innovation efforts on technology transfer and industry sponsored research. The University of Akron has developed strong programs in both technology transfer and industry sponsored research, however The University of Akron has adopted a more robust model that provides significantly more innovation related services and programs as a part of the university's strategic plan.



The University of Akron adopted several **practices and policies that could serve as a model for other universities** seeking to increase their commercialization effectiveness and in building regional innovation capacity. As best practices and policies are usually situation specific, each institution needs to consider and respond to its own regional circumstances, since as the communities grow, so does the wealth creation to that community. Nevertheless, many of the University of Akron practices are transferable. The coordinated University of Akron and University of Akron Research Foundation (UARF) model has been particularly successful for supporting innovation in the northeastern Ohio region of ca. four million residents and 80,000 companies with employees. UARF was formed as a boundary spanning structure for industry and the university.

UARF's characteristics and strategies, which could be considered *best practices include:*

Best Practice #1—Carefully assess university and community resources and periodically consider how such resources could be used, reconfigured and reallocated for mutual benefit.

- A. **Libraries**—Several regional companies donated their library holdings to The University of Akron, thus increasing university holdings—a positive for academic metrics. In most cases, the books remained at the corporate facilities. The University assumed management of the libraries and provided library services to the companies for fees, which resulted in overall cost reductions and improved services to the companies and a strong lasting repository for future researchers with the community.

- B. **Buildings and laboratories.** UARF occupies excess laboratory space at a regional corporate technology center to operate a chemical pilot plant facility for paying customers, who need occasional scale-up and pilot facilities. The landlord company also uses the pilot plant as payment for the facility and agreed to open up its unused office and lab space to emerging companies in return for equity. From their perspective, it provides a first look at the company for potential acquisition.
- C. **Equipment sharing—Companies donated equipment to the University of Akron which is available to the community after academic needs are met; all parties benefit as do future companies since it reduces start-up costs.**
- D. **UARF is developing people sharing and co-location programs so there is increased collaboration among academicians, students, and professionals from many unexpected areas.** We believe such a program is necessary to complete our portfolio of programs for long-term fiscal success. We wanted to have more industry scientists and engineers involved in the academic world and *vice versa*. We recently instituted a productive Visiting Scientist Program to complete some new technology development.
- E. **Patents and other intellectual property pooling—**In our discussions with industry, we also look for non-core intellectual property that UARF can either bundle with its intellectual property or otherwise assist in the exploitation.

Best Practice #2—Create an Appropriate Organization Structure. The State of Ohio does not allow public universities to hold equity in a private (start-up) business and until 2001, would not allow faculty to hold equity in their start-ups. Ohio would not allow technology transfer and research contracts to be made without university board of trustee approval and would not allow a contract with an indemnity clause wherein the university would indemnify the sponsor for the mistakes of the university. Thus, **a university-related research foundation was formed to facilitate university technology transfer, to administer industry contracts with the university, and to house our outreach efforts.** The new research leadership team formed in 2001 included Dr. George Newkome, Vice President for Research, Associate Vice President for Research Ken Preston and myself. Dr. Newkome and Mr. Preston came from the University of South Florida and I had recently arrived from Utah State University. All of us had been involved with university-related research foundations and knew of the benefits that would be achieved if we could successfully communicate the value to stakeholders. A research foundation provided us with a more entrepreneurial organization to respond to industry opportunities and needs. UARF is allowed to hold equity, provide indemnities to private research sponsors, and to enter into agreements under foreign jurisdictions. UARF was formed as a not-for-profit 501(c)(3), with a corporate charter to benefit the university. We invited board members, who had passion for the community and for driving the university's impact on economic competitiveness. The majority of the directors are not university personnel, thus increasing community trust and understanding. We chose directors that have a perspective of investing resources for an expected long-term benefit. UARF entered into an agreement with The University of Akron allowing UARF to participate and administer all of the University of Akron industry-sponsored research agreements as well as projects that a state university could not take. UARF essentially functions as the University's fiscal agent. UARF receives all funding, pays the direct costs to the university, allocates the facilities and administrative costs (indirect costs or F&A) portion to the university units as per policy, including the department, college, research offices and others, and keeps the balance to be used for the benefit of the University, as determined by UARF directors. UARF also acts as the fiscal agent on licensing agreements, receiving funds, and allocating them to stakeholders as per university policy, including the inventors, their research programs, the chairs and deans. The remaining amounts likewise are used for the future growth of The University of Akron's research related programs as determined by the UARF directors.

Best Practice #3—UARF's designation and hosting of outstanding industry retirees as UARF Senior Fellows and UARF Entrepreneurs-in-Residence, who, as volunteers assist the research foundation in establishing a culture of innovation within the university and span the boundaries between academia and industry. While UARF provides them modest preapproved expenses, the Senior Fellows are not employees of either the University or UARF. As such, they are eligible to receive compensation from emerging enterprises, including equity. They have become drivers of entrepreneurship within UARF and with industry collaborators in the Akron community.

We were fortunate to initially find two kindred spirits in Barry Rosenbaum and Gordon Schorr, who were completing their industry careers and were willing to invest their time, talents, and network in fostering innovation, particularly at that critical and fragile interface of industry and academia. They, in turn, have recruited additional experienced, like-minded individuals to join their team. These talented people appreciate and are being educated on academic culture while helping the academy learn to better interface with industry. **UARF provides them with a title, a computer, a telephone, an email address, some expense money and the unfettered opportunity to be connected to emerging enterprises,** where they can negotiate equity positions without the conflicts of interest inherent with those who are employees of The University of Akron or its research foundation. They do not receive a salary from The University of Akron or UARF. The majority of their efforts are provided pro bono. They do, however, underwrite some of their efforts with innovation services contracts with Fortune 500 companies. We turned this well qualified group loose with our full support. They became responsible for:

- A. Providing assessment, innovation, and ideation services to regional companies
- B. Being the primary drivers and interim executives for several spin-off companies
- C. Advising start-ups
- D. Providing on-site innovation services for innovation campus tenants.
- E. Linking faculty expertise and programs with regional companies
- F. Pursuing an early stage pre-seed investment fund
- G. Identifying, developing, and securing a multi-million dollar sponsored program for The University of Akron.

As free agent entrepreneurs, the volunteers are free to explore the environment as appropriate.

In addition to senior fellows, we have entrepreneurs-in-residence, one of whom is also a part-time employee of the chamber of commerce. This shared personnel mechanism improves the cooperation with the local chamber of commerce. The entrepreneurs-in-residence also support the senior fellows with the opportunities emerging at private sector—university interface.

Currently UARF receives donated time and effort from the senior executives in excess of five full-time equivalents.

The senior fellows formed and now lead with UARF's sponsorship, the successful ARCHAngels Investor Network, which consists of approximately 500 members and meets quarterly to consider investments in pre-qualified companies. Over half of the 55 companies presented have received subsequent investment funding and the culture of entrepreneurship in the Akron community has risen significantly. *See Infra.* p 26 Best Practice #14.

Open innovation. Our senior fellows conceptualized and implemented with UARF support, open innovation seminars for regional companies to assist the area's traditional manufacturing companies in the development of business opportunities. We now see a major trend to finding ideas and inventions from any source possible. As universities, we need to determine how we fit in and facilitate increased interactive and collaborative innovation. We have approximately 100 business leaders, policy makers and innovators, who meet to discuss and practice open innovation annually.

Best Practice #4—Promote innovation internal to the university with innovation teams made up of university personnel and UARF Senior Fellows.

The teams meet with colleges and departments to introduce research services, technology commercialization, and university outreach. UARF celebrates innovation success by having created an Inventors Wall of Fame, by financial sharing of license revenues with inventors, and by hosting social networking receptions. The quarterly meetings build trust and camaraderie and are a way of educating our inventor community of opportunities to contribute to our industrial base. In addition, research showcase events are hosted as are ideation sessions with faculty on research and development topics specific to the faculty, including potential industrial collaborations. Interdisciplinary research and project specific teams are formed at both the faculty and student level.

Best Practice #5—Provide innovation services external to the university.

University personnel and UARF Senior Fellows teams provide a range of innovation services to enterprises including large, medium, small, and start-up companies:

- A. Technology validation,
- B. Technology and commercialization advisory boards,
- C. Products and services ideation and market opportunity assessments,
- D. Business formation services and bookkeeping,
- E. Shared office space, equipment and personnel,
- F. Intellectual property procurement and management services including confidentiality agreements, patent procurement, freedom to operate assessments, licensing services, among others,
- G. Leadership mentoring interim CEO services, and linking to internship and student support teams,
- H. Formation and hosting of an angel capital network Akron Regional Change Angels (ARCHAngels) in support of emerging enterprise capital development and formation of a student led venture fund.

Best Practice #6—Build the infrastructure and trust necessary for an effective licensing and technology commercialization program.

A first step was to update the university's intellectual property-related policies. We made several modifications the most significant of which were the designating of the research foundation as the fiscal agent for licensing and the revising of the royalty sharing. After patent costs are reimbursed, 40% goes to the inventors and 10% to their research programs.

Thus, as we like to say, 50% is of direct benefit to the inventors. The remaining 50% is shared with the department, college, and UARF for long-term fiscal viability.

We experienced substantial growth in disclosures and patent applications as well as significant royalty revenue growth. We spent considerable time with faculty inventors in order to fully understand the technology opportunity and then developing an appropriate commercialization strategy. As a result, we have 61 technologies now either licensed or optioned to license.

Best Practice #7—Increase research funding and specifically industry-driven research. We approached companies to seek a comprehensive understanding of their specific challenges and opportunities. UARF representatives would declare: *"We have an assignment for you. Give us a challenge! What can we do to help make you more successful?"* One company was interested in having experts help them source and exploit emerging technology. We formed a team of UARF experts, primarily from retired industry personnel, to provide such innovation services. The R&D managers of the company now have their annual meeting at The University of Akron and we report to them on our innovation service efforts and we learn about their unique challenges and opportunities. Our team meets periodically with them at their various world-wide locations. The effort resulted in the formation of a joint venture start-up company to develop a new product, which was conceived in the process. The model provides for UARF to receive funds from sponsors with the services performed by university personnel. We experienced overall research funding increases. There are 115 active industry sponsored research agreements and the number is increasing. The key to the growth seems to be the careful understanding and the thoughtful consideration of the challenges and needs of the sponsors.

Best Practice #8—Identify and adapt excess office and lab space for use by emerging enterprises—We had noticed a "for lease" sign on two four story buildings adjacent to campus, in an area targeted by The University of Akron and the City of Akron for revitalization. We approached the owners and within a year, purchased the properties forming the nucleus of the Akron Innovation Campus, where we now have 18 tenants, house our UARF outreach efforts, and use the remainder of the space for several of our supported emerging companies. We charge competitive rates on standard leases, although on occasion we have provided space to emerging enterprises in exchange for equity. It created a location for university related innovation activity and the real estate becomes a nice visual promotion vehicle for our efforts within our community.

Best Practice #9—Support the formation of new enterprises including university-based start-ups. Overall, we have formed or supported the formation of 35 companies. Of those supported, not all are licensees of University of Akron technology and not all are spin-outs by AUTM's definition. Some were formed to facilitate access to SBIR and STTR funds. We formed one to demonstrate our commitment to action within 48 hours of our first in-person meeting with two international companies that wanted to form a joint venture with a visible U.S. presence. We also had an interim management group designated.

For Akron Polymer Systems Inc., we formed a university/faculty spin-off company to manufacture a compound already licensed to an end-user, who needed product. We had the scientific expertise in the faculty inventor and his graduate students.

They are now a company of about 15 employees, many of whom are graduates of The University of Akron polymer program and importantly, are staying in the Akron area.

As another example of our outreach activity, we pursued licensing discussions with an out-of-state company, which led to the formation of an Ohio affiliate company to develop and exploit ceramic filtration technology. The move was not a requirement of the license, but the company saw value in the linkages and infrastructure that we had created at The University of Akron and moved to Akron.

Best Practice #10—Encouraging student development—UARF has made connections resulting in over 120 assistantships with local business. UARF has also provided scholarships to selected programs and is currently pursuing a student run seed capital fund as well as a women's angel network.

Best Practice #11—Regional alliances—Recently, we entered into agreements wherein UARF personnel are made available to provide technology transfer and innovation services to other regional institutions, which for a variety of reasons do not have the critical mass to have a full technology transfer and innovation services group. Thus, we provide technology transfer services as needed to Cleveland State University, Youngstown State University and Lorain County Community College. We are also in discussion with local hospitals and companies to assist them with technology transfer and intellectual property management services. We formed the **Ohio Research Foundation**, as a non-University of Akron focused entity, to provide innovation services to regional partners.

Best Practice #12—We have been successful in developing and **teaching intellectual property management courses** primarily to law students. We plan to expand it to the science, engineering, and business disciplines. We are now working with the National Council on Entrepreneurial Tech Transfer to teach webinars on technology commercialization.

Best Practice #13—We formed an innovation fund with our regional higher education partner, Lorain County Community College. The Innovation Fund provides capital to University of Akron spin-off and other emerging technology-based businesses. The Innovation Fund is supported by a network of higher education, government and economic development partners to nurture a technology-based entrepreneurial environment for wealth creation and job growth in Northeast Ohio. The Innovation Fund provides modest awards (up to \$100,000) to promising technology-based start-ups. Recipients of Innovation Fund awards are required to provide an entrepreneurial educational experience to students and faculty of the partnering higher education institutions. The Innovation Fund is financially supported by the State's Third Frontier Program as well as partner support and philanthropic contributions from corporations, foundations, and individuals. Contributions to the Innovation Fund are tax deductible, due in a great part to the requirement for recipients to provide an educational opportunity for students, so critical to the development of the next generation of leaders in the community. The inclusion of this requirement qualified the initiative for a landmark private letter ruling issued by IRS in 2006 that deemed the initiative as charitable and, therefore contributions are tax deductible.

Best Practice #14—The UARF Senior Fellows formed and provide the leadership for the ARCHAngel (Akron Regional CHange Angel) Investor Network, a regional forum for introducing angel investors to promising market-driven, technology-based, and investment seeking companies in Northeast Ohio. The network, formed in 2005, is sponsored by the University of Akron Research Foundation and focuses on companies that leverage the region's strengths in health care, information technologies, polymers and other advanced materials. The quarterly meetings introduce prescreened companies to network members who are in a position to make cash as well as sweat-equity investments. The 500 plus members of the ARCHAngels network provide wisdom, guidance, executive services, personal energy, and passion to the companies and to the entrepreneurial programs in the region. The network is building a vibrant culture of technology innovation in this historic manufacturing region. As many as 80 students from regional colleges and universities attend quarterly meetings as part of their courses in entrepreneurship and many students find mentors and student projects within the ARCHAngels initiative.

The ARCHAngels leadership team is represented by universities, enterprise accelerators and facilitators, local government, private companies, professional service providers, and investment partners. UARF's cost of hosting the ARCHAngel events over five years has been approximately \$50,000 and has preceded the subsequent investment in the presenting enterprises in excess of \$55 million. In a sense, it is a thousand-to-one return! **The country would be well-served if this model**

could be replicated and expanded across its many innovation and technology regions.

Best Practice #15—Constant reinventing and seeking new areas for innovation capacity development is a best practice. As an example, we believe that **an emerging best practice will be that of cooperative innovation support teams among institutions of higher education and national laboratories.** The University of Akron and UARF personnel recently met with national lab representatives regarding emerging technologies. We recognize that such relationships have significant innovation potential. We look forward to the next chapters!

- 5) Do you believe the National Science Foundation (NSF) has a role to play in the “innovation ecosystem,” beyond its traditional role of supporting basic research? If so, what is that role? What changes or recommendations, if any, do you have regarding NSF’s portfolio of technology transfer and university-industry collaboration related programs?
- A. The National Science Foundation could play more of a role in “translational” activities provided resources are in addition to, and not diverted from, existing NSF programs. NSF would need to develop a new type of review system specific to translational proposals as the current peer review system and peer reviewers are not appropriate to make determinations about whether a particular discovery has commercial potential. The NSF should not get into “translational” activities merely by adding some type of new regulatory requirement onto existing grants mechanisms. **NSF should consider regional proof-of-concept centers and should reward effective and innovative model regional research and commercialization centers. NSF should not prescribe the model, but rather allow regions to experiment with models that best suit their needs and their environment and that leverage existing community and state programs. The key is to not simply give more money to the large universities but rather to create a network of universities that are regional hubs for job and wealth creation. Adding more money to the rich will be less effective in enhancing the innovation capacity of a region than an investment in a regional network that includes proven innovation service providers. We would also recommend that NSF support education and research on the overall topics of innovation and entrepreneurship.**
 - B. The NSF Grant Opportunities for Academic Liaison with Industry (GOALI) promotes university-industry partnerships by making project funds or fellowships/traineeships available to support an eclectic mix of industry-university linkages. Special interest is focused on affording the opportunity for faculty, postdoctoral fellows, and students to conduct research and gain experience in an industrial setting. Industrial scientists and engineers bring industry’s perspective and integrative skills to academe and interdisciplinary university-industry teams to conduct research projects. GOALI seeks to fund transformative research that lies beyond that which industry would normally fund. **It is of value and should be fully supported and expanded.**
 - C. The Industry & University Cooperative Research Program (I/UCRC) is also **of value.** Centers are established to conduct research that is of interest to both the industry and the university with which it is involved, with the provision that the industry partner must provide major support to the center at all times. The centers rely primarily on the involvement of graduate students in their research projects, thus developing students, who are knowledgeable in industrially relevant research.
 - D. **The NSF SBIR/STTR Program also is of high value to the innovation ecosystem and merits increased funding.** The NSF Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs support high-quality projects on important scientific, engineering, or science/engineering education problems and opportunities that could lead to significant commercial and public benefit, if the research is successful. In order to make the SBIR/STTR programs more effective, **an increased portion of funding should be available to awardees to purchase commercialization and business development services including, but not limited to, marketing, export development, and other critical elements needed to reach the market place.**

- E. The **Partnership for Innovation (PFI) program has been a success, particularly in breaking down barriers.** PFI promotes innovation by bringing together colleges and universities, state and local governments, private sector firms, and nonprofit organizations. These organizations form partnerships that support innovation in their communities by developing the people, tools, and infrastructure needed to connect new scientific discoveries to practical uses.

The goals of the PFI program are to stimulate the transformation of knowledge created by the national research and education enterprise into innovations that create new wealth, build strong local, regional, and national economies, as well as improve the national well-being; broaden the participation of all types of academic institutions and all citizens in NSF activities to more fully meet the broad workforce needs of the national innovation enterprise; and catalyze or enhance enabling infrastructure necessary to foster and sustain innovation in the long-term.

Current and any proposed NSF programs and initiatives should be wellcoordinated with related programs—in other agencies. These include current programs in the Department of Commerce such as NIST and EDA as well as the SBA and DOE programs. **These programs need to be reviewed and better aligned to ensure maximum leverage and efficiencies.**

We appreciate, Mr. Chairman, this opportunity to share our story and our perspective on university roles in our country's innovation ecosystem. Enabled and effective higher education research institutions will be major contributors to our well being and our economic security.

Thank you.

BIOGRAPHY FOR WAYNE H. WATKINS

Wayne H. Watkins serves as Associate Vice President for Research at The University of Akron and as Adjunct Professor and Intellectual Property Fellow at The University of Akron School of Law. He serves as Treasurer and directs the operations of the University of Akron Research Foundation, a regional innovation and wealth creation services organization. Mr. Watkins directs The University of Akron programs in intellectual property management, emerging enterprise creation and support, technology based economic development, and university-industry collaborations. Mr. Watkins is Immediate Past President of the University Economic Development Association, a national organization supporting universities in economic development and innovation. Prior to his roles at the University of Akron in Ohio, Mr. Watkins served as Director of the Research and Technology Park and the Office of Technology Commercialization at Utah State University in Logan, Utah. He has served as vice president and corporate counsel of a diversified business holding company and was the administrator of the Utah Innovation Center. He currently serves on several boards of directors of technology and foods related companies and served ten years as a member of the North Logan City Council. Mr. Watkins has taught courses in *Intellectual Property Management, Technology and Innovation, Business Policy, and Global Business*. Mr. Watkins has been a frequent presenter at symposia on intellectual property and innovation including seminars hosted by the World Intellectual Property Organization. Mr. Watkins has degrees in mechanical engineering (B.S.M.E.), business (M.B.A.), and law (J.D.).

Chairman LIPINSKI. Thank you, Mr. Watkins.
Mr. Crandell.

STATEMENTS OF KEITH L. CRANDELL, CO-FOUNDER AND MANAGING DIRECTOR, ARCH VENTURE PARTNERS

Mr. CRANDELL. Chairman Lipinski, Ranking Member Ehlers and Members of the Subcommittee, my name is Keith Crandell and I am Co-founder and Managing Director of ARCH Venture Partners, an independent seed and early-stage venture capital fund. I am especially pleased to be here today as a resident of Hinsdale, Illinois, testifying before my neighbor, Congressman Lipinski, who resides in nearby Western Springs. ARCH got our start, my partners and I, by being the managers of an innovative commercialization effort out of the University of Chicago and Argonne National Labs that

was spawned following the passage of the Bayh-Dole Act in the 1980s. My partners and I had, basically, the rights to the technology at the University of Chicago and Argonne put into this subsidiary of the University of Chicago, which was chartered to start new companies from the research there. We raised a small venture capital fund from financial investors of \$9 million, did 12 companies with that, ultimately took four public, sold four, wrote off four. The successes from that first fund include the EveryDay Mathematics Company, which is the number one math curriculum in the United States today, Nanophase Technologies, which *The Economist* lists as the first nanotechnology company, and then Aviron, which does the cold-adapted flu vaccine that is sprayed into the noses of children to vaccinate them against various diseases.

I am pleased to be here today to share with you some thoughts on how to improve the technology transfer of breakthrough ideas and technologies from our Nation's research institutions. Venture capital plays a critical role in the innovation lifecycle by identifying and investing in promising ideas, entrepreneurs and companies. Often these companies are formed from ideas and entrepreneurs doing work in universities, industry and government laboratories. Many would never see the light of day were it not for venture investment.

The historic impact on the U.S. economy, in terms of jobs created and innovation from venture capital investment, is significant. According to a 2009 study conducted by Global Insights, companies that were started with venture capital since 1970 accounted for 12.1 million jobs, or 11 percent of the private sector employment, and almost \$3 trillion in revenue in the United States in year 2008. Former venture-backed companies like FedEx, Genentech, Microsoft, Google and Apple were once small ideas tucked away in a lab or a living room, and that is where tomorrow's great innovations will be coming from.

Technology commercialization effectiveness differs greatly from one research institution to another, but there are three primary functions most technology transfer offices perform. The first is record keeping and compliance, and I think most universities can adequately carry out that function. The second is patenting and licensing. I think too often the staffs in the technology transfer offices do not have the resources necessary to gain full knowledge of how research can be translated into commercial applications for specific patents, and as a result, poorly drafted patent claims can result, in which case you can have a great innovation but a very narrow patent, and that stifles innovation.

Second, I think in the past ten years licensing agreement templates have been published, which simplify the licensing process quite a bit. However, these agreements still take too long to negotiate from a startup company's viewpoint. The startup cannot get to the real work of hiring management, product development and raising capital until it secures its license and knows its economic terms.

The third and most critical commercialization function is forming and spinning off startups based on those patented and licensed innovations. Unfortunately, this tends to be a particularly difficult and thankless task, since university tech transfer offices are too

often not given enough resources and skilled personnel needed to perform the job, nor are they recognized for the value they contribute to an organization that is designed first and foremost to serve faculty and students.

Successful new company formation requires three basic components to be brought together: leading researchers with breakthrough ideas, successful entrepreneurial managers and, lastly, experienced seed and early-stage investors. These interdisciplinary teams of scientists, managers and investors have been the hallmark of successful high-growth companies. Some areas like Silicon Valley have an abundance of all three components, but other regions that may have excellent research lack the other parts of the systems. In those regions where venture capital and entrepreneurial talent are scarce, a much heavier burden is placed on the commercialization staff to spin off companies.

There are several principles that define successful commercialization processes. I will briefly touch on these. There is more detail in my written testimony. The objective commercialization metrics are of critical importance. My sense is that counting things that are the easiest to count, such as visits or invention disclosures, are not particularly indicative of the success of commercialization efforts. I think those metrics should focus on things such as capital raised and jobs created. I think there needs to be an enhancement in the resources that are focused on the leading scientists. I will call it the top one percent, since historically this is where the breakthroughs have come from. I think pure scientists with successful entrepreneurial experience make the best judges of those efforts. I think researchers need to be able to fully participate in the entrepreneurial process without unnecessary encumbrance from archaic conflict-of-interest policies. The standard of conduct for scientists involved in entrepreneurial activities should be actual conflict, not the appearance of conflict, as is the standard in some institutions today, primarily the national lab system. If you go with the appearance-of-conflict standard, it allows mid-level managers with programmatic responsibilities to quash the entrepreneurial activity by pointing to less than substantive violations of those standards.

We would like to see an improvement in encouraging exclusive licenses. I think 25 years after the Bayh-Dole Act, it is absolutely clear that in order to raise capital, you need to have the ability to cut exclusive licenses with a minimal amount of time to getting those completed, and that is still an area that needs work.

And then finally, I would like to say that we would like to see the SBIR program not disqualify investor-backed companies from applying for grants. I think this is particularly damaging to companies seeking capital that are in remote geographies where it is harder to attract investor capital.

The National Science Foundation: their sponsored research has played an important role in innovation ecosystems. NSF is highly regarded by the seed and early-stage venture capital groups because of their long-term view interdisciplinary research and careful program selection and rigorous peer review.

The NSF could take a more active catalytic role in encouraging commercialization in several ways. First, the Foundation can help

expand the innovation ecosystem, particularly in those geographic regions that possess topflight research that I discussed earlier, but lack the seasoned entrepreneur and investor components necessary to complete the transfer process. The NSF should fund the formation of public-private partnerships at these research institutions to focus exclusively on identifying startup opportunities and assembling interdisciplinary teams required to build innovation into successful high-growth companies. The NSF may be uniquely suited to facilitate this partnership because of its deep relationships with leading scientists, many of whom have had successful startups emerge from their labs.

Second, the NSF can rethink the artificial separation of basic and applied research. To paraphrase an entrepreneurial chemist from Argonne National Labs some years ago, there are plenty of great basic research problems with commercial significance, if you are looking for them. The point here is, if generating an eventual commercial application is the desired goal of basic research, or one of them, then it makes sense to design the programs to allocate resources to identify, investigate and validate the commercial implications of basic research from the very beginning. It is simply never too early to start this complementary commercial investigation process.

I would like to conclude my testimony by reiterating that the innovation ecosystem in the United States remains the envy of the world. It has harnessed the brilliance of our researchers, the ingenuity of our entrepreneurs and the savvy of our investors. However, it is a frail ecosystem, and as members of this unique public-private partnership, we must do everything we can to remove and mitigate those challenges to the system that are under our control. Thank you.

[The prepared statement of Mr. Crandell follows:]

PREPARED STATEMENT OF KEITH L. CRANDELL

Introduction

Chairman Lipinski, Ranking Member Ehlers, and members of the Committee, my name is Keith Crandell and I am co-founder and managing director at ARCH Venture Partners, an independent, seed and early stage venture capital firm. ARCH focuses on commercializing the breakthrough ideas of leading academic researchers in the fields of life science and physical science. We do this by developing these innovations into products and building industry-leading companies to bring them to the marketplace. Since our formation in 1986, we have been founders or leaders in the first round of venture capital investment in more than 120 companies.

ARCH, whose name is derived from The Argonne National Laboratory/ University of Chicago Development Corporation, was formed to commercialize innovations from the namesake university and laboratory, which the university owns and operates. Prior to ARCH, very little commercialization of research had taken place at either institution. In our first five years, we raised a \$9 million fund and used it to found 12 companies. Successes from this initial batch include The EveryDay Learning Company, developer of the number one reform elementary mathematics curriculum in the U.S., Aviron, developer of the cold-adapted, nasal aerosol flu vaccine for children, and Nanophase Technologies which The Economist has identified as the very first nanotechnology company.

Overall, the founders' equity in those initial 12 start-up companies and the licenses ARCH completed during that time have generated over \$30 million. Currently, ARCH Venture Partners is investing its seventh fund.

In addition to my responsibilities as a venture investor, I am a former director of the National Venture Capital Association (NVCA), of which my firm is a member. Based in Arlington, VA., the NVCA represents the interests of more than 425 ven-

ture capital firms in the United States. These firms comprise more than 90 percent of the venture industry's capital under management.

It is my privilege to be here today to share with you, on behalf of the venture industry, our perspective on how we can improve the transfer of breakthrough ideas and technologies from research institutions to entrepreneurs and investors who can build them into products and companies and bring them to the marketplace.

The Role of Venture Capital in the Innovation Life Cycle

I would like to share a brief overview of the role of venture capital (VC) in the innovation life cycle. For decades, the venture capital industry has dedicated itself to finding the most innovative ideas and bringing those ideas to market. Venture capitalists raise money from institutional investors and their firm partners for the express purpose of identifying and investing in the most promising ideas, entrepreneurs, and companies. We only choose those with the potential to grow exponentially with the application of our expertise and venture capital investment. Often these companies are formed from ideas and entrepreneurs doing work in university and government laboratories—or even someone's garage. Many of these ideas would never see the light of day were it not for venture investment.

Once a VC has identified a promising opportunity, he conducts thorough due diligence on the entrepreneur or scientist, the technology on which the opportunity is based, and the potential market. For a venture capitalist to invest in a new idea, the discovery must be proven at least to a reasonable point. Often times, the venture capitalist will delay an investment until further research or commercial validation is successfully completed. Put another way, most venture capitalists invest in applied research—not basic research. For those discoveries that have moved through the basic research process or have a functioning product which passes muster with their firm, we make an investment in exchange for equity ownership in the business. Often at this point, no company has been formed to manufacture and market the product, so the VC takes a lead role in establishing one. Venture capitalists also generally take a seat on the company's board of directors and work very closely with management to build the company and bring the innovation to market.

The innovation process is long and characterized by significant technological, market, and entrepreneurial risk. A venture capitalist typically holds his venture investment in an individual company for at least 5–10 years, often longer, and rarely much less. During that time he continues to invest follow-on capital in those companies that are performing well; he may cease follow-on investments in companies that do not reach their agreed-upon milestones. The ultimate goal is what VCs refer to as an exit—which is when the company is strong enough to either go public on a stock exchange or become acquired by a strategic buyer at a price that ideally exceeds our investment. At that juncture, the venture capitalist “exits” the investment, though the business continues to grow and innovation continues to take place.

The nature of our industry is that many companies do not survive, yet those that succeed can do so in major ways. Our asset class has been recognized for building a significant number of high-tech industries including the biotechnology, semiconductor, online retailing, and software sectors. Within the last several years, the venture industry has also committed itself to funding companies in the clean technology arena. This includes renewable energy, power management, recycling, water purification, and conservation. Many of the young companies that we fund serve as the de facto R&D pipeline for larger corporations as, in many cases, the technology of venture-backed start-ups is usually far more advanced than the product-line extensions that receive priority in a corporate R&D environment. This phenomenon is especially true in the life sciences and software sectors, where venture-backed companies are regularly acquired for their technology and intellectual property. We believe this dynamic will ultimately become the reality in the energy and clean tech sectors as well. My partners and I are extremely proud of the work that we do each day because we are creating the future.

Historically, venture capital has differentiated the U.S. economy from all others across the globe in terms of job creation and innovation. According to a 2009 study conducted by the econometrics firm IHS Global Insight, companies that were started with venture capital since 1970 accounted for 12.1 million jobs (or 11 percent of private sector employment) and \$2.9 trillion in revenues in the United States in 2008. Such companies include historic innovators such as Genentech, Intel, FedEx, Microsoft, Google, Amgen, and Apple. These companies have brought to market thousand of innovations that have improved and, in the case of the life sciences sector, actually saved millions of lives. It is almost inconceivable that these monumental advances were once small ideas tucked away in a lab or a living room. But we assert that the next great innovation is today an idea waiting somewhere. We are com-

mitted—along with the government—to finding and funding it. Our country’s future depends on it.

The ARCH Methodology

ARCH Venture Partners works with leading researchers at the earliest possible point in their work to identify breakthrough ideas. We then evaluate market potential and technical risk, develop intellectual property strategy and bring in experienced entrepreneurial advisors with relevant industry and technology experience. In fact, our ability to integrate proven and successful technologists and entrepreneurs from previous ARCH portfolio companies into subsequent generations of start-ups and introduce them to existing networks of contacts is one of the most valuable things ARCH brings to the table.

In addition to assisting in product development and strategy, ARCH also works with its portfolio companies to recruit managers and board members, identify corporate partners, increase awareness of non-equity sources of financing from governmental agencies, and develop an overall business strategy. Periodically, ARCH partners have stepped into operating roles in portfolio companies in the roles of executive chairman of the board or interim CEO to enable continued progress even when management changes have been required.

As part of this process, ARCH actively solicits participation from other investors—a practice that venture capitalists call “syndication.” This considerably strengthens the financial position of the company by helping to insure that it can access capital until it achieves positive cash flow. Just as importantly, participation from additional investors provides extra reserves of expertise, experience and contacts for the company to tap as it grows.

Finally, ARCH shares its considerable experience in the initial public offering process and in trade sales—the two most common outcomes, or “exits,” for successful venture-backed start-ups—with its portfolio companies to make these processes more efficient and maximize the value of their exits for all stakeholders.

ARCH does not expect researchers to become the chief executives of the start-ups their innovations spawn. In fact, we have found that they prefer to stay in their laboratories and continue their groundbreaking research while serving as advisors, consultants, and board members to the start-up. The consensus of the founders and investors is almost always to recruit top entrepreneurial talent to lead the start-up full time as soon as possible.

Challenges Facing Knowledge and Tech Transfer from Universities to the Private Sector

The technology transfer process at leading universities can be broken down into three primary and interrelated functions: record keeping and compliance, patenting and licensing, and spinning off start-ups based on those patented innovations.

Most universities have adequate programs in place to carry out record-keeping and compliance. In some cases, this function also includes raising technology transfer awareness broadly in the university community.

The second function concerns the management of the university’s patent portfolio and the completion of license agreements for both established and start-up companies. Currently, the quality of the patenting process varies greatly from university to university. Constrained resources at the technology transfer office, a lack of commercial application knowledge by those who staff it, and an unwillingness to aggressively defend broader claims by the person who filed the patent can lead to challenges for start-ups interested in commercializing the innovation. In some cases, groundbreaking innovations have received only narrow patent coverage. Start-ups are particularly vulnerable to these vagaries of the system because patents offer one of the few advantages a small company has against larger, stronger, and more established competitors. While some standard licensing agreement templates have considerably simplified the license agreement process for university offices in recent years, many universities continue to spend too much time negotiating them. This is wasted time for start-ups because they cannot begin the process of attracting management and investment or start product development until the license is complete and the economic terms are known.

The third and most important function focuses on spinning off high-potential start-up companies based on their patented and licensed innovations. This is the most critical step in the commercialization process, but it can be a difficult, frustrating, and potentially thankless task for the technology transfer staff involved.

Sadly, university technology transfer offices often function as second-class citizens in bureaucracies designed primarily to serve the faculty, educate students, and handle institutional administration. As a result, these offices frequently lack resources and have difficulty attracting, retaining, and motivating the level of talent required to facilitate rapid and efficient commercialization. While universities often reward

top faculty for generating outstanding research or garnering grant funding, they rarely ever reward transfer officers for their commercialization efforts—no matter how heroic. In fact, the researchers themselves maintain a role and ownership incentives in a start-up, but the technology transfer executives typically do not receive a similar ownership incentive—even when they essentially help found the company. Sometimes, the only way they can get this stake is to leave the university.

The role of the “start-up” staffer is further complicated by a heightened degree of negative scrutiny—“fish bowl” effect, of sorts—often present at public institutions. It works like this: if a start-up is successful, the staffer may be blamed for giving away the lab’s “crown jewels” for too little economic value or charged with favoritism toward the successful group after the fact. If a start-up fails, critics assail the staffer for the tremendous time and effort that yielded nothing. If the staffer believes a leading scientist’s innovations cannot commercially justify his efforts, he may incur the wrath of a powerful faculty member. Instead of providing motivating incentives, this dynamic discourages talented staffers from giving their best effort and hurts the commercialization process.

The fish bowl effect raises another troublesome challenge: conflict of interest, and how to deal with it. It should be understood that the type and size of conflicts of interest arising from the commercialization process are not always predictable. Commercialization involves human beings moving with incomplete information into unknown territory. These conflicts should be managed not from expectations of zero defects, which is impossible and counterproductive, but from one of exemplary disclosure, oversight, review and management of conflicts when they arise.

Technology Transfer and Geographic Variance

Let me set aside the acute challenges at the university transfer office and speak more generally about the transfer process. Successful transfer, or spin off systems require three basic components: 1) leading researchers with breakthrough ideas, 2) successful entrepreneurial managers and, 3) experienced and successful seed and early stage investors. These interdisciplinary teams of scientists, managers, and investors have been a hallmark of successful high growth companies in the United States for decades.

In Northern California and in the Boston area, these three components exist in abundance across a number of different fields and industry sectors. Outside of these well-established venture capital hubs, some regions have assembled these components for single industry sectors. Examples include the medical devices sector in Minneapolis, MN, biotechnology in Seattle, WA, and communication technology in Austin, TX.

Throughout most of the rest of the United States, many academic institutions have leading researchers with breakthrough ideas. The other two critical components—experienced and successful entrepreneurs and seed and early stage investors—remain in short supply. In many cases, those who are on the scene are not coordinating their creative activity. The critical challenge for these geographies is to round out these other two components so that they can assemble the high-performance, interdisciplinary teams I described earlier.

Best Practices and Recommendations for Effective Commercialization

The process of commercializing technology is a system with many interdependent parts. It also tends to work differently at universities than it does at the national laboratory system. Despite these differences, there are a number of principles and practices for success that stretch across the commercialization spectrum. I originally developed these to share with the Department of Energy for improving their process of technology commercialization at the national labs, but I think they are relevant to our discussion today.

- 1) **Insistence on Objectivity and Transparency in Commercialization Reporting.**
The improvement of the technology commercialization process should begin with improved annual metrics that accurately reflect start-up company activity. Institutions should focus on tracking economic value created, capital raised and jobs created, instead of counting, invention disclosures, licenses, patents, and CRADAs (cooperative research and development agreements). These latter metrics are at best indirect and incomplete measures of technology commercialization. Tracking near-term cash is also problematic, as it creates an incentive in the lab to overload pre-revenue start-ups with large licensing fees—which strip the start-up of precious dollars needed to advance the commercialization of the technologies.
- 2) **Assembly of Capable Commercialization Teams:** Each institution should assemble a cadre of successful experienced entrepreneurial managers, venture

capitalists, and entrepreneurial researchers to share their best practices, network, and experience with the next generation of researchers. Successful early stage companies do this when they organize business and scientific advisory boards to gain insights in development efforts and to suggest ideas to overcome challenges. Adopting this practice at the technology commercialization office level starts this essential process even earlier.

- 3) **Focusing Commercialization Resources on Breakthrough Ideas.** The creation of new companies based on breakthrough ideas from leading scientists involves a small percentage of the research talent at a given institution (the top one percent). Entrepreneurial services, funding, and support should be focused on the top scientists with the breakthrough ideas. We have found that peer scientists with successful entrepreneurial experience make the best judges.
- 4) **Make Time for Researcher Consulting.** Top scientists (perhaps called Commercial Fellows) should be allocated at least one day per week for consulting with start-ups. This practice is typical at leading private research universities but less common at the national labs.
- 5) **Adopt Common Sense Conflict of Interest Policy.** Researchers should be able to fully participate in the entrepreneurial process without unnecessary encumbrance from archaic conflict of interest policies. The standard of conduct for scientists involved in entrepreneurial activity should be “actual conflict”—not the “appearance of conflict” standard in place at some institutions today. The appearance standard allows mid-level managers with program responsibilities to quash entrepreneurial activity (e.g., veto researchers’ ability to provide consulting to start-ups, serve on boards or advisory boards, and take equity stakes) by merely pointing to less-than-substantive violations of the standard. Procedures and policies for handling actual conflicts (such as the well-established disclosure, oversight and review process at many universities) should be put in place to afford the commercialization-oriented researcher the fullest opportunity to participate in the commercialization process, as well as due process and the opportunity to appeal conflict determinations to objective authorities outside the lab’s direct chain of command.
- 6) **Ensure Investor and Entrepreneur Access to Leading Lab Researchers.** Investors and entrepreneurs should have the ability to “walk the halls” of research institutions, meet scientists, attend seminars, build relationships, and discuss ideas and opportunities with lead researchers. This already happens today at the best research universities, but it should happen everywhere—including non-classified areas of the national labs.
- 7) **Improve the Intellectual Property Protection and Practices.** Encourage exclusive licenses based on performance and embrace the notion that intellectual property licensed to investor-backed start-ups will likely need to be exclusive in order to attract investment capital. This practice is already in place at the top research universities, and should expand to all commercialization-focused institutions.
- 8) **Streamline the license negotiation timeline.** As I mentioned earlier, time is precious for start-ups. The licensing process should be completed in 90 days. The time and effort used to extract a license from a university or national lab is wasted when the real challenges the new company faces are building a business or attracting capital or management or developing a product or finding a customer. Often universities and laboratories require the approval of too many separate quasi-independent entities.
- 9) **Improve the Breadth and Commercial Relevancy of Patent Claims.** There is too much emphasis on counting quantity and not enough on the quality and commercial importance of the patent claims made by universities and labs. Claims should be filed with an eye toward the eventual needs of the companies to whom the institution plans to license them.
- 10) **Investor backed companies should be allowed to more fully compete and participate in the SBIR program as they did prior to 2003.** SBIR provide a need source of capital to entrepreneurial companies and disqualifying entrepreneurial companies that take investor capital from participating in the SBIR program makes the new company less likely to seek the capital it needs to commercialize innovations and create jobs and economic value. This is particularly damaging to entrepreneurial companies seeking capital in remote geographies.

Roles for the National Science Foundation in the Innovation Ecosystem

Basic research sponsored by the National Science Foundation (NSF) is highly regarded by seed and early stage venture capital groups because of the NSF's long-term view, interdisciplinary research approach, careful program selection, and rigorous peer review. NSF also generally involves top researchers and their research programs are highly original in nature. These characteristics provide a strong basis for a new start-up companies.

In addition to continuing to fund such research, I believe the NSF can play a number of important roles within the innovation ecosystem in the U.S.

First, the foundation can help expand the innovation ecosystem—particularly in those geographic regions that possess the top-flight research component I discussed earlier but lack the seasoned entrepreneur and investor components necessary to complete the transfer process. The NSF should fund the formation of public-private partnerships at these research institutions to focus exclusively on identifying start-up opportunities and building the interdisciplinary teams required to build innovations into successful, high-growth companies. The NSF may be uniquely suited to facilitate these partnerships because of its relationships with leading scientists, many of which have had successful start-ups emerge from their labs. The public-private partnership model also addresses the “fish bowl” challenge for technology transfer officers because the partnership does not report to the administration of the university or lab and can also act as an advocate for the entrepreneurial scientist on the conflict of interest issues.

Second, the NSF can rethink the artificial separation of basic and applied research. To paraphrase an entrepreneurial chemist from Argonne National Laboratory some years ago: there are plenty of great basic research problems with commercial significance—if you are looking for them. The point is this: if generating an eventual commercial application is one desired goal of basic research, then it makes sense to design the program architecture to allocate incremental resources to identify, investigate, and validate the commercial implications of basic research from the very beginning. It's simply never too early to start this complimentary investigation process. It can help inform the direction of more applied research, strengthen intellectual property, and provide a platform to interest entrepreneurs and seed capital. This is a particularly acute problem in physical science research where, for example, new innovations in materials science can have diverse applications spanning everything from drug delivery to computer displays to aerospace.

For these reasons, it's better to make a scientist fully aware of the real potential and constraints for a commercially relevant breakthrough and lay the groundwork for a start-up early on, rather than ask him to perform basic research in a commercial information vacuum for years and then, after the program is complete, try to retrain him as an entrepreneur and begin the process of commercially validating the innovation.

Finally, the NSF could encourage leading researchers to include summaries of these commercial investigations of their work and what paths those applications could take when submitting their work for publication. On a parallel track, the foundation could encourage leading academic journals to ask for or even require such summaries.

Conclusion

I'd like to conclude my testimony by reiterating that the “innovation ecosystem” in the U.S. remains the envy of the world. It has harnessed the brilliance of our researchers, the ingenuity of our entrepreneurs, and the savvy of our investors to power economic growth, save countless lives, and change the way we live those lives each day. However, it is a delicate system steeped in risk and beset by challenges in today's economic environment.

As members of this unique public-private partnership, we must do everything we can to remove or mitigate those challenges to the system that are under our control. Encouraging and adopting the best practices for knowledge and technology transfer at universities and the national labs that I outline in this testimony would move us in the right direction. So, too, would increasing the role of NSF in those ways that I've described.

This brings me to a larger point: The Federal Government has played a vital role in the success of the U.S. innovation model through innovation-friendly policies and incentives. Now, however, many foreign governments have begun to emulate these policies and create innovation ecosystems of their own. If successful, these competing ecosystems could draw talent and resources away from ours. To maintain our innovation advantage, we must rededicate ourselves to what made our system successful and address those areas that pose the greatest threats. This means increas-

ing support for basic R&D, improving math and science education, supporting high-skilled immigration and patent reform, and improving access to capital through forward-thinking tax policies. Without action on these fronts, the United States may find itself in the unfamiliar role of innovation backwater—rather than the destination of choice for the world's most gifted researchers and entrepreneurs.

I want to personally thank you for the opportunity to discuss these important issues with you today. And to thank you for your service to our country in your capacity as Members of Congress.

BIOGRAPHY FOR KEITH L. CRANDELL

Keith Crandell is a Co-Founder and Managing Director of ARCH Venture Partners, a 24 year-old seed and early stage venture capital partnership with offices in Chicago, Austin, San Francisco and Seattle. ARCH Venture Partners is currently managing its seventh fund and focuses on core technology spin-outs from universities and other research organizations in the United States.

Mr. Crandell serves as a Director of the National Venture Capital Association and is a member of the Governmental Affairs Committee. He also has been active with the IVCA since inception, recently serving as Chairman. Since 2004 he has served as Chairman of the Advisory Board of the Treasurer's Fund, a fund-of-funds focused on Illinois private equity partnerships.

Prior to ARCH, Mr. Crandell worked with Hercules, Inc., a specialty chemical and polymer company. He holds an M.B.A. from The University of Chicago, an M.S. in Chemistry from the University of Texas at Arlington, and a B.S. in Chemistry and Mathematics from St. Lawrence University.

Chairman LIPINSKI. Thank you, Mr. Crandell.
Mr. Kane.

STATEMENTS OF NEIL D. KANE, PRESIDENT AND CO-FOUNDER, ADVANCED DIAMOND TECHNOLOGIES, INC.

Mr. KANE. I am Neil Kane, President and Co-founder of Advanced Diamond Technologies. I would like to thank Chairman Lipinski, Ranking Member Ehlers and the other Members of the Committee for the opportunity to speak today.

In the last 15 years, I have been founder or startup executive in six university spin-offs and I have been associated with many more. As the Executive Director of the Entrepreneurship Center at Argonne National Laboratory, our charter was to mine Argonne's portfolio of research projects and identify those that were the best candidates for launching startup businesses. I later became Entrepreneur-in-Residence for the venture arm of the University of Illinois where for three years I helped start businesses based on research conducted there. Through these experiences, and the four years since then that I have been full-time CEO of Advanced Diamond Technologies, I have encountered every small business and tech transfer issue there is.

Advanced Diamond Technologies is a nanotechnology company. We literally turn 50 cents worth of natural gas into \$500 worth of diamond in our plant near Chicago. We don't make jewelry, but the diamond that we make is used in a variety of industrial applications, such as highly durable bearings, electronics such as timing chips for phased-array radars for the military, and medical devices like heart pumps. Notably, all of the products that we manufacture today and export were the subject of SBIR awards. We are building domestic manufacturing capacity and creating highly skilled jobs. In fact, three-quarters of our 16 employees have advanced degrees, and as has been noted already by Chairman Lipinski, I should point out that not surprisingly, our most serious competition comes from China. Not only are their costs lower there, as everybody un-

derstands, but their government is also funding advanced technologies like ours much more aggressively than the U.S. is today.

As I have persevered through some of the challenges encountered when transferring technologies from universities or Federal labs, the major issues that I have identified are these four. Number one, as you have already heard from others, the transaction costs of executing licenses is too high. Number two, professors or career researchers who are integral to the success of startups sometimes face institutional impediments that inhibit their participation—conflicts of interest and other types of things. These same professors or career researchers, while obviously highly intelligent, lack business experience, and that needs to be addressed. In every startup that I have been a part of, some or all of the key research was conducted by a foreign-born student. These graduate students or post-docs are then prohibited from working in the companies that they spin off due to immigration restrictions. This reduces the chance of success for the company, and also deprives the community of the opportunity to employ a highly skilled worker. When it comes to job creation, these are the easiest jobs to create.

And finally, funding the Valley of Death, the gap that exists between applied research on the one hand and commercial traction on the other. This continues to be an enormous challenge for most commercially oriented technology businesses. And in response, I offer these five recommendations to address these issues.

Number one: The Bayh-Dole Act should be modified so that all patent licenses executed under its purview are made publicly available. In the era of transparent government, I will call this the License Agreement Sunshine Act. By doing so, and making licenses exposable to the public, it will lower transaction costs by making licensing terms and conditions more standardized, and notably, as you have heard from Mr. Crandell, it will also dramatically shorten negotiations.

Number two: Create an entrepreneurial special duty assignment for researchers in Federal laboratories, to give them the chance to properly transfer their technology and skills without sacrificing their professional tenure or salary.

Number three: Make universities provide business skills to STEM students. Large companies can offer training like the one that I got when I began my career with IBM, but small businesses cannot afford to do so. Horizontal skills like project management, budget, written and verbal communications, presentation skills and basic sales skills are valuable regardless of career choice. Better-rounded technical workers will earn higher salaries regardless of location, and I can tell you firsthand that all of the employees that we have had in my companies who haven't survived, it has usually been due to their horizontal skills and social skills, not their technical skills.

Number four: Increase the limits on SBIR and STTR awards and collapse the approval times. Sometimes it takes up to nine months, and these are cycles that startup companies cannot tolerate.

And number five: Modify the SBA [Small Business Administration] size standards to reflect the needs of very small businesses. As you know, the SBA defines a small business as one with less than 500 employees. My company, with 16 employees, doesn't have

very much in common with companies that have 450 or 500 employees. The SBA needs to recognize and define programs appropriate for businesses with less than 50 employees, much like other Federal legislation does.

In conclusion, we at Advanced Diamond Technologies are developing important new technologies, generating good jobs and exporting products today specifically because of the taxpayer investments in basic and applied research, augmented by the availability of SBIR funding through NSF. Tech transfer is an investment in our innovation economy, and I encourage you to implement the changes I have proposed to stimulate this activity. Thank you.

[The prepared statement of Mr. Kane follows:]

PREPARED STATEMENT OF NEIL D. KANE

I'd like to thank Chairman Lipinski, Ranking Member Ehlers and the other members of the Committee for the privilege and honor to speak to you today. I represent on today's panel the perspective of the start-up company founder who has launched several businesses based on federally funded research performed at Federal labs or at universities.

Advanced Diamond Technologies (ADT), a company I co-founded in late 2003 with Dr. John Carlisle and Dr. Orlando Auciello, both scientists at Argonne National Laboratory, is a company that turns natural gas (methane) into diamond. They're the technical founders and I'm the "business guy". You may remember from your freshman chemistry class that diamond is a form of carbon. Methane, a hydrocarbon, is comprised, as you might suspect, of hydrogen and carbon. At the right temperature and pressure, in a process very much like the ones used to make semiconductors, we can strip away the hydrogen, rearrange the carbon atoms, and literally turn 50C worth of a commodity gas into several hundred dollars worth of diamond. The diamond we manufacture has a wide variety of commercial uses, described later, and isn't used for jewelry. Today we have 16 full time employees which include five Ph.D.s and seven master's degrees . . . that is, 3/4 of our company have advanced degrees. We are working to build a manufacturing facility for carbon materials in our plant near Chicago that will be a model for what 21st century manufacturing will look like.

We are a nanotechnology company because we control the properties of diamond on almost an atomic scale . . . even though the products we make are very much macroscopic. What makes us unique is that our diamond, known commercially as UNCD®, is very smooth. It is smooth because it consists of individual diamond grains that are nanometers in size. We formed ADT around the vision that if we could take the world's hardest material, which has a dizzying array of beneficial electronic, physical and biological properties, and make it smooth, reproducible and affordable, then the number of uses for it would grow tremendously.

Our company, and the jobs it has created, would not exist were it not for the basic and applied research that the Department of Energy (DOE) funds at Argonne National Laboratory. The foundational technology, which we licensed in the form of a portfolio of about 15 patents, began as a research project at Argonne in 1992 supported by DOE's Basic Energy Sciences (BES). Later the Industrial Technologies Program in the DOE's Office of Energy Efficiency and Renewable Energy (EERE) provided core funding for applied R&D to develop the technology as a low friction, energy saving coating for industrial components. We are the beneficiaries of this research, which in total is about \$15 million. In return for giving us the exclusive right to use these patents, Argonne receives ongoing royalties from commercial sales of the products incorporating the technology and also is a significant equity holder.

With our innovations, diamond can be used to make game changing products like:

- Bearings and seals for industrial equipment that last tens of times longer than current components while saving energy by running cooler due to diamond's low friction properties
- High performance wireless communication chips for secure military communications and phased-array radars
- Biocompatible coatings for implantable organs like artificial retinas
- Electrodes that can neutralize toxins, carcinogens and heavy metals in industrial waste water
- Durable nanoprobes for atomic-scale imaging and nano-manufacturing

- Wearable sensors for real-time detection of biological warfare agents
- Coatings for heart pumps that change the standard of care from temporary devices for patients awaiting heart transplants to permanent devices that won't form blood clots, thus allowing patients to live with them for years as an alternative to heart transplants
- And the list goes on.

Although we are still a small company, our products are being sold around the world today. We've taken the basic research performed over 15 years ago and are now turning it into exports that help improve the balance of trade and the competitiveness of the U.S. economy. Along the way we've been recognized globally for our innovation. More importantly we are creating jobs and building manufacturing capability in the U.S. that will strengthen our future industrial tax base.

My experience with technology transfer is by no means limited to Advanced Diamond Technologies. As Entrepreneur-in-Residence for Illinois Ventures, I was part of the startup team for four other university spinoffs, three of which have gone on to raise tens of millions of dollars of venture capital and collectively employ over 100 people in areas as broad as printed electronics and micro-inverters for photovoltaic systems. Through this effort I've negotiated license or option agreements at the University of Illinois, University of Wisconsin, Northwestern University, University of Pennsylvania and Oklahoma State University in addition to Argonne. When I managed the entrepreneurship center at Argonne, I used to sit in on the licensing meetings at The University of Chicago.

The National Science Foundation's SBIR/STTR program (referred from now on as the SBIR program) has had a profoundly positive impact on ADT's ability to bring products to market and create jobs. The SBIR program has provided funding to allow us to bring the technology out of the laboratory and develop it for commercial applications. Our technology was meritorious for its potential but was not ready for prime time when we licensed it from Argonne. The road from the lab to the marketplace, we have learned, is a long one for complex technologies.

In June 2004, before we had any external funding, we received our first Phase I SBIR to develop diamond-coated seals for industrial pumps. This vote of confidence got our company started and was the catalyst that secured our first angel financing about a month later. Today, after a follow-on Phase II award and IIB supplement, we're selling diamond-coated mechanical seal faces globally and are just beginning to enter our growth phase. We've gotten one more Phase II and have several more Phase I projects in process that we hope will lead to future products. All told we've received commitments of about \$3.3 million in NSF grants, with approximately 10% of those funds going to university collaborators to support graduate students. Most of the products we are selling commercially today were once the subject of NSF SBIRs or STTRs, and each of the Phase II awards we have received is now generating commercial sales.

During the same interval we've raised approximately \$6 million from investors. The SBIR grants have allowed us to bring the technology to a level of maturity to make our investment proposition palatable to private investors since we have to compete for their money against the array of other investment opportunities available to them. We don't request grant funds just to do contract R&D. All of the grant proposals we have written have been targeted toward doing the translational work necessary to convert great science into great products.

There are many ways to transfer technology into the commercial realm, and my remarks are confined to doing so through the creation of startup entities. Through my experiences starting companies based on university or Federal lab research, I've noticed a number of challenges:

- Good researchers are often not good business people, yet
- The researchers are needed in the company at its founding to ensure that the technology is properly transferred to the commercial realm. In addition to the professors, in each company I've been involved with, the graduate students or post docs coming out of the research program had a prominent role on the founding technical team. In some cases this has been hampered by immigration issues (discussed later).
- The transaction costs of executing licenses from universities and Federal laboratories are too high, and I've seen deals go awry due to "deal fatigue". Imagine deep-pocketed investors interested in starting a company who walk away because they couldn't secure rights to the technology on reasonable (in their eyes) license terms. It has happened. In my experience the institutions always underestimate the time and money needed to turn their innovations into commercial products.

- The researchers have no calibration about what they can expect in terms of equity and compensation for participating in getting a company formed. The fear among the researchers that they're not getting treated fairly has, perhaps surprisingly, been one of the biggest impediments in getting companies started. War stories are abundant and anyone who has done this at least once has at least one story to tell.
- Institutional constraints on researchers make the process difficult. The researchers (often professors) have to pursue this as an extra-curricular activity. When we got ADT started, my co-founders at Argonne, although they started the company with the full cognizance of management, had no incentives to do so except their equity participation in the company. At the same time, there was no relief for the things they were measured on, like publications, and thus they essentially had two jobs for quite some time. They each came away with a piece of the company, but their achievements in getting the company started were not recognized in their professional trajectories at Argonne. I've heard stories of tenure-track professors at universities say that they can't participate in a company right now as it would harm their ability to get tenure. Get tenure first, they figure, and then start a company.

Despite all this, I've learned over the past ten years that *the real challenge is not transferring the technology out of the laboratory—it's transferring the technology into the marketplace*. If we do everything right except get products to market, we've accomplished nothing. A professor friend of mine said, "When the technology leaves the lab, it's 5% done."

The cost, time and expertise needed to turn great science into great products is where a gap really exists. This is referred to as the "valley of death", a term often attributed to Ranking Member Ehlers. The "valley of death" is the chasm that exists between basic research (often funded by NSF) and the private financing which becomes available once the technology has proven commercial potential. We've closed this gap by using SBIR programs to de-risk the technology to a point where we can attract private capital.

Some of our products have gone through several years' worth of qualification testing by our large customers, and these are very expensive activities to fund because the marketing and development expenses are incurred in the present whereas the payoff, in the form of sales, will happen in the future. Today we sell diamond-coated mechanical seals for pumps, such as those used on Navy ships. Even though we've got the product ready today, the Navy will need to go through at least a year of qualification testing before our products could be used on their ships.

DOE's EERE has created a program called the Technology Commercialization Fund that is geared toward these types of development activities, further bridging the "valley of death", and it expressly excludes scientific research. I encourage the Committee to review this program. The TCF has allowed us to bring a new type of diamond bearing product to market, leveraging work that was funded by an NSF SBIR, which leveraged basic and applied science originally conducted at Argonne, which was augmented by private financing (the TCF program requires cost sharing). We have a large international customer poised to order over a million dollars of new product in the next 12–24 months as a result.

The SBIR/STTR programs are among the most important programs for stimulating entrepreneurship and they are the envy of governments around the world. The programs should be expanded, and the dollar amounts should be raised. Agencies like the Environmental Protection Agency have paltry SBIR budgets compared to NSF and the Dept. of Defense, yet environmental issues ranging from clean water to environmental damage in the Gulf of Mexico are top U.S. priorities. The SBIR program is a great way to unleash the creativity and innovation of U.S. researchers in a competitive process to address these national issues. Compared to many other government programs the cost is insignificant, yet the potential return is quite high because it's an investment in America's competitiveness, not an expense.

With my experience in starting many companies, I've formulated a number of principles, or best practices, that have become part of my startup template:

- The scientific team (professors, researchers) must have equity participation in the startup companies in return for their cooperation to ensure successful knowledge transfer. Their ownership should have a vesting schedule that is conditioned on their active involvement.
- Researchers need trusted counsel to advise them otherwise the process gets bogged down by them feeling they're getting a raw deal. The earlier these advisors are identified, the better.

- To be able to attract private capital, the licenses to the intellectual property need to be exclusive even if they are for a limited field of use.
- The people that make it work and create the value—the employees of the company—should share in the fruits of their work. The founding technology is a critical element, but it often is not worth much until the employees develop it.
- Even if the company is able to attract SBIR funding, some private capital is still needed for the company to prosper. Said another way, you can't build a company if your only source of funding is the government.

My recommendations to tech transfer offices:

- Their institutions must have sabbatical programs to permit technical founders to work in the company to transfer the knowledge but have a job to come back to. In two of the companies I've started, tenured professors (or equivalent) have left their positions to join the companies they helped form. This was good for the companies, but it is unclear if it was desirable for the institutions.
- Make licensing terms and conditions more transparent to lower transaction costs and facilitate company formation. Each institution should publish its standard agreements along with stated expectations for critical deal terms and conditions (such as exclusivity and royalty rates). While some worry about giving up a technology too cheaply, the reward will be recognition as an easy place to do business. With that recognition will come more startups, more economic development activity in their communities, more job opportunities for graduates and more wealthy alumni not to mention lower overhead in the tech transfer office.
- The universities should view tech commercialization as being consistent with the career advancement of their faculty. Is it ill-advised to have tenure committees look to a researcher's record of creating economic wealth from his or her work as part of the criteria?
- Although all universities offer some type of training to their faculty about startup formation, I've not seen any that address the cultural differences between being a faculty member and being a member of a startup team, yet most of the friction I've seen occurring among startup team members is due to these issues. Matters of collaboration, confidentiality, competition, market focus and subordination are all critical for career researchers to understand. Not all academics may want a role in a startup, but if they take that role, since many other careers and investment dollars will be at stake, they should know what is expected of them. I've seen too many examples where the expectations were unmet, causing major problems, because they were not clearly explained at the outset.
- Additionally, since startup companies provide great career launch pads for graduate students with subject matter knowledge in the technology, I've often found that these grad students (or post docs) lack the horizontal skills that are necessary to succeed in a commercial company. I'm an advocate for universities providing training to students in non-traditional academic areas such as: time management, project management, budgeting, non-technical writing, presentation skills and basic sales skills. While technical acumen is paramount, the success or failure of these individuals in the startup companies, in my experience, is almost entirely due to their soft skills.

NSF, due to its historical role as the funding source for science and engineering, has an opportunity to influence practices at universities and thereby stimulate the "innovation ecosystem". NSF should:

- Create a framework whereby each university publishes its license template and financial expectations for license agreements. Right now it's an opaque process where the university always has the advantage due to their knowledge of what others have paid for their technologies.
- Encourage universities to recognize tech commercialization as an important adjunct to basic research whose aims are not in opposition to basic research.
- Shorten the review cycle for SBIR/STTR proposals. The current times are not compatible with the life cycles of small businesses.
- Take a leadership role in stimulating the commercialization of basic research. NSF does a great job at supporting basic research, and the SBIR program is integral to helping translate research into small businesses. But there's another step missing . . . that of bringing products to market. NSF funds can-

not be used for commercialization. There's a need for the government to provide additional funding sources to allow early-stage companies to get over the "valley of death". Doing so is not corporate welfare. Rather it helps to ensure that the taxpayers get a return on their initial investment in basic research.

- Encourage universities to provide training in the non-technical, horizontal skills described above.

Other recommendations to the Committee

- Rather than seeing themselves as stewards of public property, due to the Bayh-Dole Act, universities have to come to believe that innovations developed with Federal funds are theirs. I suggest modifying Bayh-Dole to require that any license agreements executed for subject technologies become publicly accessible. This should be legislatively mandated. Universities will vigorously oppose it, but it will level the playing field and reduce transaction costs across the board. This action will dramatically shorten the time needed to get companies formed and licenses executed. From the university or Federal lab standpoint, the public contract should change from "the government funded it but we own it," to "if we want to profit from retaining title to the intellectual property which was funded by the taxpayers, then we have to be willing to tell the taxpayers what we charged them for it."
- Lower the size standards for SBIR/STTR. Today the limit is 500 employees and that's set by the Small Business Administration. Any company with 500 employees is a going concern that has over \$30 million in annual revenue . . . and probably much more . . . whose ability to fund research and product development is much different than companies with less than 50 employees that are still not profitable. The needs of startups are different than companies with hundreds of employees, and the SBA needs to create segregated programs that reflect these differences.
- Encourage the SBA to create a Micro Business Administration—the MBA—to focus on the constituency described above. Small businesses are the source of most net job creation in the U.S., but for startup companies based on federally funded research to get big, they need programs that are appropriate for their fragile state when they are embryonic.
- A tax policy that favors investing in small businesses. In some states, like Illinois did recently, tax credits are available for qualified investments in startups. This needs to be part of Federal tax policy.
- A major impediment to our getting started was the risk to the inventors of leaving their positions in a Federal lab and joining the company. There was no program whereby they could join the company for a period of time and then return to their position. A sabbatical program for Federal laboratory employees who start companies based on their research is something this Committee can make happen. It will lower the career risk for the scientific founders and ensure higher probability of technical success.
- An overwhelming majority of the technical professionals who have applied for jobs with us are foreign students without permanent work visas. The policy of educating foreign students and sending them home against their desires when they graduate doesn't make sense on any level. Others have proposed the "earn a degree, get a work visa" program, and I wholeheartedly endorse this. The Startup Visa initiative is a twist on this theme, and it also makes good sense. Current immigration policy limits our ability to attract the best and brightest into U.S. companies. What's worse is that we nonsensically will educate anyone only to then deprive them of their desire to ply their trade in the U.S., and we demand that they grow the economies and competitiveness of their home countries.

I know of one instance where a foreign student graduated with a Ph.D. and he was offered a position in a startup company that was based on his thesis work. But the company couldn't get a work visa for him because the H1-B quotas had been exceeded. So his thesis advisor, who was the founder of the company, had to get him a research position at the university to keep him in the country until the H1-B visas opened up. Needless to say this activity created manifest conflicts of interest all around. An enlightened immigration policy would eliminate these kinds of behaviors.

Summary

My company is developing important new technologies and generating good jobs today because of taxpayers' investments in basic research augmented by the avail-

ability of SBIR funding from NSF to refine that technology. Our success benefits many facets of the U.S. economy—its tax base, its exports and its global competitiveness. But with advanced technologies, it can often take years, even under the best of circumstances, to secure commercial success. I encourage this Committee to see tech transfer as an investment in the economy, not an expense, and to implement the changes needed to stimulate this investment.

BIOGRAPHY FOR NEIL D. KANE

Neil Kane is president and co-founder of Advanced Diamond Technologies, Inc., a firm he founded in 2003 by licensing technology from Argonne National Laboratory (U.S. Dept. of Energy). Mr. Kane is the former co-Executive Director of the Illinois Technology Enterprise Center at Argonne and Entrepreneur in Residence with Illinois Ventures, LLC. In these roles he was founding CEO of several startup companies based on university or Federal laboratory research. He has closed multiple rounds of venture capital from various sources and has secured numerous SBIR/STTR and other government contracts and awards.

Earlier he was Regional Business Development Manager for Microsoft Corporation in Chicago. In this role he identified, negotiated and closed a \$25 million equity investment. He began his business career at IBM where he was the liaison to Andersen Consulting (later Accenture) and helped create the strategic business alliance between IBM and Accenture that became the model for the industry. In this capacity he earned membership into IBM's Golden Circle. He began his career as a manufacturing engineer in IBM's San Jose, California disk drive facility where he designed robotic tooling.

He holds a Bachelor of Science degree in Mechanical Engineering from the University of Illinois at Urbana-Champaign (high honors) and a Masters of Business Administration from The University of Chicago. He has attended graduate school at the Australian Graduate School of Management at The University of New South Wales in Sydney and did further graduate study in Japan on a scholarship from the Japan External Trade Organization (JETRO). He was named a 2007 Technology Pioneer by the World Economic Forum and attended their annual meeting in Davos, Switzerland in 2007 and 2008. In 2007 he received recognition from the National Science Foundation for Outstanding Entrepreneurship, and in 2009 he was named a "Mover & Shaker" by Frost & Sullivan.

Chairman LIPINSKI. Thank you, Mr. Kane, and I am sure we would have—I would have known by now if you were related to Patrick Kane, who scored the game-winning goal last night, so I assume you are not.

Mr. KANE. Unfortunately not.

Chairman LIPINSKI. But, you know, that could be a good selling point that maybe you could try to use back home.

Mr. KANE. It is nice to see jerseys with Kane on them all over Chicago.

Chairman LIPINSKI. I think they are all for you.

Before we begin questioning, the one thing I wanted to mention, that Mr. Crandell raised this issue about the exclusion of startup companies in SBIR that involve venture capitalists. The House bill did not exclude venture capitalists. The Senate bill does, and that is a battle that we have still ongoing there, but I wanted to put that out there, and I never miss an opportunity to tweak the Senate for something they are doing wrong.

But with that, I am going to first recognize for five minutes Ms. Fudge.

Ms. FUDGE. Thank you, Mr. Chairman, and I thank all of you for being here today and sharing your expertise. It was very interesting to hear your views.

I happen to be from Ohio as well, and I am fortunate to represent Case Western Reserve University, one of the Nation's top research institutions, and what you are talking about today is of particular interest to Case and to myself. So my first question for any

of the panelists: the Kauffman Foundation has recommended that university tech transfer would be improved if university inventors and not technology transfer offices controlled the patent licensing. Do you agree or disagree? Anyone.

Mr. WATKINS. I will start. We have tremendous respect for the Kauffman Foundation and we agree with them on 99.9 percent of everything they do. I think it is problematic when the ownership of a property and the control of a property are separated, so I think there ought to be flexibility in terms of how the technologies are commercialized, and Kauffman makes a good point, but making it mandatory I think is problematic.

Ms. FUDGE. Thank you. Okay.

My second question is for Ms. Mitchell. Are the Kauffman Foundation's efforts to improve the efficiency of academic tech transfer based upon data-driven assessment of existing intellectual property portfolios at any given institutions, and if not, wouldn't a data-driven approach be better?

Ms. MITCHELL. Unfortunately you can't prove a negative, as the economists that we both fund and employ would tell me, so our data is based upon many economists, including well-noted individuals like Paul Romer and others that we have funded, understanding and looking at outcomes for the economy based upon the amount of research inputs.

As I noted when we began here this morning, there is no question on our part that the United States has done a phenomenal job of capitalizing on university innovation. We are also in a period of economic crisis and recovery and we think that this is an opportune time for us to revisit, and as we have heard from entrepreneurs like Mr. Kane and Mr. Crandell, who have tried to commercialize technologies, the Kauffman Foundation—as you know, entrepreneurs really don't have a voice, they don't have lobbyists, so we are unfortunately the home of every entrepreneur in the country who has tried to license technologies from universities. And while there are unbelievable, wonderful stories about innovations that have made it to the market, there are an equal number of unfortunate stories of long transaction times, as we have heard from Mr. Crandell and Mr. Kane, and unfortunately many, many, many cases of mishaps where patenting has not occurred appropriately or broadly enough, and in fact those technologies sit on the shelves of our universities today. So our goal is to help economic recovery through looking at the models that are out there today and looking for new pathways to the market.

Ms. FUDGE. Thank you.

Dr. Watkins, your institution is part of a major regional economic initiative focused upon research and subsequent commercial transfer. How confident are you that downstream economic impacts, such as those projected by Austin Bioinnovation Institute, will be met, and can you elucidate a bit about the rationale employed to calculate these projections?

Mr. WATKINS. That is a great question. We are tremendously enthused about the potential of the Austin Bioinnovation Institute. Just briefly, it is a consortium made up of three local hospitals, the University of Akron and a related medical school, the Northeastern Ohio Universities Colleges of Medicine. And I guess no model is

proven until we go through with it but I think the thing that is most impressive to me about the model of the Austin Bioinnovation Institute is the people that are involved. This is a business where it is people-driven. It is people that create the success. I spent the last two weeks working with the Institute on a particular proposal, and to see the ideas come forward, I am very confident that we will see results. Now, I think the different models have to be reviewed. The universities are institutionalized. They are long term. We hope the Institute is there long term. But I think all these things need to be sorted out over time, but we are very confident about having that kind of relationship and having that type of expertise.

Ms. FUDGE. Thank you very much. Even though you are not from my district, you are close enough, so welcome. Thank you.

Mr. WATKINS. Thank you.

Ms. FUDGE. Thank you, Mr. Chairman. I yield back.

Chairman LIPINSKI. Thank you, Ms. Fudge.

I recognize Dr. Ehlers for five minutes.

Mr. EHLERS. Thank you, Mr. Chairman.

I have very little in the way of questions. This is one of those panels that did so well at describing a situation, you answered most of my questions during your testimony. I do want to thank you for your work and your testimony. I am frankly encouraged by what I heard.

When I first got to the Congress, I was assigned by Speaker Newt Gingrich to try to clarify United States science policy, and so over the course of a year or two I produced a booklet basically labeled "Toward a Good Science Policy," since writing a science policy would take a lot more time than I wished to devote to it, but it stimulated a good discussion. But probably one of the things we did was publicize the concept of the 'Valley of Death,' and it seems to me that what most of you have done is either tried to bridge the Valley of Death or fill it up so that you can stroll across it, and I commend you for that. It is a very good thing.

One thing I am interested in, based on the work I have done on this—it seems to me that the American workers tend to be more innovative than the workers of other countries. By this, I am talking about the line workers who, when given something to work on to try to develop to eventually manufacture, often come up with good ideas that can reinforce or mesh with the ideas that the basic researchers have done. And when you are a Member of Congress, you get invited to tour many different factories. I have not had the privilege or the benefit of touring factories in other countries, but is my impression right that America does better than most countries at the basic bench level, the industrial worker level, in contributing to the development of ideas, turning them into practical solutions and so forth, or is that just my wishful thinking? Any comments?

Mr. CRANDELL. I will jump in.

Mr. EHLERS. Mr. Crandell.

Mr. CRANDELL. Thank you. You know, it is my sense that small, focused, entrepreneurial groups that are at risk have really been the hallmark of successful innovation, and I think that continues in small companies. I think in larger companies where there tend to be more bureaucratic layers, they no longer embrace or look for

the heroic effort, they look for a standard process which is eminently repeatable, and to some degree I think that is understandable. So in my experience, this paradigm of the small, focused group that is really interested in the best ideas, sort of a true meritocracy, is alive and well. I think we need to do all the things we can to make those sorts of teams come together, and I think that is really where the solution lies to this commercialization challenge from the national labs and from the universities, to continue to enhance the things that make that innovation in small groups succeed. Thank you.

Mr. EHLERS. Ms. Mitchell.

Ms. MITCHELL. Yes. The data would show that the United States in the past has done a better job than other companies in terms of start and growth of new firms, and that job growth is literally based upon firms that are less than five years old.

That being said, while we are looking, in most cases, at data that are three to five years old, I think it is extremely important, and I believe that Chairman Lipinski made comments to this in his opening remarks, it is extremely important to understand that our friends in China and India and other countries across the world—we have over 18,000 people who come through the Kauffman Foundation every year, and I can tell you, almost every leadership member of Singapore, of China, and of India have been to the Kauffman Foundation and talked to us about economic growth through new firm formation, job growth, and entrepreneurship. And they are rapidly implementing policies that will work in order to support that, so I don't think that we should sit on our laurels relative to our ability to create new firms relative to technologies in our labs.

Mr. EHLERS. Thank you. Dr. Peterson, you testified that a key element of assembling an innovation ecosystem is that the university research should be explicitly driven by industrial needs. How is this an appropriate venue for NSF to fund, because your mission is so fundamentally basic research as opposed to applied research? Could you clarify that for me, please?

Dr. PETERSON. Yes. I would be happy to. First of all, I think it is important to state that the NSF's mission is, as you correctly point out, first and foremost the focus on support for basic research in science and engineering. Even within the engineering directorate, which has probably more substantial interactions with industry than any of the other directorates, we would not argue that point at all.

But there is an element of our portfolio, investment in those kinds of research activities that take the discoveries from—that were generated from basic research, and conduct research to the next level that would perhaps provide more evidence of potential marketability and commercialization, that we feel is an important element of our portfolio.

That is not to take away from investments in basic research, nor is it to redirect support or move the mission, the primary mission of the Foundation away from its fundamental mission of supporting basic research. But particularly for directorates like engineering—and by the way, I think it is not just engineering but other directorates as well, that have an important social contract with industry or commercialization—in the education arena, for example,

there are applications that are developed through research and education that are important for school districts and interactions throughout the country, so I think having that capability is an important part of the NSF portfolio.

Mr. EHLERS. Thank you. My time has expired. I yield back.

Chairman LIPINSKI. We will get back to that a little later maybe in my questioning.

The Chair will now recognize Dr. Baird for five minutes.

Mr. BAIRD. I thank the Chairman, and I thank our witnesses. This is a fascinating topic, and I commend the Chairman for raising this issue. It is something that we have talked a fair bit about in this committee.

I met with a lot of entrepreneurs in academia and the private sector, and particularly in academia one of the things that has come out is the—and as a former department chair I sure see this—the internal reward structure within academia is antithetical to innovation development in the practical world.

And by that I mean, you publish a paper, which is—you give it a conference that no one listens to, and then it sits on a shelf and makes no difference at all in the world. But you get tenure, and once you got tenure, you can then teach your students to publish papers that you can present at conferences, and you make no difference in the world except that you get a nice salary and summers more or less off.

I don't think that is very constructive to our economy to have such bright people doing meaningless things, and I won't make it as a university professor again, but my question is isn't there some fashion in which we can seriously look at the reward structure for innovation within the university setting, and is there a way—Mr. Watkins, you have extensive recommendations in your documents, Mr. Kane, all of you. But I am particularly interested, is there some way to sort of leverage this, either explicitly or implicitly, meaning, can we not urge universities to say, if you have got a really bright, typically young entrepreneurial faculty member, that they may fail in their endeavor, but if I had a choice of presenting one meaningless paper or really vigorously digging into an alternative energy source that could transform the world, pick B and reward B.

Our culture in universities is the opposite of how high tech gets going. So I am going to throw that out there. There is some allusion to this in some of your comments, but I think we really need to push this.

So let me put it out and see what we can do with it.

Ms. MITCHELL. Thank you, Mr. Baird. I am really happy to be here today. I would like to note, in my testimony I have a quote from Michael Crow. The Kauffman Foundation was asked to co-host a summit at the White House, an energy innovation summit with the Department of Energy and a few other agencies, and I can tell you this was a topic of vigorous discussion and agreement in that meeting. And Michael Crow, the President of the Arizona State University, was quoted as saying, "We must first design and implement new models of higher education to achieve the levels of connectivity, transparency, and speed of technology, commercializa-

tion to accelerate the innovation pipeline,” which would include, obviously, changing our incentive system as well.

As you mentioned, not only do we not reward innovative faculty members for commercialization through tenure, but we also don’t reward this in most Federal agencies relative to funding. And I would like to use that to go back to a comment to address Mr. Ehlers. You know, there seems to be—and this was much of a discussion at our innovation summit—there seems to be this long-standing myth of basic and applied research that many—most industry leaders, and Nick Donofrio, the former head of technology at IBM, addressed this at our meeting, would tell you is in most cases not reality. And we would love to fund research that would help, essentially, identify the fact that there are a significant amount of innovations in the marketplace today that came from what one would consider very basic research.

Mr. BAIRD. I think that is true. I want to—but my guess—I think that is true, but my belief is that those things happen because some really energetic, committed entrepreneurial faculty do things in spite of—

Ms. MITCHELL. Correct.

Mr. BAIRD. —the university reward structure, not because of it, and I would like it to be a ‘because of’ thing.

Mr. Watkins, you come from this background, and Mr. Kane, you have got some, and we will get to Dr. Peterson, because I think NSF may have a way to leverage this. They have got a lot of money to give out, and maybe you could encourage people to do this.

Mr. WATKINS. The key is leadership, and change is difficult in an academic environment, and there are many things we do not want to change about an academic environment.

Nevertheless, and I don’t speak for all of higher education on this point, but having said that, I fully agree. We are seeing examples, although they are few and far between, of institutions where people have received tenure, have been promoted based on an entrepreneurial or a service component in addition to their research and teaching component, and we think this is significant.

Again, it is people driven, it is leadership driven, and we have seen some great examples in some departments where they are really recognizing this, but you are right. We have a long ways to go, and it is a culture change, a culture adjustment is probably the better phrase, that needs to occur, and it is going to be dependent upon leaders as well as faculty. Faculty control their own destiny. Administrators don’t, and so as the faculty become more aware, as we teach and train and make them more aware of what this innovation system is all about, we think it will come. It is just too slow for me.

Mr. BAIRD. It is way too slow given the problems we face, and my experience also, and that of many entrepreneurs, is that the faculty who sit on the tenure review committees are often jealous of the applied people and actually penalize rather—it is not only do we not reward them. We may actually penalize them.

Mr. Kane or Mr. Crandell.

Mr. KANE. Thank you. I will give you very—three very brief anecdotes that amplify that point.

When we started Advanced Diamond Technologies, my two co-founders were scientists at Argonne, and even though the efforts that we underwent to get the company started were done with the full cognizance of management, their efforts were not recognized in their career trajectories. So in effect, they had two jobs for the duration of the amount of time that it took to get the company off the ground.

Ultimately, one of them, who was a real high-potential scientist at Argonne, quit to join our company full time, as he then deemed that professional opportunity to be better than staying in career research, and it is unclear to me whether that was a good outcome for Argonne or not.

I know of a tenured professor at a Big Ten university who started a company and is now leaving, also to join that company, and I know of another professor who was on the tenure track at a Big Ten university who had some very promising technology, and when I went to approach him, was basically told, leave that guy alone until he gets tenure, because we don't want to distract him with a start-up company.

Mr. BAIRD. Thank you. QED [quod erat demonstrandum].

Mr. CRANDELL. Maybe just to add a little bit to Neil's testimony in that I think these issues are solvable at large, private research universities by providing start-up incentives to faculty that are interested in spinning companies off. They can own a piece of it, they can usually sit on the Boards of Directors, they can serve as advisors, they can stay at the university and continue to do great research.

I think at public universities there is more of what I would call a fish-bowl effect, which is—gets a little bit to jealousy, but I think also to issues of hindsight, the 20/20 rule, where sometimes the problems of success from a conflict of interest standpoint are much more severe than the problems of failing quietly.

And then I would say it is most severe in my opinion in the national lab system, where it is extremely difficult for a host of reasons, including conflict of interest, handling very thorny IP issues, and then the notion of holding equity in a startup which you spin off are still very, very difficult problems to solve and take an extraordinary amount of time to work through.

Chairman LIPINSKI. Thank you, Dr. Baird. My experience, and I probably shouldn't go too much into this, but I was going to say, my experience even in political science certainly mirrors what Dr. Baird was speaking of and the idea also that someone would—there is a stigma to being too recognized in the popular press and ever getting your hands dirty by ever doing anything that had anything to do with real government or politics.

So I think it is a university, academia-wide issue, and I think it is going to take a real effort to try to change the, you know, change the environment.

So with that I will—the Chair will recognize Mr. Bilbray for five minutes.

Mr. BILBRAY. Thank you very much, and Mr. Chairman, I just got to say as a layman that the Doctor's explanation of academia and the way it functions almost makes me start understanding quantum physics because obviously a bunch of very intelligent peo-

ple doing nothing is the—a parallel opposite universe from what we see here in Congress too often, so I think that I am going to miss Brian's enlightenment on this committee in the future.

I think that there was some discussion here that I would like to get around to, and one of the things I want to clarify on is Mr. Watkins used the term 'government' generically, and we do that all the time here. In fact, I will tell you something. That is one thing I am upset with my Republican colleagues in talking about government as if all government is the same, and there isn't a separation in this country, which is, I think, one of our great, unique advantages we have.

But when you were talking about government, were you mostly talking about the Federal Government and every once in awhile talking about state or—

Mr. WATKINS. That is correct.

Mr. BILBRAY. Okay. I just wanted to make sure we clarify that because I think we, especially in this town, have a problem with being so generic we forget about many of the universities are being financed by state governments and the essentials in there.

One thing that I really feel strongly about is that we don't look at what we are doing right and what we are doing wrong, and I get into this, Mr. Kane, you know, government always throws money at situations, and we threw tons of money at Mr. Langley when he was going to develop flight, and his planes kept falling into the Potomac, which is kind of—is an academic exercise on one side. And I think that when we talk about the mix, what is, you know, practical science applications, some people might have thought that the Wright brothers' study in their wind tunnel with laminar flow was some abstract thing that may not have had a practical application, but I think history has proven that was the difference—not the amount of resources, but the type of research that was done that made one program successful and the other one with massive amounts of government effort was very unsuccessful.

The question I have to you, though, is that you talked about the importation of those minds that we may be able to use as a natural resource. Do you have any idea what kind of numbers, annually, we would need to bring in—change our visa policy to be able to reflect that need?

Mr. KANE. I am afraid I really don't have those numbers, but I will respond by sharing with you a strong sentiment that the government's perspective needs to change from picking winners to knowing that by stimulating scientific research, it is also stimulating the private sector to compete with those companies.

And so in the case of the example that you gave, and I am not familiar with the work that Langley did, but arguably if he created competition which spurred the Wright brothers on, then it was probably a wise investment and I—

Mr. BILBRAY. No. He had connections in the House and the Senate that was able to get him that—but go ahead.

Mr. KANE. Well, I have made my point. I—if I may—

Mr. BILBRAY. We shouldn't pick winners and losers, and that is one problem we have got to be very careful of here is giving into the pressures of lobbying rather than allowing the system to work, allowing science to work.

Mr. KANE. I learned authoritatively the other day, and perhaps Dr. Peterson can comment further on this, that in the SBIR programs at NSF, where we often compete, as you might expect, there is a lot of focus right now on creating technologies for clean water and water remediation, and we learned the other day that NSF rejected 70 proposals in the SBIR program for clean water technologies because they didn't think that they would be competitive in the commercial marketplace.

So NSF is doing its job in ensuring that—

Mr. BILBRAY. My question is, getting back on this other issue about our visa policy, would 5,500 scientists help in the process? Would that make a major impact on the effort?

Mr. CRANDELL. Maybe I can jump in a little bit. I am a past director of the National Venture Capital Association, and I think that the number is really a couple hundred thousand of the top scientific talent that—

Mr. BILBRAY. Annually?

Mr. CRANDELL. Yeah.

Mr. BILBRAY. Okay. That gives me a lot, because right now we have a program that is left over from the '40s called the lottery system where we are actually just accepting people in based on a lottery, which I think any reasonable person would say really doesn't reflect the realities now. A 1940 program design, we have had a lot of changes, and to be able to continue that while we continue to deny access to high-tech scientists I think are real important.

So I just ask that—appreciate the fact that we have been able to back this up. And Mr. Chairman, I would just like to point out that when we talk about governments and the obstruction, we have problems, too. My scientists at Scripps and UC System developed algae strains for the production of fuel, clean fuel, which can be used for sewage treatment, too, which most people don't talk about, but they had to pack up and leave California and create the manufacturing capabilities out of state because it wasn't legal to produce it under our regulations.

And thank God that there wasn't somebody around for the Wright brothers to ask them what kind of permits they had to fly airplanes over the dunes at the time, but there is a lot of these kind of things that we need to work on. And hopefully the Federal Government can lead at helping science move along and also challenge our—the other forms of government to participate and be part of the answer rather than being part of the problem.

Thank you very much, Mr. Chairman. I yield back.

Chairman LIPINSKI. Okay, Mr. Bilbray. The Chair will recognize himself now for five minutes.

I want to make sure I make the point—we like to joke a bit about the—what is going on at our universities, but there certainly are the incredibly intelligent people doing a lot of great work at our universities, and it is not all—Mr. Baird talked about the—everyone knows, everyone who has been involved knows that at these conferences, all these papers, you know, most of them aren't going to produce something really incredible.

But there are some that will, and part of that is part of the whole research endeavor. So it is not just a question this is—it is not just that this is all hopeless. We have a lot of great people

doing a lot of great work, and it is how do we better, first of all, incentivize the research towards things that we will be contributing to our society, to our economic growth, and then what we are talking about here especially, where do we go from there to give the best opportunities, create the best environments where these will, you know, we will spur economic growth and rate, you know, products, jobs, companies.

So I want to start with, I think, Mr. Kane and Mr. Crandell. Mr. Crandell talked a little bit about this already, but I want to ask if you could provide us with some insights in to how you identify promising investment opportunities and develop relationships with academic researchers.

And the second part of that, how do you think the NSF can help facilitate more interaction between researchers and entrepreneurs and, you know, we are also talking, of course, venture capitalists. So start with Mr. Kane.

Mr. KANE. Thank you, Mr. Chairman. The second part of your question, which I think was directed to me, was how can NSF facilitate more interactions with entrepreneurs and stimulate start-up businesses. Did I get that right?

Chairman LIPINSKI. Yes.

Mr. KANE. Thank you. I addressed some of that in my written testimony, and I will reiterate it here. First, I think that NSF needs to be a catalyst for encouraging the development of business skills among STEM students. I know that that may not sound as though it is the primary mission, but I have observed firsthand in all of the companies that I have been involved with that the lack of what I will call 'horizontal' or 'soft' skills among technical students coming out of school is a major impediment not only to their professional success, but ultimately to the success of the companies that get formed. That is number one.

Number two, I do think that NSF has a mission and perhaps a voice in government to encourage university policy, as has already been discussed, to make sure that efforts that faculty undergo to help start businesses is not viewed neutrally or negatively on their tenure track or professional trajectories.

I think if we do those two things, coupled with many other efforts that have been discussed here, I think you would remove the stigma, such as it were, among academics, from pursuing startup businesses and instead have that activity be encouraged by the Administration and have it be consistent with academic meritocracy. And if you did that, I think there would be quite an explosion in new businesses.

Mr. CRANDELL. Fair enough. I would perhaps make a couple of quick observations, and thank you, Chairman, for the opportunity to speak on this.

Fundamentally, companies are built around people. Even though we have been talking about patents and technologies, you need to find a way to find—to develop these teams of scientists that have breakthrough ideas, of entrepreneurs that are excellent managers, and of investors that are—that know enough about the things that they are investing in to be comfortable putting money behind those individuals, to build these efforts.

So in order—in our experience at ARCH we backed, I think in the last 25 years, over 120 companies; the vast majority are university- or national lab-related. I will say, parenthetically, it is certainly not the easiest way to make a living, but it is what we know how to do, so that is what we are doing.

You know, it is a critical element to get the people that have the money and have entrepreneurial skills into the labs and develop those relationships with the leading scientists, and, again, in my view, the easiest place to start is to look for the centers of excellence, the places where individual universities or research are at a global scale, and you can develop your own indexes to do that. You can look at publications, you can look at the size of programs, you can look at awards that faculty have won to triage the broad group of faculty at a university, and maybe identify the 10 or 15 that you really—that really have the big ideas.

And then we spend a considerable amount of time talking to those individuals and having them tell us about the future, and then we look to build companies along the thrust lines that they tell us about. And then we have to go out and try and validate that with industry, and all that sounds probably very complicated and involved, and it is, and it may take six months or a year, and it takes some level of resources on what I would term very, very high-risk capital, to take the time and the effort to run down and understand the constraints that an industry application would impose on a breakthrough. So much of it is walking the halls, trying to spend time with the people that are the leaders, trying to identify them early.

Second, we spend a considerable amount of time looking for that validation because you clearly do not want to invest a ton of money and then hope it all works out. Our ‘hope’ model has been largely invalidated. And the last part would just be that we need to be able to capture strong, intellectual property in order to enable that type of capital to come together, and that means the more you know about the industry application, the earlier, the better patent applications, the better, you know, are probably going to result.

Chairman LIPINSKI. Mr. Crowell.

Mr. CROWELL. Thank you, Mr. Chairman, for allowing me to take a quick crack at that from the university perspective.

I certainly agree with the comments from my panel, co-panel members and Congressman Baird and others about the importance of things like tenure policy and incentivizing faculty participation, rewarding success, and particularly impact in the tech transfer and innovation arena.

But at the same time I will also say that those types of things are the subject of policies and cultures and histories that are awfully hard to influence. It doesn’t mean we shouldn’t try, but we really need to keep after that.

What I think—responding to your question about what the NSF could do, from my perspective, is really focus on this translational proof of concept space. I think they do a great job of funding basic research, as does NIH and other Federal agencies. Where we really need to, I think, roll up our shirt sleeves and go elbow to elbow is to partner with the academic scientists, the technology transfer personnel, regional, local venture capitalists, entrepreneurs, and

industry representatives so that we can have a very high-touch, high-contact interactive process to be sure that we are taking science that really does have commercial and market potential and bringing the types of expertise together to be sure that the follow-on work is actually relevant to getting it out.

That is, I think, an area of great need, and one where the NSF, through initial programs and PFI, the I/UCRCs, some of the programs that Dr. Peterson mentioned, have already started to create that sort of an environment. At the end of the day, creating an ecosystem within the university is really what I am talking about, in order to make it easy for faculty to participate, for them to see this as a logical part of their scholarly and intellectual endeavors.

And I believe that the rewards and the recognition from that will follow in due course.

Chairman LIPINSKI. Thank you.

Ms. MITCHELL. As I mentioned in my introductory remarks, we absolutely agree relative to proof of concept centers. One thing I would definitely want to underscore, and I think the NSF is one agency that has absolutely started to do this, but it needs to be done in a much bigger way—the Kauffman Foundation over the last five years has funded and worked collaboratively with entrepreneurs and venture capitalists in developing commercialization education programs, both in the energy space as well as in the biomedical device and the biotechnology area and has reached out to what we thought were university graduate students across the country that might be interested in this.

What was amazing to us is that the interest level was at the level of the faculty who are being asked to teach their students about commercialization but didn't understand commercialization themselves. And while we are a foundation, we don't have enough money to afford educating all university faculty across the country in science and engineering, as well as graduate students, and it is a trickle-down effect.

And so I believe if we are interested in commercializing science at the level of our universities, we need to develop broad commercialization education programs, and frankly, I wouldn't even use the word—there was a wonderful woman that teaches in the Stanford Medical School that told me that she has been teaching a class there for six years, and her class is in the medical school, and she tells them, what I want to teach you is opportunity, recognition, and analysis, so that if something in the lab strikes you as market relevant, you have the skills to know how to analyze that and go out and find the closest entrepreneur that can help you take that to the commercial marketplace.

Chairman LIPINSKI. Thank you. Dr. Peterson, do you have something to add there?

Dr. PETERSON. Well, if you would like me to—

Chairman LIPINSKI. Since we are speaking about the NSF.

Dr. PETERSON. Right. Yeah. My resume is up to date, and it may need to be after I answer some of these questions, but let me say, first of all, as the head of an engineering directorate and as a former engineering dean, I certainly am very sympathetic and, I think, understanding and appreciative of the importance of the entrepreneurial activities of faculty.

And I do believe that through many of the programs that have been talked about here today, programs that I have mentioned at NSF, we are providing a culture and an environment in which those sorts of contributions are recognized and rewarded. And I can only say, it has been, in my experience, that at least within communities like the engineering community, contributions to entrepreneurship are recognized.

I think there is a long—universities have a long ways to go with regard to, say, parity of understanding and appreciation for those contributions to the same level you would for other research endeavors, but I do think we have made some progress.

I also think it is important to point out that even for those who perhaps don't believe that there is a mission at all for basic research, and I certainly don't subscribe to that, and I am sure not all—any of you do, either, but even if you accept that as a premise, there have been many important commercially-viable ideas that have been developed through pure serendipity. Research concepts that were going in one direction and resulted in fantastic contributions for commercial application in quite a different direction. And I don't think you are going to get that without the support for basic research and science and engineering.

Chairman LIPINSKI. Dr. Ehlers, do you want to—

Mr. EHLERS. If you would yield me some time, I would like to just make a few comments.

Chairman LIPINSKI. I certainly will yield.

Mr. EHLERS. Especially picking up on what Dr. Peterson just said. The Langley example, which my colleague from California gave, I noticed some puzzlement in the audience about what it was, but Mr. Langley was trying to build an airplane, and I am not quite sure why he launched it over the Potomac. I guess he was confident it would fly, but it plunked.

That could be regarded as a failed experiment, but when I was at Berkeley I remember when Luis Alvarez was trying to investigate something by watching cosmic rays go in through the—he was trying to locate a tomb in a pyramid by looking at the cosmic rays which went through and trying to find it, and he didn't, and newspapers said, isn't it terrible to not find—not get a result? He said, no, I got a result. I now know where it isn't.

And that is similar with the Langley case. His experiments proved how you should not build an airplane, and I think most of us who have worked on experimental science have uncovered that.

I don't have the same dim view that my colleague from the West Coast has about the results. I actually enjoyed all the experiments I did. I learned something from all of them, and I am convinced the world is a better place because of them. Even if, though, there are only five other people besides me who understand the results.

But, in fact, you learn a great deal by experiments that fail. I recall I spent four months on one experiment and discovered that it simply could not be done because of the characteristics of that particular material.

So I think failure makes science fun, because when something doesn't work, it is very frustrating, but trying to find out why it doesn't work is, indeed, very important to the advancement of science, and so I always take up the defense against laymen who,

well, particularly, what was the Senator's name who had the Golden Fleece Award? A number of those projects were very good projects, and I—you never know what you are going to learn in science, and you never know what potential commercial experiments you can perform with it that would really be productive, in fact, profitable.

One great example is when AT&T was trying to establish a link across the Pacific Ocean to communicate by telephone to Asia, and they built this immense magnet because they were going to have the world's biggest transmitter, and it failed. However, E. Lawrence across the bay in Berkeley was looking for a great magnet, so he went over, so he went over and said, may I borrow your magnet. He did and produced the first large-scale synchrotron.

So virtually every failure has a good side to it, and as long as the researcher still gets paid for it, I think it is a good thing.

Thank you.

Chairman LIPINSKI. Thank you, Dr. Ehlers.

The Chair will now recognize the Chairman of the Full Committee, Mr. Gordon.

Chairman GORDON. I thank you, Chairman Lipinski. This has been a very good hearing. This is an important hearing, and I don't want to be late. My daughter just graduated from third grade, so that is why I am late today, but it no—it doesn't take anything away from this important hearing.

Dr. Peterson, could you tell me a little bit about the STAR METRICS, what you are doing there, and—or anyone else that might have some interest in that. Where does it stand, where is it going? I know there is a lot of information, you know, and how hopeful are you that you really can bring this, you know, together.

Dr. PETERSON. In the social, behavioral and economic sciences directorate, one of the primary program officers is focusing on this particular issue Foundation-wide. It is broader than that activity. In addition to that, there are a number of ongoing activities looking at evaluation and assessment throughout the Foundation, looking at not only the metrics in this program but also other metrics.

I think we have within, particularly within the directorates like engineering, we have been pretty good at evaluating programs that have industrial ties or other activities but perhaps not as good at evaluating long-term what the overall outcome of our investments have been in certain specific areas of fundamental research, and so we are looking at ways that we could do this in a more organized and quantitative fashion.

Chairman GORDON. I think as we go forward, obviously, if we are going to maintain our lead technologically, you know, if my third-grade daughter and Brian's twins are not going to inherit a national standard of living less than their parents, then we are going to have to continue to invest. We are going through a difficult time right now in terms of dollars available, and so I think that we need this kind of research that would let us—show us that the dollars are invested wisely.

And if something isn't paying off, then we need to go somewhere else. And I was at an inter-parliamentary meeting on this last week, and there are some parliamentarians from the EU that are very interested in this, too, and doing something on a joint basis.

So does anyone else want to add to this, and could you also tell me a little more about what kind of timeframes that you have?

Dr. PETERSON. Yeah. Actually, let me say that we also are collaborating with the activities in the UK and EU in general on this, and let me just articulate one challenge to this process, and this is not meant to excuse lack of progress or anything like that but just to kind of explain what some of the challenges are. I think we are all in agreement that we really do want to get a better grasp on just what we have accomplished globally in our investments and specific research areas, not just with respect to commercialization but with respect to advancing any particular research field.

One of the challenges, however, is that oftentimes, particularly when you are looking at commercialization, you don't really see the fruits of those developments until long after the support for that particular project has come and gone. Sometimes it takes 10 or 15 years for certain commercial products to develop from the basic research ideas.

So you can do assessment and evaluation while the—for example, while NSF is supporting projects or continuing projects, or you can take an historic look back at the ensemble of programs that you have supported and try and determine how your investments have paid off in that respect.

So those are the two challenges that we are trying to face.

Chairman GORDON. Yes. I mean, I am a little skeptical of just being able to get your arms around it, and we certainly don't want to, I mean—I hope when I say 'skeptical' it is not that I don't want to see success, but I think it is going to be very difficult, and we don't want to get into a situation where we are disincentivizing basic research for the more applied research, where those metrics will be easier.

Dr. PETERSON. Right. No. I think that is exactly right, and as I said, we understand that it is perhaps easier to make those kinds of evaluations when you can look at quantitative specifics like patents or licenses or companies spun out and so forth and perhaps not as easy on the basic research side, but nonetheless just as important.

Chairman GORDON. So what is your timeframe, and are you 90 percent or 20 percent optimistic about being able to accomplish this?

Dr. PETERSON. Congressman, could I get back to you on that? I can tell you where we stand right now with regard to our activities in the engineering directorate. We have an evaluation and an assessment group that is going to deliver a report to us this summer, and I do know that Julia Lane and her colleagues working on the STAR METRICS Program have similar timeframes. Whether that is sort of an interim report or an interim result or a final report, I am not sure, but I would be happy to get a specific answer to that question for you and get back to you.

Chairman GORDON. Does anyone else want to give a quick response there?

Thank you, Mr. Chairman.

Chairman LIPINSKI. Thank you, Chairman Gordon.

I am going to officially start a second round of questions here, and the Chair recognizes Dr. Baird.

Mr. BAIRD. Thank you, Mr. Chairman.

I just want to underscore, I am well versed in basic research and the importance of that. I have studied the history of science, taught science research methods. You know, Feynman has got this great thing about the pleasure of finding things out and this wonderful personal anecdote of trying to figure out the rate—the relationship between the rate at which a plate was spinning and its wobble, and that led to some fundamental physics. I get it.

But I have also seen too many times where the application—when you ask, so what, the explanation comes as rationalization, not as reasoning, and it is, well, I guess you could, and somebody has done a line of research, and they haven't really thought about the applications.

We have got a \$13 trillion debt, \$1.3 trillion to \$1.5 trillion deficit, the climate is overheating, the oceans are acidifying, we have got energy challenges, we have got healthcare challenges, drug-resistant diseases, et cetera, et cetera, and the public is paying taxes for this.

Now, we have got to fund basic research. I am passionate. I have defended it at the risk of my career, quite literally, on the Floor of the House in the face of negative earmarks by our friends on the other side of the aisle.

So I get it, but the community has to change its perspective as well, and I want to drill down on this a bit. Has anyone done a content analysis, and maybe Ms. Mitchell, this is germane to your work, a content analysis of the tenure and promotion criteria of major universities as incorporating the themes we are addressing here? In other words, look at them, read them. Do they give you any credit for doing this stuff?

Ms. MITCHELL. No, I don't believe that analysis has been done. I do know that there are at least two universities over the last couple of years that have changed their tenure requirements. Unfortunately, I don't know that we are even going to see an outcome from that. I mean, my fear of adding patents as a component of tenure is that it could lead us to down the road of over-patenting inappropriately.

Mr. BAIRD. Yes. I am not saying you add it as a mandatory thing. What I am trying to say is you get some flexibility to this process so that if somebody spends a couple of years working on an actual, applied, and it doesn't have to be commercial by the way, because I am a big believer in supporting non-profit entrepreneurial efforts which are excluded now from our SBIR money and shouldn't be, but it is the applied, the bench work that goes beyond the basic research.

So I just want to urge us to try to see what we can do on that, and maybe there are some best practices that have really spawned some successes.

The second thing I want to ask about is, so we have got the basic NSF model, which is as good as there is in the world, and we have done some great stuff with that. But it has been mentioned a little bit, so what is the logical next sequence? You know, if you were to—if this were a manufacturing process, and I know it doesn't work like manufacturing, blah, blah, blah, but you still have to have a sequence where something starts here and it gets to here.

And we talk about the Valley of Death in terms of capital, but what about the Valley of Death in terms of intellectual structural assistance, and some of you have alluded to it.

My point would be, let us suppose NSF gives a grant to some bright, energetic person, they do some basic research, and then they have, whatever, the opportunity analysis, that was a felicitous phrase somebody used earlier, what is next? What do we have, structurally, that is next so that we would say to them, once you do this, you go here, and that can lead you to here.

Dr. PETERSON. Let me just give you a very brief answer with regard to what is next as far as NSF is concerned. You have heard in a number of the testimonies this morning that there sometimes is a disconnect between the technology and the entrepreneurship of the faculty, and the ability of that faculty member's institution to support the potential commercialization.

I don't believe NSF is in a position of making wholesale changes in investments and tech transfer offices and legal aspects and so forth in intellectual property offices. But what we can do is recognize that as part of the criteria for next steps in support, one looks not only at the technical content and the technical strength, but also the university's capacity to handle these kinds of entrepreneurial activities.

So in other words, there would be review of both the technical strength as well as the university structure. So we haven't fully formed the criteria for this kind of a solicitation, but I can tell you that is going to be an important element, if the FY 11, budget is approved for us, going forward in our partnerships for innovation, where we—we are a component of that. We will look to support institutional, center-like activities. Again, not to provide money for, you know, lawyers or tech transfer officers and so forth, but to make a clear statement that from the point of view of NSF, it is equally important to have strong technical background as well as institutional support for this kind of activity.

Mr. BAIRD. Excellent point. I have got to run in just a sec. Can I ask the Chair for a 30-second indulgence?

When we passed the *America COMPETES Act* out of this committee a few weeks back, there was an amendment offered that would have said the following. I am reminded of Mr. Kane's testimony. The amendment said none of the money authorized by the program, which included National Science Foundation, ARPA-E, et cetera, could go to anybody who was not a United States citizen, let alone a legal resident.

I am just asking. Good idea or bad if you want to stimulate the American economy? We will just go down—Dr. Peterson.

Dr. PETERSON. Very bad idea.

Mr. BAIRD. Ms. Mitchell.

Ms. MITCHELL. Very bad idea.

Mr. BAIRD. Mr. Crowell.

Mr. CROWELL. Very bad idea.

Mr. BAIRD. Mr. Watkins.

Mr. WATKINS. Bad.

Mr. BAIRD. Mr. Crandell.

Mr. CRANDELL. Bad.

Mr. BAIRD. Mr. Kane.

Mr. KANE. Ditto.

Mr. BAIRD. Thank you very much. I just would insert that for the record. Thank you, Mr. Chairman.

I concur by the way. We had the vote, so we had the votes. In this case we had the votes. We defeated the amendment, but it would have been destructive to so much. Thank you.

Chairman LIPINSKI. Thank you, Dr. Baird. I think I knew where you were on that one before you said that but I am really looking forward to your new career here to completely remake the American university system.

Mr. BAIRD. Countless universities are looking for me.

Chairman LIPINSKI. Thank you. I just want to—I will recognize myself for five minutes and see how—I don't want to keep this going for too much longer, although there is—this has just been a wonderful opportunity, and I would like to continue this, and we will see what we can do formally and informally to continue this discussion.

But I want to—the question I wanted to—one thing I just wanted to make sure, I wanted to ask here, is a number of you have voiced concerns over the ability of institutions to attract and retain the necessary level of expertise, you know, talking about universities, within an institution's technology transfer office.

I have just anecdotally, and I haven't even—I have not looked into this, and it is something I have often asked but haven't really dug into it. I have noticed that so many more universities seem to be having a technology transfer office. And my understanding of it is that these vary tremendously in what exactly they do.

In some ways it seems like it's just sort of the—it is a fad in some ways, because I think that there is an understanding—fad not in a bad way, but universities are seeing other universities do this, and they also see the opportunity to make money in this, and this is not a bad thing, but I think we need to be focusing on how to do this correctly.

And one thing I want to ask for is, do you have any suggestions on how we can incentivize, increase the recruitment of qualified individuals to an institution's technology transfer office? I mean, specifically Mr. Crowell and Mr. Watkins and Ms. Mitchell I wanted to ask about that.

What in general can be done? What makes a good technology transfer office?

Mr. CROWELL. Yeah, I would like—thank you very much for that wonderful question, and obviously it is a subject that is near and dear to my heart.

I think your observation is correct that more and more universities are getting into the technology transfer business. You mentioned one reason was that many presidents or perhaps Boards of Trustees see the opportunity to make money. Let me add one more, and that is, many are being pressured to do it because their governors, their legislators, their regional economic development entities are really wanting to partner with the universities, no matter how large or small and no matter how intense the research infrastructure may be, in order to capitalize on the innovation capacity that exists there.

So there is a real push to create a resource, and not just the major research universities but regional and very small universities. In North Carolina I think most of the 16 campuses of the UNC system, for example, now have a technology transfer office. Those research budgets range from \$750 million a year to less than \$10.

So you might argue that each one doesn't need one, but when a brilliant idea comes up at the university with \$10 million, what are you going to do to get it out?

Specifically with respect to the training and attraction and retention of really good people in the field, whether you are talking about a large, well-established program or a relatively new one, there are a number of resources certainly available. There are certification programs; there is the Licensing Executive Society; more and more business schools are teaching courses related to product commercialization, intellectual property management. Sort of the key concepts and key principles that a qualified technology transfer officer needs to know. There are certification programs starting to appear. There is a certified licensing professional process underway within just the last few years seeking to bring a level of some common practice, if you will, and common levels of ethics and understanding and of competence and experience, if you have those initials after your name.

Those programs are quite new, but I think it is an effort that is underway to perhaps address a problem or concern that is underpinning the question that you have asked.

Your question about what makes a good technology transfer professional—I think the slate is absolutely wide open on that issue. I have been in the field 23 years, as I mentioned. I have seen—some of the best people have come out of science with no business background. Others have come out of MBA programs where they had to learn enough science to succeed. The fact is that there are a large number of skills and functions and attributes necessary to manage IP, to negotiate deals, to assess value, to understand markets, to interact within the innovation ecosystem to bring value and results to the process, and I think a 'one size fits all' or a specific prescription on where those people come from is probably not wise or not available.

So thank you.

Ms. MITCHELL. I would just like to comment here. Mr. Crandell being on the panel and also having a rich history in venture capital, the role that a venture capitalist takes is looking at very early stage technology and trying to determine the market relevance and bringing it to market, and that is not dissimilar to the role that our current technology licensing offices take.

And Mr. Crandell in his role, and I would assume the expertise of many of the people on his staff and the amount of money that they probably are paid in the free market is significantly different. And that is why I will refer back to comments in my testimony—is that we at the Kauffman Foundation believe that there should be a free market directive and that would lead university technology licensing officers to specialize, or in many cases turn to outside agents with appropriate expertise.

In some cases the university might not need to, other than for administrative reasons, have their technology licensing office, but could continue to earn licensing revenues and less the fees charged to outside TLOs [Technology Licensing Offices]. Federal agencies funding research need to be active in reviewing these institution-specific technology commercialization practices somewhat similar that we—what we just heard here, but most importantly I think—and this discussion happened a little bit earlier but not to the degree that it should—is how do we measure the performance of that office, and I think that needs to drive, you know, what kind of people we need to be doing, completing this role.

And I would put forward that performance should first be measured by innovations moved to market, not revenue generated, and that we really need to address this question of how are we evaluating the outcomes and measuring the outcomes of university innovation in addition to the kind of people that are in this role.

Thank you.

Chairman LIPINSKI. Thank you. May I add one quick remark? I have encountered many licensing offices, and what I can tell you is that irrespective of the background, the tech transfer officers who seem to be most successful are the ones who are able to earn the trust of the professors.

The ones who, when the professors think that they are acting in their best interests and are easy to work with, et cetera, those are the ones who are successful. When the professors are hostile to the process, it doesn't matter what the qualifications are of the tech transfer officer.

Chairman LIPINSKI. Thank you. Mr. Watkins.

Mr. WATKINS. I would echo the concept of trust there. It is absolutely essential. But when I started in this business in the mid '80s, I attended what was called the Society of University Patent Administrators, for the one year, and that kind of shows where this industry began. We were administrators of patents. That evolved into AUTM, the Association of University Technology Managers, and the question is what does it go to next. And I think there is another generation that is emerging that really has to do with more of a full service, we are calling it, kind of an innovation service provider, and it does much more than just the licensing, but it looks at the resources, it looks at what is happening in the community and the industries with the technologies, and then has idea-tion sessions and figures out how best to deal with those.

My experience is the best technology transfer professionals are those who have had experience in industry, had experience in developing and commercializing technology, have experience in the universities where they appreciate that culture. They have had touch with venture capital and often times you don't find all that in one person or you need to bring them in.

And so I think that is why a model similar to what we have done, of bringing in the community resources and the retirees, has really leveraged our internal talent to where I think we can be more effective.

So I am very excited about the future of this industry, but I think we have come a long ways, and we have a good way to go, but I am very hopeful.

Chairman LIPINSKI. Thank you. Any other—

Mr. CRANDELL. Maybe put a finer point on one aspect of this, and that is that, you know, commercialization or technology commercialization is a broad term, and in the context of a university or a national lab there are many relatively routine administrative functions that I think that compensation structures and the incentives are probably adequate for today, in part because these functions get performed.

It is not to say they can't be improved, but if you look at the best university licensing operations, they do get these things done in reasonable periods of time and make good choices on things like patent claims.

The crux of it, in my opinion, to really take the commercialization process and increase it by a multiple, is focused around a little bit more difficult challenge, which is the one of starting companies out of university research. Starting companies, period, is an incredibly difficult task. Starting companies out of universities is even more difficult, and if you are good at that, you are going to create a huge amount of value, and if you don't want to be rewarded or if psychic utility is the thing that you are chasing, then you may stay in that position forever.

Most individuals that have families, that hope to increase their wealth over time, are going to look for market rate compensation.

So I don't think we have to change the entire compensation structure of the commercialization effort, at least that wouldn't be the first step in my mind, or to study it. I think we need to look at the folks that are doing the incredibly heroic efforts to help pull these companies together to make these teams of entrepreneurs, scientists, and investors, and we need to find a way to get those up to market rates in order to help the process be as sustainable and productive as possible.

Thank you.

Chairman LIPINSKI. Thank you, and with that I want to thank all the witnesses for their testimony today. I know I could stay here all day, but I don't think we will be doing that. The record will remain open for two weeks for additional statements from the Members and for answers to any follow-up questions the Committee may ask of the witnesses.

And at that the witnesses are excused, and the hearing is now adjourned.

[Whereupon, at 12:08 p.m., the Subcommittee was adjourned.]

Appendix 1:

ANSWERS TO POST-HEARING QUESTIONS

ANSWERS TO POST-HEARING QUESTIONS

Responses by Ms. Lesa Mitchell, Vice President of Advancing Innovation, Ewing Marion Kauffman Foundation

Questions submitted by Chairman Daniel Lipinski

Q1. The need for gap or proof of concept funding has been identified as one of the barriers to increasing the commercialization of university-based research discoveries. What is the appropriate role of the National Science Foundation in proof of concept funding? If NSF were to provide proof of concept funding, how would such funding differ from and complement the grants it awards through the Small Business Innovation Research program?

Specifically, a number of organizations have recommended the establishment of university-based proof of concept centers. Is this an appropriate funding mechanism for NSF to pursue, or is this more appropriate for other agencies that perform mission-specific applied research? If so, which agencies should be involved in the establishment of proof of concept centers and how should the funding be structured?

A1. Proof of concept (POC) resources (include project management, external boards and actual funding to support a project) are needed pre-firm formation and preferable when a technology still lie within the university. POC resources are important at this stage as they will not only allow the technology to be exploited while still within the confines of a not for profit but they will also provide graduate students actual commercialization experience as a critical component of their education.

The National Science Foundation is uniquely positioned to manage this model as a pilot. Their productive experience defining and managing Engineering Research Centers uniquely qualifies them to provide over site to what could be considered a pilot program. That being said, all Federal agencies provide research funding should be supporting POC models to enable translation of the research funded into the commercial market.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Mr. W. Mark Crowell, Executive Director and Associate Vice President, Innovation Partnerships and Commercialization, University of Virginia

Questions submitted by Chairman Daniel Lipinski

Q1. The need for gap or proof of concept funding has been identified as one of the barriers to increasing the commercialization of university-based research discoveries. What is the appropriate role of the National Science Foundation in proof of concept funding? If NSF were to provide proof of concept funding, how would such funding differ from and complement the grants it awards through the Small Business Innovation Research program?

Specifically, a number of organizations have recommended the establishment of university-based proof of concept centers. Is this an appropriate funding mechanism for NSF to pursue, or is this more appropriate for other agencies that perform mission-specific applied research? If so, which agencies should be involved in the establishment of proof of concept centers and how should the funding be structured?

A1. Quoting from my testimony before your Committee, “at the University of Virginia, we fully support the President’s proposed FY 2011 Budget Request for \$12 million for a new “NSF Innovation Ecosystem” component within the Partnerships for Innovation program. But we believe much more investment is needed in order to ensure that proof of concept initiatives . . . are in place and accessible to capture and translate the innovations emanating from universities nationwide.” We urge funding at levels much higher than that noted above—and suggest consideration that 0.5–1.0% of the NSF budget (and other agencies as well) be allocated to this need. We suggest that this funding take the form of Translational Research Supplemental Awards, or even *de novo* Translational Concept Grants available for good ideas even if not based on another Federal grant.

We also feel strongly that this funding should be accessible to universities in all regions and not just in selected regional settings—because talent and innovation exist everywhere. We thus support the concept of “democratizing innovation.” We believe the review process for such funding should be rigorous, market-focused and “high-touch”, with corporate partner input and development milestones being key components for initial and ongoing funding. We feel strongly that the same kind of rigorous review process employed with extramural research grant applications could be brought to bear with respect to Translational Research Supplemental Awards, or Translational Concept Grants. We are pleased to note that these recommendations were supported in the “wrap-up” portion of the recent NSF PFI conference on “Innovation Ecosystems” organized by U.Va.

We also support the concept of incorporating into the review process for NSF grants—especially those focusing on or leading to translational research—an assessment of the technology transfer and innovation management capacity of university applicants. Relevant review criteria should be developed which reflect input and best practices derived from interactions with senior and successful technology transfer practitioners, investors, entrepreneurs, corporate business development officers, patent attorneys, and others, and care should be taken to coordinate the development and utilization of such criteria with the numerous efforts underway among research funding agencies and higher education associations to develop meaningful metrics for research and innovation impact.

We do not offer this suggestion as a substitute for the current SBIR and STTR funding initiatives. Such awards, of course, are provided to small business concerns which, in turn, are eligible to collaborate in their research activities through a sub-contract to universities. SBIRs/STTRs are, of course, later stage awards simply by virtue of the requirement that the applicant must be a small business concern. The proof-of-concept funding recommended in this discussion would be aimed at—and restricted to—pre-company and pre-commercial research projects. It is related to SBIR/STTR initiatives in that we would hope that successful proof-of-concept projects would lead to high quality, high impact SBIR/STTR applications, but criteria should be developed for any proof-of-concept funding to indicate that such funding is intended for proving technical feasibility, market assessment, and commercial potential of basic research discoveries.

More than at any time in the past, university research provides the pipeline of innovation for America and the world. Accordingly, Federal investment in basic, or “discovery” oriented research, as well as in research that moves ideas into proof-of-concept work (“translational research”), is essential to the national and global econ-

omy. We feel strongly that there is no alternative other than for the government to support this critical investment in the innovation pipeline. University ideas are a small but essential step on the path to final commercialization, and the private sector provides the vast share of development and scale-up work to push new ideas to the marketplace. However, the first steps along the pathway from basic research, to translational or proof-of-concept research, to development, and finally to product introduction are a critical and unmet focal point for Federal funding—without it, our national pipeline for innovation will run dry, leaving future generations with fewer possibilities for economic success.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Mr. Wayne Watkins, Associate Vice President for Research, University of Akron

Questions submitted by Chairman Daniel Lipinski

Q1. *The need for gap or proof of concept funding has been identified as one of the barriers to increasing the commercialization of university-based research discoveries. What is the appropriate role of the National Science Foundation in proof of concept funding? If NSF were to provide proof of concept funding, how would such funding differ from and complement the grants it awards through the Small Business Innovation Research program?*

Specifically, a number of organizations have recommended the establishment of university-based proof of concept centers. Is this an appropriate funding mechanism for NSF to pursue, or is this more appropriate for other agencies that perform mission-specific applied research? If so, which agencies should be involved in the establishment of proof of concept centers and how should the funding be structured?

Response to part 1 of the question:

A1. The primary role of the National Science Foundation (NSF) should continue to be supporting education and research across all fields of science and technology by creating and maintaining the infrastructure that leads to discoveries. NSF brands itself as “where discoveries begin.” Supporting discovery is NSF’s most critical role and should remain its primary focus.

A proof of concept of an idea is generally considered a milestone on the way to a fully functioning prototype. Notwithstanding, there are different meanings for the phrase “proof of concept” in general usage today:

1. There is a narrow but important portion of the technology discovery to commercialization continuum, where it becomes necessary to *prove the concept* of an invention or an idea. “Proof of concept” in this instance is the development of an idea or lab concept only to the point of a prototype capable of being demonstrated, tested or otherwise evaluated for its further commercial potential. This proof of concept is to prove the validity of the idea or concept. It is to demonstrate the efficacy of the technology. It is not to effectuate commercialization.
2. The “*proof of concept center*” phrase as used by the Kauffman Foundation, refers to an organization that “provides seed funding to university-based early-stage research,” and also “performs services such as market research, mentoring, business-plan development, and commercial connections to entrepreneurial faculty and students.” [See <http://www.genomeweb.com/biotechtransferweek/kauffman-study-proof-concept-model-can-supplement-support-academic-tech-transfer>] Such use of the phrase “proof of concept” includes a full range of commercialization activities beyond mere proving of an invention concept. Thus it is important to clarify one’s intended meaning when using the phrase “proof of concept.” The Kauffman Foundation also references the von Liebig Center at the University of California San Diego and the Desphande Center at the Massachusetts Institute of Technology as leading “Proof of Concept centers.” These programs are more in the nature of full technology commercialization centers, the latter definition. Although the “proof of concept” phrase captures significant portions of the discovery commercialization process, I believe it is insufficient. Thus, the House Committee and NSF may consider the phrases “discovery commercialization” or “innovation services,” rather than “proof of concept.” Discovery commercialization components beyond “proof of concept” include:
 - a) Invention and product development
 - b) Scale-up and manufacturing process development,
 - c) Capital and financing,
 - d) Entrepreneurial expertise development and acquisition,
 - e) Deal structure and licensing,
 - f) Technology and commercialization advisory boards and leadership mentoring of key employees.

- g) Business formation and operation services including accounting and bookkeeping,
- h) Shared office space, equipment, and personnel,
- i) Intellectual property assessment, procurement and management services

The commercialization of technology, (the broader definition of proof of concept,) resulting from federally funded research should be performed by the research organizations that develop the inventions and should not be performed by the Federal Government. Commercialization is not an appropriate governmental role, and commercialization should not be dependent on Federal funding (other than for the funding of the underlying basic research). The research organizations, with appropriate support from the private sector and state and regional organizations are better structured and equipped to commercialize inventions. The Federal Government and its processes are relatively too bureaucratic, and less capable of ongoing improvement adjustments, to effectively provide innovation and commercialization services.

Notwithstanding, funding for prototype development (that is the narrow definition of “proof of concept”) is presently considered to be beyond the purview of Federal “research” funding. Yet, prototype development is usually too early stage and too risky to generate interest from angel, venture capital, foundation, and typical state and local economic development funding sources. Some research organizations provide such funds internally. Accessing funding for this narrow definition of proof of concept is a significant challenge in the discovery to commercialization continuum. The Federal Government should consider providing funds for such “proofs of concept”. Our experience at the University of Akron suggests that a prototype under this definition can typically be constructed for \$10,000 or less. There is no need for additional personnel, programs, or facilities—only funding for the actual proof of the idea or concept.

I propose that the Federal Government fund a five year experiment, to be administered by one of the agencies, (preferably Department of Commerce Economic Development Agency) by providing block grants to multiple regions of the country, to be further distributed as grants based on merit to universities, hospitals, and other not for profit research organizations, for the narrow definition of proof of concept (prototype or sample development). Each region would be responsible for tracking the impact of the grants. Metrics could include: product introductions to the market, patents, licenses, follow-on funding generated, licensing revenues, new companies formed, and jobs. The sponsoring Federal agency would periodically assess the effectiveness of the program to determine the appropriateness of continuing and/or modifying the program. According to the traditional Carnegie listings, there are approximately 200 public and private research institutions identified as having high or very high research activity. Perhaps 20 regional *Proof of Concept Associations* could be established, each comprising ten such Carnegie institutions, along with other institutions, hospitals and individuals located within their region. Each association would have an annual budget of \$1 million, funded by one or more Federal agencies. Each association would be volunteer-operated with team members having at least bio-medical, engineering and science expertise. Simple two-page requests for prototype funds between \$10,000 and \$25,000 would be reviewed bi-monthly and approved by a volunteer committee of regional experts from academe, industry and retired business executives. The funding would provide 40 to 100 concept ideas annually from each region, to be carried forward to the prototype stage, and capable of being commercially evaluated by the traditional angel and venture capital investment communities. This will result in 800 to 2000 prototypes per year of the best concepts nationally, vetted by professionals, to be made available for evaluation and commercialization by the traditional business communities.

Alternatively, such services could be administered by the Economic Development Agency of the Department of Commerce using the existing six EDA regions with perhaps \$2.5 million per region per year.

As an example, Dr. Joseph Kennedy of The University of Akron College of Polymer Science and Polymer Engineering recently developed a new polymer. Dr. Kennedy is a prolific inventor with more than 100 patents, including the original bi-compatible polymer, which is the basis for many medical devices that are compatible with human tissue. Industry interest in the new polymer was insignificant as they had no product to evaluate, only the theory. The University of Akron Research Foundation agreed to pay for production of a few samples for a cost of approximately \$10,000. Industry immediately became interested once they had actual material to test. An offer to license resulted. It is this type of funding that is elusive.

Response to part 2 of the question:*A. How proof of concept funding would differ from SBIR grants.*

SBIR grantees are limited to qualifying small businesses. The eligible grantees for proof of concept funds should be higher education institutions, hospitals, and other not-for-profit research related organizations. Funds would be used to prove the validity of an idea or concept, the narrow proof of concept definition, rather than discovery commercialization.

B. How proof of concept funding would complement SBIR grants.

Funding for a regional proof of concept model would support the SBIR grants program by increasing the number and quality of innovations ready to be licensed to the business community from higher education and hospitals. This would be consistent with and complementary to the current SBIR program funding.

Response to part 3 of the question:*A. Should NSF pursue funding university-based proof of concept centers?*

NSF should not pursue funding of discovery commercialization.

However, NSF may pursue funding proof of concept associations (prototype and invention validation as opposed to full commercialization) if it is determined that EDA or NIST is not in a position to fund such proof of concept associations.

B. Or, is funding university-based proof of concept centers more appropriate for other agencies that perform mission-specific applied research?

If the decision is to federally fund proof of concept associations, then NSF and NIH (to include the medical innovations) are the agencies that best cover the range of scientific inquiry that leads to commercialization activity. Notwithstanding, Department of Commerce EDA is the preferred Federal agency because efforts leading to commercialization are more consistent with its mission.

Response to part 4 of the question:*A. Which agencies should be involved in the establishment of proof of concept centers?*

If it is determined that Federal funding is appropriate for proof of concept associations, then, the Department of Commerce and possibly NIST would be the preferred agencies. Funding commercialization support services is more consistent with their missions and it is important to not dilute the focus of NSF in supporting the discovery infrastructure.

B. How should the funding be structured?

Funding for proof of concept, as opposed to commercialization, should be provided through block grants to regional associations that distribute the grants based on merit to qualifying universities and hospitals.

Thank you.

Appendix 2:

ADDITIONAL MATERIAL FOR THE RECORD

COMMENTS FROM CONNECT® SUBMITTED BY REPRESENTATIVE BRIAN P. BILBRAY



Comments by CONNECT

Submitted to the House of Representatives

Committee on Science and Technology

Hearing in the Subcommittee on Research and Science Education on

“From the Lab Bench to the Marketplace: Improving Technology Transfer”

Held on June 10, 2010

CONNECT commends the Committee for its interest and efforts in reviewing this important issue. As the nation’s economy struggles to jump start itself, the Committee’s focus on improving technology transfer is not only timely but critical.

CONNECT is a nonprofit organization, originally partnered with the University of California—San Diego, that is dedicated to creating and sustaining the growth of innovative technology and related businesses. Since 1985, CONNECT has assisted in the formation and development of over 2,000 companies and is widely regarded as one of the world’s most successful regional programs linking inventors and entrepreneurs with the resources they need for success. CONNECT focuses on research institution support, business creation and development, entrepreneurial learning, access to capital, public policy advocacy, awards, recognition and networking. More than 40 countries and regions have adopted the CONNECT model, including New York City, the U.K, Sweden, Norway, Denmark, Australia and India. To learn more, go to www.CONNECT.org

CONNECT is encouraged to learn that the Committee intends to hold hearings later this year to further explore the Bayh-Dole Act and related technology transfer issues. We look forward to submitting more detailed and topical comments at that time. Until then, CONNECT submits these comments as broad general principles to serve as guiding themes to the Committee’s review.

General Principles:

As Congress partners with the Administration to review tech transfer issues and innovation policies in general, CONNECT submits the following ideas for consideration:



- Discover what is already working: The U.S. is the global leader in innovation because American creativity and ingenuity has been allowed to develop on public policies that foster competition and equal playing fields. Although innovation already drives the U.S. economy, other countries are rapidly and intentionally closing the gap on America's innovative edge.

In order to protect America's competitive advantage, Congress and the Administration should undertake a thorough review of where tech transfer and commercialization efforts are thriving. Once successful tech transfer and innovation regions are identified, field visits and hearings should ensue to investigate what ingredients exist that catalyze such success in those regions.

CONNECT would be happy to host the Committee in San Diego for a field hearing to get a close-up view of San Diego's tech transfer success stories.

- Explore what legislative and regulatory modifications should be implemented to incentivize investment into the "valley of death": Attention is growing to the obstacles that face emerging technologies trying to find a bridge over the "valley of death." Good ideas and viable start-up small businesses exist in that pre-venture valley. Without the lifeblood of angel and venture capital, many innovative ideas will wither on the vine. Congress and the Administration should review where existing law and regulation can be modified to draw capital into the valley to assist the development of these technologies.
- Apply academic interdisciplinary models to foster collaboration within and between Congress and the Administration: In a town notorious for turf battles, the global competition America is trying to keep winning, calls on Congress and the Administration to turn over a new page in government collaboration. Congress should consider joint hearings with other committees and subcommittees of shared jurisdiction, as well as bicameral hearings. Agencies should break down traditional silos and bureaucracies that keep ideas cloistered away from each other. Through governmental interdisciplinary efforts, synergies will be discovered that will positively shape America's innovation strategy.
- Create the "U.S. Innovation Corps": Just as the U.S. successfully created the U.S. Peace Corps to loan human capital to developing countries, the U.S. Innovation Corps would loan human capital to developing innovation regions within the U.S. Several regions in the U.S. with developed innovation ecosystems have benefited from "Entrepreneurs in Residence" that use their expertise to spark creation of new businesses. Building from those models,



these entrepreneurial mentors would not only guide start-ups through the commercialization process but act as a link to larger social and professional networks.

- Evaluate how to successfully support Proof of Concept Centers: There is agreement that Proof of Concept Centers offer a model that can assist emerging technologies move their concept to the marketplace. More evaluation needs to occur to discover how to successfully replicate the model and what role government can play to sustain viable centers when private capital is absent.
- Enact innovation-related laws and regulations only when a clear consensus of support emerges: It is understandable that Congress and the Administration want to act to spark innovation that can lead the country into economic recovery; however, Congress and the Administration should be careful and wise in ensuring that the public policies being advanced are not actually hindering or frustrating innovation. In just the past few months, the House and Senate have passed bills out of their chambers that will constrict the flow of angel and venture capital to start-up small businesses. Additionally, Administration agencies have advocated policies without a clear understanding of whether innovation will be stunted. Some of these actions have advanced despite the innovation community clearly warning of the negative consequences. Enacting consensus-backed innovation policies will not only advance good public policy but will secure America's standing as the global leader in innovation.

In conclusion, CONNECT stands ready and willing to assist the Committee in the coming months. Additionally, CONNECT can provide the Committee access to a wealth of subject-matter experts not only centering on various technologies but experts in successfully navigating technology transfer and commercialization.

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STATEMENT OF SUSAN HOCKFIELD, PRESIDENT, MASSACHUSETTS INSTITUTE OF TECHNOLOGY (MIT)

The following written statement for the record is submitted to the House Science and Technology Committee, Subcommittee on Research and Science Education, in regard to its June 10, 2010 hearing entitled “From the Lab Bench to the Marketplace: Improving Technology Transfer.”

This written statement provides a description of the Massachusetts Institute of Technology’s (MIT) technology transfer practices and “Innovation Ecosystem,” offered in the hope they may prove informative to the Subcommittee and a useful model for others. This discussion is drawn from a filing on May 26, 2010 in response to a Request for Information from the Office of Science and Technology Policy and the National Economic Council in the Executive Branch.

In 1861, an act of the Massachusetts State Legislature launched MIT and charged the Institute with the “development and practical application of science in connection with arts, agriculture, manufactures, and commerce.” The MIT motto, *mens et manus*—mind and hand—underscores our distinctive commitment to serving society through the practical fruits of university research.

Our history also teaches us, however, that—without expert guidance and support—the path from laboratory discovery to world-ready product can be long, circuitous and frustrating. Brilliant scientists and engineers may know next to nothing about protecting their intellectual property or starting and managing a business; even breakthrough technologies can languish without funding at sufficient scale or a clear vision of their application. With its longstanding focus on problem solving and its constructive relationship with industry, MIT has long instilled in students and faculty an entrepreneurial attitude; in recent decades, we have also worked to provide the practical tools and advice to help their entrepreneurial ventures succeed. The result is an “innovation ecosystem” that helps good ideas traverse the “valley of death” to reach the distant heights of market success, and it has served us so well that we believe it may provide useful examples for others.

Based in part on MIT’s experience, and after consultation with those involved with technology transfer across the Institute, this statement will focus on three areas:

- Specific suggestions for changes in Federal policies, recommended targets for additional funding, and ideas regarding certain areas of technology transfer that may require additional focus;
- A detailed description of MIT’s Innovation Ecosystem, along with recommended best practices for fostering commercialization and diffusion of university research; and
- The critical role the Bayh-Dole Act plays in the successful commercialization of federally-funded research.

I. Recommendations

I believe the following recommendations for government action would encourage increased investment in basic research, enhance the impact of federally funded research, and improve the process of transferring research in the lab to commercialization by the private economy. In Section II, I provide an in-depth description of MIT’s Innovation Ecosystem, which provides additional details and best practices to support several of these recommendations.

- **Implement Model Innovation Centers.** Implement ten pilot model innovation centers across the U.S. at research universities to develop, document, and assist in nationwide dissemination of “best practices” for encouraging innovation and entrepreneurship by students, faculty, staff and alumni. These centers, similar to MIT’s Deshpande Center (described below), would engage in a variety of activities including making connections to industry and capital; educating and mentoring; creating ties to regional businesses; providing grants or seed money; and connecting faculty and students. These centers would also disseminate best practices and form the nucleus of a community amongst U.S. universities enhancing innovation. The Administration is seeking modest initial funding for such an effort in its Fiscal Year 2011 budget request for the National Science Foundation; this requires expansion.
- **Support On-Campus Mentoring Services.** Support expansion and escalation of mentoring services based on the proven MIT Venture Mentoring Service model (described below) at research universities across the U.S. Additionally, support formation of an Innovation Mentoring Consortium that would enable the sharing of knowledge, experiences, and best practices

amongst mentoring organizations to enhance effectiveness and further increase innovation output.

- **Add Technology Transfer Costs to Indirect Cost Pool.** Many schools, particularly in the current economic climate, lack funding to build a patent portfolio and hire the staff to create successful technology transfer offices. Many existing offices are now facing cutbacks. Allowing technology transfer costs (e.g., patents and staff) to be included in the indirect cost pool for federally funded research (and perhaps excluded from the administrative cost cap) could provide schools with the resources to bolster and build their Technology Licensing Office (TLO) programs.

At the same time, Federal programs (including at the Departments of Energy and Agriculture) are increasingly asking for “matching funds” from non-profit universities for applied research. This is a very detrimental move in the wrong direction, and these cost-sharing policies should be reversed. University funding streams, unlike those in the private sector, do not have a profit pool that could be allocated to such sharing.

- **Promote Policies that Encourage Entrepreneurship.** Encourage government and universities to examine their rules and regulations to eliminate barriers to responsible faculty/staff entrepreneurship. Medical schools and teaching hospitals have especially high potential for entrepreneurship that could benefit society broadly, while also contributing to economic growth, consistent with high standards of integrity. In those institutions, policies that strongly promote openness of relationships, appropriately overseen by senior faculty committees, can ameliorate the potential problems that arise from the needed medical faculty connections to biomedical industry.
- **Host Technology Innovation Fairs.** Federal R&D agencies should consider holding bi-annual technology innovation fairs that bring groups of outstanding university inventors together with supporting government agencies, companies, venture capital (VC) firms, and financial institutions in emerging technology sectors. The inaugural Advanced Research Projects Agency–Energy (ARPA–E) Energy Innovation Summit could provide a very useful model.¹
- **Support Small Firm/University Collaborations.** Encourage research agencies, where appropriate, to adopt the Defense Advanced Research Projects Agency (DARPA)-hybrid model for a portion of their funding as part of their R&D portfolios. This approach provides awards for collaborative efforts involving small firms and university researchers.
- **Examine How to Attract More Venture Capital Investment.** Conduct an examination of the factors that induce Venture Capital firms (VCs) to invest in early-stage technologies. Typically, VCs only invest in physical-science-based technologies when they are near commercialization, and they invest in very few startups during economic downturns. We need to consider what factors are leading to the decrease in VC investment rates. If these issues are studied and better understood, incentive systems could be devised to influence these trends.
- **Encourage SBA Investment in New Technology Startups.** Examine the policies of the Small Business Administration (SBA) to be sure that adequate emphasis is placed upon new businesses with high growth potential (i.e., “gazelles”). In particular, there should be an explicit focus in agencies’ administration of the Small Business Innovation Research (SBIR) Program for new technology startups and new business recipients that will accelerate technology implementation.
- **Enhance and Add Tax Credit Programs to Encourage Technology Transfer.** In addition to improving some of the structural problems in the research and development (R&D) tax credit and making it permanent, provide additional credit for funding for collaborations between industry and university researchers to accelerate technology transfer. Also consider dropping the incremental feature of the current credit, so it rewards significant, sustained R&D investments by firms.
- **Provide Post-Degree Visas.** Foreign-born immigrants have an unusually strong record of starting firms and bolstering our science talent base. This has long been an historic competitive advantage for the U.S. that few nations

¹ ARPA–E Energy Innovation Summit (<http://arpa-e.energy.gov/ConferencesEvents/tabid/69/vw/3/ItemID/12/d/20100301/Default.aspx>)

have been able to match. In order to preserve this strength, the U.S. should award five-year, post-degree visas to all foreign students in accredited university programs in STEM and management fields. These special visas should be converted easily into green cards, and their holders fast-tracked to U.S. citizenship if they continue employment in U.S. science and technology-based research and enterprises, or if they start their own U.S.-based companies.

II. The MIT Innovation Ecosystem

MIT takes a holistic and comprehensive approach to entrepreneurship and innovation that spans from education to business connections to the commercialization of university research. MIT's Innovation Ecosystem serves the entire MIT community, including students, researchers, faculty, staff, alumni, and members of the local business community. This ecosystem is founded on the concepts of: 1) nurturing and mentoring potential entrepreneurs; 2) pursuing patent protection for technological innovations resulting from MIT research to foster commercial investment in bringing such innovations to the marketplace to benefit the public; 3) engaging deeply with the surrounding business and VC community; 4) integrating entrepreneurship and innovation across all schools and departments; and 5) focusing on long-term relationships, rather than short-term gains.

The success of MIT's model is outlined in a 2009 Kauffman Foundation report that describes the Entrepreneurial Impact of MIT,² and documents the development of its Innovation Ecosystem. The report estimates that living MIT graduates have founded approximately 25,800 active companies, which employ approximately 3.3 million people and generate estimated annual world revenues of approximately \$2 trillion—producing the equivalent of the world's 11th-largest economy.

As these numbers suggest, MIT's most important contribution to the innovation economy stems from the education that MIT provides to its students, who are the inventors and entrepreneurs it educates and inspires. The richest source of innovation is a deep understanding of fundamental science and engineering, which MIT has instilled in its students for decades. However, I also believe that MIT's entrepreneurial success flows in part from a number of initiatives that over the past fifteen years have created an Innovation Ecosystem centered on our campus and spilling into the surrounding region as well. As each of its components has taken shape and expanded over the years, the bonds between them have strengthened to form a true ecosystem that is imbued with MIT's culture of innovation and entrepreneurship. Although a host of additional factors strengthen our ecosystem, below I detail its main components:

- A. The Technology Licensing Office
- B. The Deshpande Center for Technological Innovation
- C. The Entrepreneurship Center
- D. The Venture Mentoring Service
- E. Innovation Prizes
- F. The Industrial Liaison Program
- G. Cross School/Cross Disciplinary Initiatives

A. *The Technology Licensing Office*³

MIT'S Technology Licensing Office (TLO) has a successful track record that spans decades of helping MIT faculty and researchers with patenting, licensing, and starting firms that build upon technology developed at MIT. In Fiscal Year (FY) 2009, MIT received 153 U.S. patents (second in the U.S. after the combined total of the ten universities in the University of California system) and filed 231 new U.S. patent applications. Approximately 20 to 25 new companies spin out of MIT each year.

MIT's TLO aims to benefit the public by moving results of MIT research into societal use via technology licensing, through a process that is consistent with academic principles, demonstrates a concern for the welfare of students and faculty, and conforms to the highest ethical standards. This process benefits the public by creating new products and promoting economic development. It also helps MIT:

- show tangible benefits of taxpayers' support for fundamental research;
- attract faculty and students;
- encourage industrial support of research;

²Roberts, E. and Easley, C; *Entrepreneurial Impact: The Role of MIT*; The Kauffman Foundation, February 2009 (<http://www.kauffman.org/research-and-policy/mit-entrepreneurs.aspx>)

³About the TLO (<http://web.mit.edu/tlo/www/about/>)

- create discretionary revenue to support education and research;
- produce new job opportunities for graduates; and
- contribute to economic development locally and nationally.

While the TLO fosters commercial investment in the development of discoveries through licensing of intellectual property, MIT's TLO does not focus on short-term gains from licensing revenues. Rather, it focuses on the importance of building long-term relationships with companies, whether established firms or startups. This long-term approach has encouraged the development of an innovation cluster surrounding the Institute. Within easy walking distance of MIT, one can find some 150 biotech and pharmaceutical companies, a host of Information Technology (IT) and robotics firms, and now an emerging energy cluster.

In MIT's view, the following practices contribute to a successful TLO:

- Operate with a consistent mission that guides its activities, for example "impact not income" or "license as many technologies as possible, rather than focusing on income from a few."
- Be visible—particularly to the faculty—and have explicit senior administration support. Technology transfer should be seen as an important mission of the university.
- Encourage rational expectations, especially when it comes to expected income from licensed technologies.
- Develop and communicate clear and simple policies—concerning publication, Intellectual Property (IP) ownership, conflict of interest, and promotion criteria—that are consistently followed by senior management.
- Work closely with the Office of Sponsored Programs with respect to IP to align sponsored research contracts with University policy and TLO mission.
- Encourage improved awareness in the academic community about creation of IP, its value, and implications.
- Provide sufficient financial support to the TLO to build a patent portfolio, with sufficient administrative support for licensing officers.
- Engage a talented, well-trained TLO staff, with positive staff retention. Candidates with business experience are preferable, as well as those with a real understanding of academic goals and principles.
- Work closely with and be responsive to the needs of faculty and students. The staff should be easy to contact and offer prompt follow-up.
- Develop strong relationships with the outside business community, including investors, lawyers, companies, etc., through participation in industry conferences and networking, and through recruiting volunteers from the business and technical community to help in mentoring, judging, speaking at the university, etc. Encourage informal contacts between business community and faculty. This includes a strong engagement with regional technology clusters.
- Minimize "review and approval" outside the TLO to streamline the process; delegate authority downward to complete transactions promptly.
- Develop and track relevant metrics such as the number of invention disclosures per million dollars of research; number of licenses; number of startups; and, if applicable, amount of industry-sponsored research. Licensing income is a poor measure of success.

B. The Deshpande Center for Technological Innovation⁴

University faculty and researchers are unlikely to be trained or skilled in forming companies and commercializing technologies, which can be a major barrier in the technology transfer process. When it comes to recruiting investors, many also need help bridging the gap between basic research and a valid proof of concept. Equally important is reducing the technology and market risk so investors feel comfortable committing the resources to develop the technology outside of the university. To confront these issues, another fundamental component of MIT's Innovation Ecosystem has become the Deshpande Center for Technological Innovation. Established in 2002 with an initial donation by Jaishree and Desh Deshpande, the Deshpande Center is a Proof of Concept Center (POCC) that increases the impact of MIT technologies in the marketplace. Today, the Center depends on the financial and professional support of successful alumni, entrepreneurs, industry and investors to provide sus-

⁴About The Deshpande Center (<http://web.mit.edu/deshpandecenter/>)

tainable funding for innovative research and the expert guidance to help it reach the marketplace.

The Deshpande Center supports focused translational research whose data can convince investors of an innovation's technical feasibility. The Center allows faculty and students to move from an idea and invention, through the innovation process, to a prototype product. It also fosters entrepreneurship and innovation among MIT faculty and students by providing early assistance and guidance to those with great ideas who are interested in commercializing them. It's a boot camp for innovators—they learn how to do milestone-focused research, understand market opportunities and needs, and are matched with mentors from industry and their specific technology field. The Center also connects them to resources in the external ecosystem including VCs and angel investors.

Since 2002, The Deshpande Center has funded more than 80 projects with over \$10 million in grants—a process that involved more than 200 faculty and students and more than 100 volunteers. Twenty projects have spun out of the center into commercial ventures, collectively raising more than \$180 million in outside financing and employing more than 200 people. Supporting projects across a wide range of emerging technologies (including biotechnology, biomedical devices, information technology, new materials, tiny tech, and energy innovations), the Deshpande Center achieves its mission through several programs including Grant Programs, Catalyst Program, Innovation Teams (i-Teams), and holding special events.

The Deshpande Center *Ignition Grant Funding* (up to \$50,000 per grant) enables researchers and their students to pursue new avenues of market-driven research and participate in partnerships and programs that will help accelerate the commercialization process. Supporting work done by MIT faculty and in MIT research labs, these grants target novel, enabling, and potentially useful ideas in all areas of technology.

Innovation Grant Funding (up to \$250,000 per grant) benefits projects that have progressed beyond their earliest concept stages—projects that have established proof of concept and identified a research and development (R&D) path and IP strategy. Ultimately, each grant will help a project build a package around the new technology that includes these elements to bring to VCs or companies that might invest in its technology.

The *Catalyst Program* brings together volunteers from the business community and MIT innovators to identify the best way to maximize market impact. “Catalysts” are a highly vetted group of individuals with experience relevant to innovation, technology commercialization, and entrepreneurship; they serve as mentors to faculty and student research teams. In their role as Catalysts, they provide individual contributions to the Center and do not represent any company interests.

The *i-Teams Course* is an educational collaborative effort between the Deshpande Center and the MIT Entrepreneurship Center (outlined below), where multiple research projects from within MIT are selected each semester to allow students to evaluate their commercial feasibility and develop go-to-market strategies. The Deshpande Center also hosts a variety of *events* throughout the year to bring together MIT innovators and the surrounding ideas and business communities.

C. MIT Entrepreneurship Center⁵

MIT graduates start between 200–400 companies per year, and approximately 20 to 25 of these are started through the MIT TLO. The remaining spring to life because MIT students have acquired excellent skills in recognizing and commercializing other innovations. The MIT Entrepreneurship Center (E-Center) looks to develop precisely this in-depth grasp of the process in MIT students.

Proposed in 1990 by the then Dean of the MIT Sloan School of Management as a center to support entrepreneurship across the five Schools at MIT, the E-Center creates great value for its stakeholders by connecting technologists and business people and fostering an environment that helps them accelerate the creation of new companies together. Within MIT's decentralized Innovation Ecosystem, the E-Center's programs help instill in students the skills and attitudes it takes to succeed as entrepreneurs.

The E-Center also builds alliances between MIT entrepreneurs and local corporate and venture capital leaders, building a community of academic, government, and industry leaders focused on entrepreneurial ventures. MIT uses the E-Center to connect with regional technology clusters in such areas as biotechnology, energy, and robotics. As part of its mission to train successful entrepreneurs who will drive the global high-tech economy, the E-Center also partners with institutions, compa-

⁵About the Entrepreneurship Center (<http://entrepreneurship.mit.edu/mission.php>)

nies, and individuals in other regions of the world interested in innovation-based entrepreneurship.

Home to many of the world's leading researchers on innovation-based entrepreneurship and the development of entrepreneurial ecosystems—including Professors Ed Roberts, Fiona Murray, Scott Stern, Antoinette Schoar, Michael Cusumano, and Matt Marx—the E-Center is also a center for rigorous research.

The following is a sampling of E-Center initiatives, programs, and activities that aim to educate students in entrepreneurship, nurture their development, leverage MIT's network to accelerate their growth, and celebrate their entrepreneurial efforts and successes.

Educate

- The E-Center coordinates more than 50 classes each year involving more than 20 faculty, which educate thousands of students in the basic skills of entrepreneurship.
- These include for-credit classes and non-credit classes that may be introductory, skill-specific, or sector-specific. Current classes are primarily geared at the graduate level, with growing undergraduate participation.

Nurture

- The center provides physical facilities for students to meet other students, brainstorm ideas, and get projects off the ground, including a space designed like a start-up, with telephones, IT systems and common space to promote informal dialogue.
- Through the E-Center's Entrepreneur-in-Residence (EIR) program, students benefit from honest broker advice and support at the very earliest stages of venture creation from people who have founded companies before. Conducted through office hours, this service complements the more extensive mentoring support offered by the Venture Mentoring Service (VMS) or the Catalysts in the Deshpande Center once a project has developed to a more mature stage.
- To help students apply what they learn in the classroom, the E-Center uses its facilities, staff, contacts, and IT services to actively support the many clubs and activities related to entrepreneurship, including the MIT \$100K Competition; the MIT Clean Energy Prize; the MIT Entrepreneurship Club; the MIT Venture Capital and Private Equity Club; the MIT Energy Club; the MIT Sales Club; the Sloan Women in Management Club; the MIT Sloan Energy & Environmental Club; the MIT Sloan Biomedical Business Club; and the MIT Entrepreneurship Review.
- The E-Center helps organize and sponsor a speaker series on entrepreneurship. This year, for example, the series focused in part on entrepreneurial opportunities in U.S. natural gas.

Network

- Believing that learning emerges from interactions with others and that entrepreneurs' capacity to get things done depends on the number and quality of their contacts, the E-Center actively seeks to build for its stakeholders a broad community of meaningful contacts.
- Networking occurs through formal receptions twice a year as well as through specific topic-focused conferences (e.g., Venture Capital, Energy, Private Equity, Sports Analytics, Sales, Biotech).
- In January of each year, the E-Center organizes and runs a one-week study tour of Silicon Valley to allow students to meet entrepreneurs, funders, and government representatives. Other informal tours or treks are organized based on demand.
- The E-Center also promotes less formal interactions through brown bag luncheons with entrepreneurs and drop-by visits when people are in town. Students often find the greatest value in these informal interactions.

Celebrate

- The E-Center actively seeks to celebrate examples of entrepreneurial risk taking and success through a series of awards—the McGovern Award, the Anderson Fellows, the Heller Award, the Monosson Award—available to our students, faculty and/or alumni.

- The E–Center also encourages and fully supports the celebratory aspects of activities such as the MIT \$100K Competition, the MIT Clean Energy Prize and other awards and recognition by the student clubs.
- To generate positive exposure, especially with the community of MIT entrepreneurs, the E–Center will be launching a “Digital Shingle Project” to give instant visibility to students and alumni who start companies through special displays at the center and, more importantly, on our web site.
- This year, the E–Center launched the MIT Entrepreneurship Review, a prestigious student-run organization that produces an on-line publication that promotes and highlights thought leadership in the community and beyond. It also offers visibility and positive recognition for recent “success story” firms.

D. Venture Mentoring Service⁶

Many discoveries and inventions never make it to market because researchers lack the necessary knowledge, skills, and access to resources. The MIT Venture Mentoring Service (VMS) addresses this gap by providing MIT students, alumni, faculty, and staff with powerful advisory resources to both increase successful outcomes and accelerate the commercialization of university innovations.

The MIT VMS harnesses the knowledge and experience of volunteer alumni and other business leaders to help prospective entrepreneurs in the university community bring their ideas and inventions to market. Entrepreneurs receive practical education through a hands-on, team mentoring process that builds a trusted long-term relationship. MIT VMS offers its services without charge.

This un-biased, hands-on mentoring has proven effective in helping scientists and engineers who are passionate about their ideas learn how to be entrepreneurs—how to conceive of and perfect their products and services, identify markets, build business organizations, and seek funding. For potentially game-changing innovations, this process may take five to seven years or even more before a company and product are truly launched.

Furthermore, VMS’s innovative experiential learning process is more efficient than traditional institutional approaches because it leverages university resources and the collective knowledge and capacity of a large pool of highly qualified volunteer mentors who commit many thousands of hours of time each year.

Since its launch in 2000, more than 1,400 entrepreneurs involved in nearly 800 ventures have enrolled in VMS mentoring. Of these, more than 130 have advanced to become real operating businesses. Currently, more than 175 ventures are participating (and we continue to enroll between 5 and 10 new ventures each month). Collectively, these ventures have raised more than \$700 million in investments, grants, and other support—funding that flowed largely to employees, contractors, suppliers, and service providers in our community. Through mentoring and program leadership, MIT VMS mentors have contributed an aggregate of more than 60,000 hours of volunteer time.

Because the VMS model has attracted interest worldwide, we have sought to share with others the knowledge that VMS has gained, through an active outreach program including presentations, workshops and customized training. To date, 12 universities and economic development organizations have instituted programs based on the MIT VMS model.

Leaders from VMS participating organizations estimate that their VMS training likely saved them from one to three years in start-up time. Although these programs have only been in place for a few years, hundreds of ventures and entrepreneurs have enrolled and participated in mentoring programs based on MIT VMS practices.

E. Innovation Prizes

In addition to the initiatives detailed above, a number of prizes at MIT spur students and faculty to explore difficult problems, including the MIT \$100K Entrepreneurship Competition⁷ and The MIT Clean Energy Prize.⁸

The *X PRIZE Lab @ MIT*⁹, founded in 2007 through the Deshpande Center, partners with the X PRIZE Foundation to engage leading thinkers in pinpointing areas ripe for breakthrough innovation. MIT students and faculty explore the strengths of prize philanthropy with academic rigor and the excitement of the X PRIZE model helps engage youth in the world’s biggest challenges.

⁶About the Venture Mentoring Service (<http://web.mit.edu/vms/>)

⁷About the \$100K prize (<http://www.mit100k.org/>)

⁸About the MIT Clean Energy Prize (<http://www.mitcep.org/>)

⁹About the X Prize Lab @ MIT (<http://www.xprize.org/education-initiatives/x-prize-lab-mit>)

*F. Industrial Liaison Program/Office of Corporate Relations*¹⁰

MIT has long held that breakthrough research hinges on open, consultative dialogue. The Office of Corporate Relations' Industrial Liaison Program (ILP) was established in 1948, making MIT the first academic institution with a formal program designed to nurture university/industry collaboration. For six decades, the ILP has connected member companies with the latest research developments at MIT and enabled industry to support the Institute's research and educational activities. Industry-sponsored research at MIT totaled \$116 million in FY 09, or 16% of all MIT research funding.

For companies interested in pursuing significant, multi-year, multi-disciplinary involvement with MIT, the ILP provides professionally coordinated access to MIT experts, research facilities, and information resources to help them bring innovations to market. Each ILP member is assigned an Industrial Liaison Officer (ILO) who consults regularly with the corporate member to match their needs with relevant MIT faculty and resources. Having earned the respect and responsiveness of MIT faculty and armed with a deep understanding of the given industry, the ILO is ideally positioned to be an effective advocate for the member's needs and goals within MIT. By creating connections with the right MIT people and programs, the ILO helps members:

- stay abreast of new technology developments
- gain insight into a variety of issues related to their core business units
- learn about—and exploit—new opportunities
- anticipate changes in the marketplace
- sustain growth and profitability

Connections with established firms, such as those cultivated through the ILP, are also an important part of MIT's Innovation Ecosystem.

G. Cross School/Cross Disciplinary Initiatives

Our Innovation Ecosystem has grown most recently through two major cross-school, cross-disciplinary initiatives:

Established in September 2006, the MIT Energy Initiative (MITEI)¹¹ aims to help transform the global energy system to meet the needs of the future and to build a bridge to that future by improving today's energy systems. It connects all five MIT schools and numerous departments and has built an energy research portfolio of approximately \$250 million for the next five years, including participation from a number of major companies in collaborative industry-Institute research projects.

MITEI also undertakes major cross-school, cross-disciplinary policy studies on energy issues, including such noted reports as "The Future of Nuclear Power," "The Future of Coal," and "The Future of Geothermal." Five more major energy policy studies are now under way. MITEI's policy efforts also help inform research directions. These cross-cutting, multi-disciplinary efforts have enlisted some 200 researchers and multiplied the opportunities for energy research advances.

MIT's second major cross-school, cross-disciplinary initiative is taking shape through the new David H. Koch Institute for Integrative Cancer Research, which builds on MIT's earlier Center for Cancer Research, founded by Nobel Laureate Salvador Luria. Soon to be housed in a state-of-the-art research building, the Koch Institute capitalizes on the convergence of the life, engineering, and physical sciences as a strategy for achieving medical breakthroughs.

Researchers from these fields will collaborate to target five areas of research at the intersection of biology, engineering and physical sciences, including: (1) defining the specific vulnerabilities of cancer cells by creating a complete "wiring diagram" of the key pathways that allow cancer cells to keep dividing and remain alive; (2) engineering entirely new nanotechnology paradigms for cancer treatment; (3) understanding how tumors evade immune recognition and developing methods to overcome these avoidance mechanisms, including more effective anti-cancer vaccines and other forms of immunotherapy; (4) using powerful new engineering tools to dissect the molecular and cellular basis for metastasis; and (5) shifting the curve of cancer diagnosis and prevention to earlier and earlier stages using advances such as genomics, novel imaging agents, and micro-scale monitoring devices.¹²

Such collaborative, cross-disciplinary, cross-school initiatives appear to be generating significant new opportunities for major research advances in the energy and

¹⁰ About the ILP (http://ilp-www.mit.edu/display_page.a4d?key=H1)

¹¹ About MITEI (<http://web.mit.edu/mitei/>)

¹² About the Koch Institute (<http://web.mit.edu/ki/about/index.html>)

life science fields. Not incidentally, both initiatives include a conscious focus on technology transfer.

III. University Role in Commercialization of Research

University discoveries have set the seeds of numerous new industries in the United States. We saw this with the emergence of the Information Technology (IT) and biotech industries, where universities, including MIT, played a central role. We are also beginning to see the initial signs of such growth in a new energy sector. In Massachusetts, approximately 90 new energy firms represent an emerging new cluster for the New England economy. A growing number stem from MIT's major energy initiative noted above.

Much of the success of these and other clusters can be attributed to the Bayh-Dole Act of 1980 (BDA), which gave universities the right to retain the patents—and therefore to license the technologies—developed from federally funded research. Although I understand it is not an issue in this Committee's jurisdiction and not a subject of this hearing, I do want to note, because of its importance, that some now advocate modifying the Bayh-Dole Act (BDA) to curtail university rights to intellectual property stemming from Federal research dollars. I believe this move could gravely damage technology transfer by hampering universities' commercialization efforts.

The BDA was intended to encourage the formal transfer of university-generated research results to the public. The MIT technology transfer system is based on decades of day-to-day experience on the ground with entrepreneurs, VCs, and small companies. This experience is exceptionally valuable to faculty, who would be much less willing or able to negotiate the highly complex and often expensive path to commercialization without support from an experienced TLO office and supporting ecosystem.

University technology transfer offices are also quite aware of their duties and obligations to the public good and to the U.S. government, which has invested its resources in their research, and are therefore in the best position to be neutral, objective, and unbiased advocates of federally funded inventions with clarity, consistency, and transparency of policies and practices. Finally and very importantly, the proposed change to BDA would remove a key incentive for encouraging universities to promote economic clusters that are so important to local, regional, and national economic growth.

A New Survey of Best Practices

That being said, there are certainly practices that can be adopted by MIT and other universities to improve the performance of their TLOs. I have listed above what we have found to be our "best practices" for technology transfer, and many major universities have adopted similar rule sets. The university associations concerned with technology transfer have also attempted to broadcast the most successful university approaches, which require continual updating to keep pace with ongoing economic developments.

I have charged a group at MIT to survey and understand the current forces and trends in university-industry technology transfer. This group will not only review MIT's policies, procedures, and practices related to technology transfer and industrial sponsorship of research, but also identify best practices by reviewing similar policies, procedures, and practices at peer institutions. The survey will also solicit input and ideas from the MIT community and outside individuals in both the private and public sectors. The results of this survey will be recommended changes, if any, to MIT's policies, procedures, or practices to enhance, simplify, and accelerate technology transfer and to enable the formation of beneficial strategic partnerships with industry while preserving MIT's fundamental values and principles. When this report is completed, I would be pleased to forward it to the Administration.

In closing, I would like to underscore two points. University technology transfer has come a long way since the BDA was passed, delivering remarkable advances for our society. Improvements certainly can be made in technology transfer. But the Bayh-Dole Act provides a critical foundation for university-based Innovation Ecosystems, and it should continue to do so.

I want to express MIT's appreciation for Congress' recognition of the importance of technology transfer to local, regional, and national economic growth. I hope you find this statement useful in identifying possible recommendations to improve technology transfer. MIT's faculty and staff stand ready to assist you in your efforts.