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HIF210.179

NANOTECHNOLOGY: UNDERSTANDING HOW SMALL SOLUTIONS DRIVE BIG INNOVATIONS

TUESDAY, JULY 29, 2014

House of Representatives,

Subcommittee on Commerce, Manufacturing, and Trade

Committee on Energy and Commerce

Washington, D.C.

The Subcommittee met, pursuant to call, at 10:20 a.m., in Room 2322 of the Rayburn House Office Building, Hon. Lee Terry [Chairman of the Subcommittee] presiding.

Members present: Representatives Terry, Lance, Harper, Olson, Bilirakis, Johnson, Long, Schakowsky, Sarbanes, and Barrow.

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Staff present: Leighton Brown, Press Assistant; Graham Dufault, Policy Coordinator, Commerce, Manufacturing, and Trade; Melissa Froelich, Counsel, Commerce, Manufacturing, and Trade; Kirby Howard, Legislative Clerk; Paul Nagle, Chief Counsel, Commerce, Manufacturing, and Trade; Michelle Ash, Democratic Chief Counsel; Carol Kando, Democratic Counsel; and Will Wallace, Democratic Professional Staff Member.

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Mr. {Terry.} Welcome all to our rock and roll--our hearing that is in a series of hearings called Nation of Builders where we explore American technology and its impact on job creation and manufacturing. I want to thank all of you here today. Now I feel like I am giving a speech on the National Mall. So while they are trying to fix it, I will continue to talk and be the guinea pig.

So just as electricity, telecommunications and the combustion engine fundamentally altered American economics in the ``second industrial revolution,'' nanotechnology is poised to drive the next surge of economic growth across all sectors.

Nanotechnology refers to the ability to manipulate matter between 1 and 100 billionths of a meter, an endeavor that is no small feat. Pun intended. This capability is helping solve long-intractable problems. For example, as computers get smaller, the problem of heat generation becomes more and more severe, and nanotech could hold the solution.

Currently, there are natural barriers to making transistors, semiconductors and computers any smaller because the heat generated during use destroys the material if that material is below a certain size. The ability to harness the inertia of an electron could one day allow a computer to operate on its own recycled waste heat. This capability is called spintronics, and it would allow electronic computer parts to break through that size barrier.

Dr. Binek, who is here from University of Nebraska--probably off of the Big 10 media days in Chicago--will expand on the idea of spintronics and describe his excellent work in this area of nanotechnology.

Advances in nanotech don't just mean we can make things smaller. It is the ability to harness matter at the nanometer level, which has applications across many industries. In medicine, nanotech research has revealed that advanced nerve regeneration and cancer detection, diagnosis and treatment methods could be just around the corner. In manufacturing, nanotech research has allowed us simply to make better materials. For example, nanocomposites can be used to decrease the weight of the bumper on a car, while enhancing its resistance to dents and scratches. And with three teenage boys, that is appreciated. And wires used to

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transmit electricity made from carbon nanotubes could one day eliminate such--much of the electricity loss that occurs in transmission.

Today, we seek to learn more about what obstacles stand in the way of nanotech research, but also any barriers that exist between the research and development stage and full-scale commercialization.

There is no question that the U.S. is a leader in nanotech researching, but as U.S. researchers make new discoveries and the applications are revealed, I am concerned that other countries are doing more to facilitate nanotech development than we are. Nanotech is a true science race between the nations, and we could be encouraging the transition from research breakthroughs to commercial development.

I believe the U.S. should excel in this area. Historically, we have a great track record on generating startups, which is fueled by our entrepreneurial spirit in this country. However, for the first time since the Census Bureau started measuring this statistic, more businesses are failing than starting in the United States. Four hundred thousand businesses are born annually nationwide, while 470,000 are not--are failing. That is a disturbing statistic.

Accordingly, I am curious as to whether--given this hostile business climate--there are regulatory obstacles to adoption of nanotechnology in the commercial context.

As Dr. Binek notes in his testimony, Moore's Law tells us that the performance-to-cost ratio of computing power doubles every 18 months or so. I believe we ought to be careful not to slow down the progress described by ``Moore's Law'' with ``more laws.''

Again, I thank our witnesses, and introductions will be right after the ranking member's opening statement. Yield to the ranking member, Jan Schakowsky, for her statement.

[The prepared statement of Mr. Terry follows:]

*************** COMMITTEE INSERT ***************

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Ms. {Schakowsky.} Well, it looks like our macrotechnology might have been fixed. I am not sure. Is this working, this on here? Okay.

So I want to thank you, Chairman Terry, for holding this important hearing on the issue of nanotechnology. I look forward to hearing from each of our accomplished witnesses about this exciting field. I was about to ask you all for some help here. I figured maybe the scientists know.

But I would like to take this opportunity to introduce one of the witnesses today. Dr. Milan Mrksich is a professor at my hometown school of Northwestern University and a leader in the field of nanotechnology. Dr. Mrksich has focused his research on biomedical advances that would not be possible without the development of nanotechnology. He has been involved in research that has made Chicago one of the premiere destinations around the world for nanotechnology, from research and development on Northwestern's campus to the commercialization at the nearby Illinois Science and Technology Park, and other sites. So I look forward to getting his valuable perspective on this.

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From real-time monitoring of critical infrastructure to water purification to more effective treatment of cancer, nanotechnology has the potential to solve some of the world's most important challenges. Few fields of scientific research have as much breadth or potential.

That being said, nanotechnology's impact on public health and our environment is not yet well understood. Certain studies have indicated potential hazards. For example, titanium dioxide nanoparticles, which are used in sunscreen to block UV light can also kill microbes used to treat municipal water supplies. That is why we need to be careful to ensure that federal regulators responsible for public health and chemical exposure, from EPA to FDA to CPSC, coordinate efforts to better understand any possible toxicity of nano materials and protect the public from harmful impacts, while enabling their beneficial use.

The United States recognized the promise of nanotechnology early on, and the National Nanotechnology Initiative has benefitted from nearly $20 billion in federal investment since 2000. Other world leaders have followed suit, and more than $70 billion in global investment in nanotechnology over the same period.

The Federal Government must continue to play a lead role in supporting nano research and development. Last year, Congress appropriated $1.5 billion for nanotechnology, more than 10 percent below the Administration's request, however. According to the GAO, some other nations may already have surpassed the U.S. in terms of public investment in nanotech, and we can be sure that those competitors will maintain significant investments in this promising field moving forward.

Congress, I believe, should commit to adequate support of cutting edge research, and I hope all my colleagues will join in working to increase National Nanotechnology Initiative funding moving forward.

We should focus on the areas of nanotech pipeline that are in the most need of additional support. There is a demonstrated lack of financing for nanotech as it moves from the development stage to the commercialization stage. I am concerned that without consistent and significant financial backing, the advancement of nano in this country could slow. We should work to ensure that promising technologies, especially those that can save and sustain human lives, have the support needed to reach and benefit the public.

Again, I am very excited about the promise nanotechnology holds for our country and the world. I look forward to hearing the perspectives of our witnesses today, especially about where we go from here.

I yield back my time.

[The prepared statement of Ms. Schakowsky follows:]

*************** COMMITTEE INSERT ***************

Mr. {Terry.} Does anybody wish to make an opening statement on the Republican side?

Mr. {Olson.} Mr. Chairman, introduction please, sir?

Mr. {Terry.} Yes, I will do that right now then. So hold on.

So our witnesses today, I want to thank all four of you for being here. We have three universities represented that are leaders in nanotech development and research, and I will just take a personal note and say we allowed one outside of the Big 10.

So I want to introduce from the University of Nebraska Professor of Physics and Astronomy, Christian Binek. Then we also have Milan Mrksich from--he is a Henry Wade Rogers Professor of Biomedical Engineering, Chemistry and Cell and Molecular Biology at Northwestern University. Jim Phillips, Chairman and CEO of NanoMech, Incorporated. And now I yield for opening statement/introduction to the gentleman from Houston, Texas.

Mr. {Olson.} Thank you, Mr. Chairman.

As our guests can see by my nameplate, another Rice Owl is in the house this morning. That owl is James Tour.

Dr. Tour and I share a common idol, the late Dr. Rick Smalley, who won a Nobel Prize in 1996 for his work in nanotechnology at Rice. Dr. Smalley changed my life by showing me that I had no future, none, in nanotechnology. After my first year of chemistry with him, that was pretty apparent. But he changed Dr. Tour's life by recruiting him to Rice to a leader in the Nanoscience and Technology Institute.

Dr. Tour is a perfect witness to teach this committee about nanotechnology. He has created a thing called NanoKids, teaching kids K-12 about nanotechnology. If he can teach a fourth grader, man, he can surely teach members of Congress.

So with that observation, Mr. Chairman, I yield back. Thank you.

Mr. {Terry.} We can all hope.

So if you guys--have any of you testified before? A couple of you, good. For the two that haven't, this is an information hearing. It is not like a GM hearing where you have to raise your hand and get grilled. You are here to teach us. We want to hear what your work has been about, and we appreciate your testimony, which most of us have read.

So we will start from my left to right. You have 5 minutes. There should be a clock up there if you want to look up. If you are still speaking about the 5-minute mark, I will just kind of lightly tap the gavel, which will--is the international symbol for wrap it up.

So with that, I recognize the gentleman from the University of Nebraska, Dr. Binek.

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^STATEMENTS OF CHRISTIAN BINEK, PH.D., ASSOCIATE PROFESSOR, PHYSICS AND ASTRONOMY, UNIVERSITY OF NEBRASKA-LINCOLN; JAMES M. TOUR, PH.D., T.T. AND W.F. CHAO PROFESSOR OF CHEMISTRY, PROFESSOR OF COMPUTER SCIENCE, MATERIALS SCIENCE AND NANOENGINEERING, SMALLEY INSTITUTE FOR NANOSCALE SCIENCE AND TECHNOLOGY, RICE UNIVERSITY; MILAN MRKSICH, PH.D., HENRY WADE ROGERS PROFESSOR OF BIOMEDICAL ENGINEERING, CHEMISTRY AND CELL AND MOLECULAR BIOLOGY, NORTHWESTERN UNIVERSITY; AND JIM PHILLIPS, CHAIRMAN AND CEO, NANOMECH, INCORPORATED

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^STATEMENT OF CHRISTIAN BINEK

} Mr. {Binek.} Thank you, Mr. Chairman, for inviting me and having this opportunity to testify, and also, thank you, Congressmen and Congresswomen. So I--

Mr. {Terry.} Can you pull your microphone just a little bit closer?

Mr. {Binek.} --am on faculty at the University of Nebraska in Lincoln and also an active nano scientist and I would like to give you a smooth start, let's say, into nanoscience and nanotechnology, so maybe we can start with the question, what is that all about?

And starting by the prefix of the word nano, which actually comes from the Greek word nanos, and it means dwarf, so we deal with something very small, as we all know by now. But what we probably lack is an intuition for what it means, one billionths of a meter, so we need actually a proper ruler, so to say, to have comparison. And if we think of something small, we may think, for example, of the red blood cell in our bloodstream. But it turns out that is actually on the order of 6 microns in diameter. So a nanometer is 10,000 times smaller than that. Or maybe it is better to look at the molecular scale, and then we would identify a nanometer as being 5 atoms next to each other. So that gives us the scale, and that sets the stage for Feynman's celebrated remark ``There's plenty of room at the bottom.'' And indeed, we can sort of say create and hope to create nanostructures from the bottom up, which are extremely small, much, much smaller, for example, than a cell, and have function and can, for example, travel in our bloodstream and monitor and maybe even increase health. So that was

Feynman's vision of ``swallowing the doctor'' as he called it.

From there, I would like now to switch over and give us an idea of what is the special physics that happens at the nanoscale. What are those emerging properties at the nanoscale? And again, it is Feynman who asked the question, what happens if we can arrange atoms at will? And today, we are actually in a position where we can start to do that. We can image and manipulate atoms at will, and the answer is that if we can do that, then we can basically design material properties at will, because it turns out that all material properties--I mean, literally all of them, electric, magnetic, optic, thermal, mechanic, you name it--they all depend on the underlying atomic structure. So if you can arrange atoms at will on the nanoscale, then we can design within certain limits, for example, dictated by quantum mechanical loss, we can design materials properties.

Now, that is not the end of the story. We can actually do more. An example for such a design for nanostructures would be--a simple but effective example would be nanoparticles specifically tailored in magnetic properties to be applied in magnetic hypothermia weight of potential cancer treatment.

We can do more. We can bring different materials into close proximity. We have tools now, for example, multilayer--techniques, and we bring materials A and B in proximity, which traditional chemistry doesn't allow us to do. And when that happens, new effects, new physical phenomena can emerge at the interface, and that sends the whole is indeed more as the parts A and B. Or as Herbert Kroemer said it already 40 years ago, today we can say the interface itself is the device. So from there, we can speculate and we can build a larger, more complex structures, nanostructures, and we can--we have the tools to do that from the bottom up, like scanning macroscopy or from top down.

And with all that, we can look a little bit into the future and can see that nanotechnology will certainly transform information technology, medical applications, energy and water supply, smart materials, and manufacturing. And there is--specifically in the information technology, there is a nonlinear trend going on now for 5 decades known as Moore's Law, where we can see that the performance to cost ratio is actually exponentially growing, so beyond our actual intuition. To give you an example of the hard drives of IBM from 1956 had less than 5 megabyte storage capacity, was two refrigerators big and weighed 2 tons. Fifty years later, we could make hard drives with 100 gigabytes capacity of storage and just the size of a deck of cards. That is 100 million fold improvement in that kind of performance to cost ratio.

So the industry is well aware that Moore's Law is not necessarily a law of nature. It can and most likely seems right now to stop and to come to an end, and there are processes funded like spintronics, where I am involved, which allow us to tackle those problems and come to new types of electronics that we utilize the spin degree of freedom is just one example.

So I am running out of time here. I would like just to conclude with an impact nanotechnology most likely has on society and economy. We need to recognize that nanotechnology is highly interdisciplinary and that there is a positive feedback which excels the progress. We have to prepare the workforce for this interdisciplinary and have to continue funding from the industry side and from the government side.

With that, let me thank you for having me.

[The prepared statement of Mr. Binek follows:]

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Mr. {Terry.} Thank you, Dr. Binek.

Dr. Tour, you are now recognized for 5 minutes.

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^STATEMENT OF JAMES M. TOUR

} Mr. {Tour.} My name is James Tour, and I am the T.T. and W.F. Chao Professor of Chemistry, Professor of Material Science and Nanoengineering, and Professor of Computer Science at the Richard Smalley Institute for Nanoscale Science and Technology at Rice University in Houston, Texas.

Rice's home is the home of nanotechnology where carbon 60 was discovered. I have over 500 research publications and 70 patents in nanotechnology in the fields of nanomedicine for treatment of traumatic brain injuries, stroke, and autoimmune diseases, nanomaterials including graphene and carbon nanotubes for electronics, optics, and composites, and high surface area nanomaterials for environmental capture of carbon dioxide and for water purification. All of these technologies are licensed to companies from my laboratory at Rice University, and all are transitioning from basic research to deployment in the U.S. and abroad.

It is possible for Congress to directly improve the research enterprise in U.S. universities and to mitigate the current brain drain of our best and brightest scientists and engineers. This can be done without commitment of any new spending.

Among the most ingenious pieces of legislation in my view was the Bayh-Dole Act dealing with intellectual property arising from Federal Government funded research. Prior to the enactment of the Bayh-Dole Act, the U.S. Government had accumulated 28,000 patents, but fewer than 5 percent of those patents were commercially licensed. The key change made by Bayh-Dole was ownership of the inventions was made--ownership of the inventions that were made by federal funding. Bayh-Dole permits a university, small business, or nonprofit institution to elect to pursue ownership of an invention in preference to the government. Government got out of the way, and this spawned enormous entrepreneurial endeavors and led to startup companies and jobs being birthed throughout the country. And most interestingly, the legislation required no new allocation of funds.

Unfortunately, there has been a dramatic loss of research funding to U.S. universities on a per-investigator basis over the past 5 years. The situation has become untenable. Not only are our best and brightest international students returning to their home countries upon graduation, taking our advanced technology expertise with them, but our top professors are moving abroad in order to keep their programs funded. The trolling by foreign universities upon top U.S. faculty has become rampant due to the declination of U.S. funding levels on a per faculty member basis. The brain drain is not something that we can recover. The impact of what has already been lost will last decades.

I am not here to present to you an apocalyptic scene and then cry for money to slow the problem. I realize the cupboards in Washington are bare, and I offer you a no new spending solution. I have a large research laboratory, 30 graduate students and post-docs working busily to make new nanotechnology discoveries and translate those into exploitable applications. In 2008, my program was 90 percent federally supported and 10 percent industrially supported. Then for the first time in my 26-year career as a faculty researcher, I could no longer survive. One federal grant after another was unfunded. So I started to appeal to industries, showing them how our nanotechnology research could solve technical problems in their industries. Presently for company funds research at an academic institution through a sponsored research agreement, thereby guaranteeing the company access to research reports and their setting of milestones, then the company loses the benefits of a significant tax deduction of their allocation of funds. In other words, their allocation to sponsored research no longer has the same tax deductible benefits as a non-researched based gift would have afforded them.

I am asking Congress to consider legislation that would incentivize industry to fund academic research universities and nonprofits by granting the companies with a total or significant tax deduction for such university research investments. This permits companies to take up the slack where the Federal Government has been unable to maintain the research enterprise. Help me and my colleagues to raise our own research funds through partnerships with corporations. If I can explain to industries that there will be a complete or significant tax deduction for sponsored research--for the sponsored research agreement, then I can sell my research to them with the utmost attractiveness.

Let me close with this. King Solomon wrote in Proverbs 25:11, ``Like apples of gold, in settings of silver, is a ruling rightly given.'' I pray your kind consideration for new Bayh-Dole-like ingenious legislation to be enacted, nullifying the dire conditions facing the U.S. research enterprise and loss of our U.S. trained scientists and engineers. This legislation would require no new federal allocations, and it can become part of the holistic approach to funding of academic science.

Thank you.

[The prepared statement of Mr. Tour follows:]

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Mr. {Terry.} Thank you. Dr. Mrksich, you are now recognized for your 5 minutes.

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^STATEMENT OF MILAN MRKSICH

} Mr. {Mrksich.} There it is. The last name is not easy. My mother-in-law struggled with it for many years.

But I am currently the Henry Wade Rogers professor at Northwestern University in--with appointments in chemistry, biomedical engineering, and cell biology. I direct a research lab that develops nanomaterials for applications in drug discovery and diagnostics, and medical devices. I have also been involved in the translation of university-based science into companies, having co-founded SAMDI Tech, 480 Biomedical, a stent company, and Arsenal Medical. I am glad to be here to share some of my perspectives.

As you have heard, the nanotechnology field has been enabled by the development of methods that can create materials with dimensions that are tiny, thousands of times smaller than the width of a hair. And we now know that the properties of a material that can vary strongly on their dimensions, and we have the ability to tailor-make materials with novel and important properties. This is a broad-based field. Unlike traditional disciplines, it cuts across the entire science and engineering enterprise, and has really led to paradigm shifting technology across the board.

The National Nanotechnology Initiative recognizes transformative potential and required federal agencies across the board to invest in nano. And that really was important to creating a national strength and infrastructure in this new and exciting area.

At Northwestern, we started the International Institute for Nanotechnology, now one of the largest such centers. This partners with departments across campus and to date, has raised over $600 million in research funding to develop this next generation of technology. It has also trained hundreds of students, many of which are now faculty members across the globe in this area.

This investment has already led to a nascent but growing and important industry. Again, at Northwestern, our institute has seen about 25 companies get started, and those have raised greater than $700 million in research support to commercialize their products. And these success stories aren't unique, of course, to Illinois. They are found across our Nation.

At the same time, there is a wide recognition that a lack of predefined regulatory processes can still present challenges to the commercialization of nanotechnologies. While regulations for safety and environmental impact are important, they should be effective at providing for the public's concerns and safety, but they need to be tailored to different classes of materials used in different sectors, and they need to be defined to remove the risk of uncertainty that product developers face when taking on these initiatives.

Similarly, the manufacturing methods and standards that will be important to all companies in this space are still not well-developed. We don't have the standard tools we can rely on to produce in volume products based on nanomaterials, and this is an area where a public/private partnership based perhaps on the National Network for Manufacturing Innovation Centers could be quite effective at providing the entire industry with engineering practices that will enable the growth of this area.

I would like to add comments to the theme of globalization that we have heard. The scientific and economic promise of nanotechnology has certainly been recognized by our foreign partners and competitors, and recent trends in those regions point to challenges that the United States has not faced before. First, governments in Europe and Asia continue to make targeted investments in nanotechnology, with annual growth rates that are in the double digits, and approaching 50 percent in China. Second, the culture and infrastructure has changed in Europe and Asia, and unlike 10 and 15 years ago, researchers there are quite effective at starting new companies. And finally, as you have heard, we are seeing the recruitment of our best scientists to full-time and part-time positions in other countries. And the globalization has certainly had and will have many benefits, but it will also level the global playing field for translating basic research into commercial entities, and it will dilute the positive impact of nanotechnology on our own economy.

We must act now to ensure that our early investment and the very substantial impact it is positioned to deliver can be realized. We must renew our support for fundamental research in the nanosciences, as this will retain and continue to attract the best researchers to the United States, and keep our development pipeline full. We must remove barriers that make it challenging to start new companies that are in the early stages of product development. We must develop effective regulatory standards, but also clearer standards that remove the risk of uncertainty that many companies face in product development. And we must make the patent system more efficient, and remove the five or more year delay it can take to realize patent protection and keep out would-be competitors. We must engage our partners in industry, academia, and the government to create a manufacturing toolbox and kit that is universal, and again, serves the entire field.

I thank you for your time, your attention, your service to our--to the country, and I am happy to answer any questions that you may have.

[The prepared statement of Mr. Mrksich follows:]

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Mr. {Terry.} Thank you.

Mr. Phillips, you are now recognized for your 5 minutes.

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^STATEMENT OF JIM PHILLIPS

} Mr. {Phillips.} As a manufacturer of nanotechnology, you know, it is a great time to be alive. With the inventions of the chip and the software storage and the internet, more will be invented in the next 10 years than in the history of mankind, and no more place than nanotechnology will achieve these great new inventions and competitiveness that America is going to depend on, especially in manufacturing where we see manufacturing drop as part of our GDP from about 79 percent to 17, 18 percent, giving us a distinctive competitive disadvantage on a global basis.

I am proud to be chairman and CEO of NanoMech. We are based in northwest Arkansas, down the street from the likes of Walmart, Tyson headquarters, and we have, over the last year, won a portfolio of award-winning inventions and commercial products, including innovations in machining and advanced manufacturing, lubrication and energy, biomedical implant coatings, and strategic--very strategic military applications. We feel we are posed--poised for dramatic expansion of our manufacturing operations. I am proud to say we are in the process right now of adding an additional 25,000 square feet to our existing factory. We have bought up the entire technology park that we live in with the belief that we will be needing that kind of manufacturing capacity to keep up with our demand.

Today, the United States is locked in a moon race, in an absolute moon race with other major countries trying to take the lead in materials science and bio nanoscale engineering research, development, commercialization in what is sure to be the next industrial revolution of progress. While these competitive countries lost out to an extent to the U.S. in the information technology revolution, they are determined to put enormous amounts of public and private capital to work to win this more important race. Given the monopolistic efforts of China alone to control all of the world's dwindling resources--today they control about 85 percent--the U.S. is now at great risk of not having the materials and the rare earth metals that are core to the most important manufactured goods that are essential to our daily lives. Nanoscale engineering is our greatest hope in providing a way to do more with less and amazing and sustainable ways to keep America secure, and the world leader in commerce, technology, and especially defense. Speaking of defense, it is clear by now that the country with the best UAVs wins. And no weaponization area more than UAVs will benefit from the tremendous advantages of nanoengineering and manufacturing. This, of course, is not to mention the huge gains already realized in defense and national security and weapons systems deploying quantum leaps in super-advanced nanoengineered coatings, lubricants, fuels, energetics, faster processors, and battlefield gear, all due to nanotechnology.

Over the past 2 years, I have had the opportunity to participate in the Council on Competitiveness executive committee, as well as its U.S. Manufacturing Competitiveness Initiative, and the Office of the Comptroller General's Study on Nanotechnology. I take this opportunity to offer my perspective as an entrepreneur and a nano-manufacturer.

Many U.S. States and localities do too little to attract manufacturing facilities, imposing complicated time-consuming procedures on top of federal rules to site and build production facilities. The permitting process for a manufacturing facility in the United States might take months, if not years, where in some countries the time required is merely a few weeks or less. We are certainly offered by China and Russia it seems like on a quarterly basis to move our entire operation there. Never will do it. Former ex-pilot in the Air Force and definitely a patriot, and we just won't do those kind of things. We don't even take their money, even though they offer it to us all the time. Consider, for example, NanoMech, though, as our very safe product platforms. I don't know of any nanotechnology lawsuits for liability in the 30-year history of nanotechnology to date. We utilize convergent assembly so that we can nanoengineer tremendous improvements in many products and through this process, what we ship, even though nanoengineered and nanomanufactured, is no longer at nanoscale, but vastly superior to conventionally manufactured products. We are developing cutting edge technology that enables dramatically more efficient industrial processes, and therefore can save billions of dollars across several industries, while dramatically increasing performance.

At the nanoscale, we and other manufacturers can reduce or eliminate harsh chemicals and materials and replace them with more environmentally sound and sustainable components. We do that every day. One of our products is called nGlide. This is a new super additive for the energy space. For that reason, we have opened up in Texas and are working with some of the largest companies in the energy manufacturing space. We add just a small amount of lubricant, and we reduce the coefficient of friction down to literally zero. No wear--hardly any wear for that product going forward. We work with the largest companies around the United States in this. We also work with racing teams where this has all been demonstrated. Think of it, no wear, yet higher performance. The ability to increase miles per gallon, miles per hour, reduce heat, reduce wear.

One of the other products we have is called TuffTek. This is where we spray a nano spray in a very safe facility with cubic boron nitride, the hardest substance known to man. When we do that, it creates a very hard coating surface on cutting tools. When we do that, cutting tools can last as much as 10 times longer. Of course, cutting tools are at the core of everything that is manufactured. This year, we were awarded the R&D100, the Edison, and the Tibbetts Award for that, the Tibbetts Award coming through the EPA.

Talent is perhaps the most important driver for manufacturing competitiveness, especially nanotechnology. The United States needs highly skilled workers to realize the productivity gains essential to remain globally competitive in the digital and nano age. Yet current and anticipated human capital deficiencies exist across the board. Not only are current openings for highly skilled workers challenging, manufacturing workers are retiring at a much rate than they are being replaced. For that reason, we ask this committee to consider taking a real hard look at the area of visas. Visas have turned out to be a huge problem for us as we try to man and staff our company with the very best and brightest.

At this point in time, it looks like time is up so I will defer to questions.

[The prepared statement of Mr. Phillips follows:]

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Mr. {Terry.} Thank you.

Mr. {Phillips.} Thank you.

Mr. {Terry.} So all witnesses have testified. This is our opportunity to begin our questions for you, and so as chairman, I get to start, and I will start with Dr. Binek.

Now in your testimony, Doctor, you mentioned the interdisciplinary field. Could you expand on how you and the University of Nebraska are engaged in in interdisciplinary practice, and who is part of that and how it enhances the ability to advance nanotechnologies?

Mr. {Binek.} Yes, thank you, chairman, for that question.

Let me first start locally, at the University of Nebraska, we have Nebraska Center for Materials and Nanoscience, which is an interdisciplinary center where we work together as physicists, chemists, and engineers on nanotechnological problems that includes building where all the tools and for electro-microscopy to x-ray machines to lithography, all housed in our actually quite new Walt A. Keaton building. And in addition, we are fortunate to have an NSF-funded MRSEC, Materials Research Science and Engineering Center, and in the same spirit interdisciplinary, we have physicists, we have chemists, and engineers all coming together and working on nanotechnological problems.

I am also involved in two centers. One center is located also at the University of Nebraska, led by us. It is the Center for Nanophotonic Devices. It is an interdisciplinary research between six universities. And another center I am involved in as--is the C-Spin Center, where 18 universities nationwide--

Mr. {Terry.} That is C-Spin, and what is that?

Mr. {Binek.} It is a lengthy acronym for a center where we, again, look for spintronic solutions, mainly to sort of say the barrier which is anticipated by extrapolations of scaling. It is known today that--in the semiconductor industry it is known that if you continue the scaling, making things just smaller and smaller, we will hit a barrier latest by 2020, which is determined by many reasons and also fundamental reasons, like quantum tunneling. We are asked to look for solutions to solve those heat problems you mentioned in your introduction, and spintronics is one of those

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potential solutions where you use the spin degree of freedom and we can have new functions in our devices, not only processing, but also processing and memory in one device. The spin or the collective phenomenon of magnetism is ideal for non-volatile memory, and we can switch those state variables also by electric means, avoiding electric currents, and that seems to be one way in the future to solve that problem.

Mr. {Terry.} And as I understand, there are industries that are also involved, and so how do they participate? Talent, money, whatever.

Mr. {Binek.} They participate on various levels, mainly money, and that is a good thing. So for example, the C-Spin center, if I am not mistaken, we talk about a volume of $31 million of funding for a 6-year period. It is mainly by the Semiconductor Research Corporation, which is--has--is a consortium of who is who in the semiconductor industry from IBM, Intel, Global Foundries, Micron, you name it. And in addition, also--with the contribution.

Mr. {Terry.} Thank you.

Mr. Phillips?

Mr. {Phillips.} Yes, sir.

Mr. {Terry.} You take that nanotechnology and then apply it in manufacturing. I am interested about how you make that shift and the capital that is necessary to get that done. How do you do it?

Mr. {Phillips.} Well, it is pretty conventional, the way American businesses always run. You know, you have got to raise capital to build anything, whether it is a space shuttle or, you know, a Dairy Queen. You have to got to be able to capitalize it, and sometimes it comes from purely private capital, in my case, my capital as well. And then sometimes you also are able to get grants, both on a state and federal level, and those are very important. So we have received over time grants from like National Science Foundation, the Office of Naval Research, Department of Energy, and so forth. Although very minimal compared to the totality of capital we have raised.

When you build a company like this, the first thing you have to do is have the incredible ideation and invention, the concept and everything, and then you have to turn that into something that is manufacturable. You have to be able to create assembly lines that have quality control with repeatability, scalability, so that it prices out whatever it is you are manufacturing, that it becomes a must-have that people can afford. So it is basic business practices. In this technology which is very, very new, there are more regulatory probably than conventional. We know in the U.S., we appreciate the regulatory. We believe in safety and the controls that are in place, albeit we have to compete against countries that perhaps--have 5 percent total regulatory costs against our 30 to 35 percent regulatory cost. So we have to build in an effort to accommodate that.

Mr. {Terry.} Thank you, and my time is expired.

I recognize the ranking member, Jan Schakowsky, for your 5 minutes.

Ms. {Schakowsky.} Instructor Tour, I appreciate all of the commercialization, especially that--and the problems that you face because companies seem--you are saying would want these tax breaks. But I want to just make the very clear point that you say without any new federal dollars. Not true. It is a decision on whether there is direct federal subsidies and grants, or we give tax breaks. There is a reason that we talk about tax breaks as tax expenditures, because clearly, that is a cost to the Federal Government as well, any tax dollars that would be lost because we would-- and so there is a lot of other considerations. Is it better for the Federal Government to make some of the decisions about where the money goes? Do we just leave it to the private sector? And I know others have mentioned public/private partnerships as another way to go.

So I just wanted to make the point that this is not a freebie for the Federal Government when we say that we do it through tax breaks that we would give to corporations. Not ruling that out, but it is a tradeoff that we have to discuss.

I wanted to ask Dr.--

Mr. {Tour.} May I comment on that?

Ms. {Schakowsky.} Yes, of course.

Mr. {Tour.} I think that I said no new spending and no new allocations, because I well appreciate what you are saying, Congresswoman. It is a reality that when you don't have taxes, you don't have money coming in. So that is why I used the words that no new spending, no new allocations.

But the other thing that I hope that I underscored is that it is really a dire situation in the federal dollars that are able to come in and by doing this, somehow we are spreading the load out a little bit to incentivize industry coming in.

Ms. {Schakowsky.} I am all for that and it is not a criticism. I just wanted to make sure that we are clear that it is--one way or another, it is money to the--from the Federal Government.

I wanted to--I just have a suggestion, Dr. Mrksich. If you added another vowel between the M and the R, if you added an E, everyone could pronounce your name.

Mr. {Mrksich.} You should see my mailbox. I have about 10 good versions of improvements on my name.

Ms. {Schakowsky.} Just, you know, an idea. Four vowels--four consonants in a row makes it hard. Okay. I don't want to take up too much of my time.

I wondered--I know that you primarily focus on nanomaterials for biological and medical applications, and I am wondering if you could provide a little more detail on the research that you are doing. What kind of advances might happen over the next 5 to 10 years due to your--the research?

Mr. {Mrksich.} I would be happy to. In the area of therapeutics, one of the--kind of a very special properties that nanomaterials give us is the ability to target tissues more selectively. So a lot of drugs that are intended to act in the brain, whether it is for Alzheimer's Disease, those drugs are being developed, Parkinson's and others, those drugs have a difficult time crossing the blood brain barrier. So they can be taken, they are in the system, but they don't get to the site where they can act and improve health.

We have now found that nanoparticles, because of their small sizes, but larger than molecules so they avoid some of the systems that molecules get tied up in, are much more effective at crossing that barrier. So this could be a platform to deliver medicines to the site where they can act so that when we have a medication, a pharmaceutical that is not useful because it doesn't get to the site, one can literally have to drill through the skull and put a device in the brain, or one might be able to use nanoparticle carriers to get them there. We still haven't worked through all of the safety issues and what the dosing should be, what the properties of those particles--but that is one example where nano would take existing trends and just put them at a different--on a different plane.

Ms. {Schakowsky.} I was going to ask you about the support gap, but I think we have really heard from everybody that one way or another, the United States needs to figure out how we support this industry, and I just want to make sure that that has been--that has absolutely been heard.

In your testimony, Dr. Mrksich, you mentioned the multi-agency structure of the National Nanotechnology Institute, but I don't know if you know that Congress has not reauthorized that or provided an updated vision for it since 2003. I am wondering if there are any particular changes you think need to be made in order for it to get new life.

Mr. {Mrksich.} Absolutely. This--the NNI, started in 2000, has absolutely been a success in terms of creating an infrastructure in the U.S., making the U.S. the global leader in innovating, and having the opportunities to translate into commercial entities. The NNI never kind of had its own money. It required the agencies to redirect a fraction of their budgets to nano-related research. I think we are at the point where we have got this incredible infrastructure and we are now beginning, just in the last 3, 4, 5 years seeing a reverse brain drain. Our best people leaving and other folks who would have come to the United States staying. And this is a direct reflection of the imbalance of research money and infrastructure that is available.

So there is no question in my mind that in renewing, it is really reinventing the NNI to put real money behind it and to ensure that our best people have the tools, have the funding to continue on this incredible first 15-year history we have created.

Ms. {Schakowsky.} So for me, lesson learned. Private and public money is really needed to keep us in the forefront. Thank you.

Mr. {Terry.} Recognize--I will not recognize the gentleman from Kentucky. Mr. Olson, you are recognized.

Mr. {Olson.} I thank the chair, and my questions, first off, will be for Dr. Tour.

Doctor, you mentioned in your testimony you have 30 grad students and under--and doctor--PCs, post grads working for you at Rice. You mentioned concern about the brain drain, because many of these people come from overseas. How many people of that 30 are not from here in America? Half, two-thirds?

Mr. {Tour.} Of that 30, probably 25 are not Americans.

Mr. {Olson.} How many people stay--find a way to stay here after they graduate? You give them that great diploma, that sheepskin?

Mr. {Tour.} I would say that half of them will stay. More would stay if they could. The very best of the international students are returning to their home countries where they can get faculty positions. There are no opportunities for them here. There are very few faculty positions opening up in the United States because of the funding situation, and that funding situation being a lack of money that is coming in in federal grants, and mechanisms for that. So they are getting very attractive offers from their home countries, or from countries like Singapore, and also, interestingly enough, the U.K. and Europe because of the large amounts of money in the area, specifically in carbon nanotechnology graphene. So many of them are leaving that would have liked to have stayed.

Mr. {Olson.} And Doctor, you said in your testimony that corporations get a deduction if they fund research through your institute. Any example of a corporation that has lost their deduction--that has not invested in your institute because they lost a tax credit, tax--whatever you want to say about the tax preference, whatever--any example of somebody said listen, Doctor, I want to help you out but I just can't do it. I have to have that--

Mr. {Tour.} Oh, there are companies that have said that they just can't swing this, but they are--the companies that have come forward are doing it anyway, but it is very hard to get companies to step forward, and if I can use this as a leveraging point, it actually works out quite well for both of us. And as to the amount of deduction that they presently get, it is very hard even to figure that out. I am not a tax person and I tried to get that data even to bring it in here to speak to these companies how much they say definitely that it would help if we had had that tax deduction. But they didn't know how much they are really allowed to deduct. And different companies had different views on this in trying to understand the tax law even.

Mr. {Olson.} It sounds like it does hurt for sure. I mean, these guys sort of sit back and say hum, Dr. Tour, you are doing great work, but I have got shareholders I got to take care of, a legal obligation to do that, so I may not invest in your great research because of our tax policies.

Mr. {Tour.} Absolutely, and there are companies that may even be in your district that have said that. I am not exactly sure where the border of your district is.

Mr. {Olson.} It changes dramatically. But sir, you and I live in the energy capital of the world, and so I am thrilled about what is happening in the energy sector with nanotechnologies.

On your website, it mentions oil and gas, enhanced recovery operations, those type of things. Elaborate on those--what is going on, how you are getting help from industries around there, and what we should be excited about.

Mr. {Tour.} So we have a project that is funded in total by Apache Corporation where we have been able to capture CO2 coming out of a natural gas well, so natural gas is a very clean sort of carbon fuel, 30 percent lower CO2 emissions than running a car on gasoline. But coming out with natural gas is CO2. That CO2 is generally just vented to the air. We have figured out how to trap it and how to send it back down whole. Apache is working on the conversion of that to industrial scale for the deployment. We are working on nano reporters, which these are--this is funded by seven different oil companies in a consortium called the Advanced Energy Consortium, where we developed sensors that can go down hole and they can travel through the sub-three nanometer ports, the sub-three nanometers ports down hole, and then bring up information as to how much oil is down there. And also nanoparticles for enhanced oil recovery, when they see that oil to grab that oil and bring it back up, and then self separate. So those are a few examples from the oil industry.

Mr. {Olson.} Finally, healthcare, medical. As you know, right across--spanning--across from Rice University is the Texas Medical Center, the largest research institution in America for healthcare research. You mentioned--I am sorry, your website mentioned carbon nanovectors involved in this. What is so exciting about carbon nanovectors?

Mr. {Tour.} Okay, so we can take these carbon particles now, and all of this has been licensed to a company. They bought the whole suite of patents, licensed the whole suite of patents. This is in collaboration with Baylor College of Medicine across the street, UT Health Science Center, M.D. Anderson Cancer Center, and Methodist Hospital and joint patents between us all. These carbon particles, they can trap something called super oxide. Super oxide, if someone gets a traumatic brain injury--traumatic brain injury is the number one disabler of young adults--and super oxide causes great degradation to the brain in the first several hours after. It is exactly the same as the biggest disabler in older adults, which is stroke. It is a lack of oxygen. There has been a blockage. There is a lack of oxygen. When that blockage is removed and oxygen comes in, super oxide forms which degrades the brain. We inject the nanoparticles just before we clear the blockage, and then what happens is this sequesters the super oxide and makes it unreactive towards the brain, and so you get far less brain degradation.

Mr. {Olson.} I am out of time. Thank you.

Mr. {Terry.} Recognize Mr. Johnson. Bill, you are recognized.

Mr. {Johnson.} Mr. Chairman, I pass. Thank you.

Mr. {Terry.} Okay, then the gentleman from Missouri, Mr. Long, you are recognized for your 5 minutes.

Mr. {Long.} Thank you, Mr. Chairman, and Mr. Phillips, as someone who started a firm from the bottom, can you give more insight into the hurdles that startups deal with with nanotechnology?

Mr. {Phillips.} Thank you, sir, I would be glad to. We, too, as a company and as a scientific nanotechnology company, the majority of our scientists are on visas or trying to get visas, to the tune of about 80 percent of those, and trying to maintain them in the United States is one of our most difficult problems. I mean, basically the visa program in the United States is so out of date, and so difficult that it is like we are telling our Einsteins and our Wernher von Brauns to get the heck out of the United States, go home. It is exactly like that. We face that issue very day. We have--a number of our scientists have become American citizens while working at NanoMech. I am proud to say they have gone down to Judge Parker's courtroom down in Ft. Smith, Arkansas, raised their hand, and some of the greatest scientists ever come out of the Ukraine, India, China, have become American citizens through working at NanoMech on our nanotechnology. One of the scientists that came out of China ran the entire water management program for China when he was 29. He is now a proud American citizen. But every day it is harder and harder with this visa program. We have one our top researchers right now that is working on the most advanced systems for the Department of Defense in the way of creating the best body armor that ever has existed, totally fireproof, totally waterproof, totally antimicrobial, antibacterial. We basically finished and we have been trying for 2 years to get his wife a visa to join him here in the United States, although he was educated here in the United States, received his Ph.D. here in the United States. That is kind of an everyday problem for us in terms of visa programs.

Other things in nanotechnology that are difficult, I am not a state-run company. I don't want to be a state-run company, but I have to compete against state-run companies. In China today they have the Nanopolis. The Nanopolis is a multi, multi, multi-billion dollar project to create commercialized nanotechnology. They invite us over there every day. I have been invited to be their keynote speaker in China this year for the third year in a row, and for the third year in a row, I will turn it down. But they are really outspending us at this point in time in a big way, along with Russia. Russia has a $10 billion fund that they are operating in the United States called RusNano. Dmitri, who is based out in Silicone Valley, is a Russian who has been trying to either invest in us or in other companies, and have successfully invested in many nanotechnology companies in the United States, as well as venture capital companies in an effort to gain access, or if not even control, of our nanotechnology that has been produced through billions of dollars worth of research through National Science Foundation, NIH, down through our incredible university system. So we have to capitalize this company in order to build a very fast--I think we are the fastest growing nanomanufacturing company in the United States--to do things like we do to create new types of greases and lubes. That may not sound like a very important thing, it may sound kind of boring, but the world runs on machines. Machines run on lubricants. Without it, they don't run as well. So we are able to create lubricants that make machines basically last a lot longer. For instance, we believe if we were lubricating the Navy ships--I have had conversations with the Secretary of Navy on this--we could extend the life of our Navy fleet immediately 10 to 20 years without any other expenditures, and many things like that. So getting access to government-type contracts is very tough for smaller companies. Getting access to competitive capital on a national and global scale through--as public/private partnerships is becoming harder and harder. Overcoming this thing called the valley of death where you go to full-scale scaling companies like ours--and we operate on patents that we have licensed from leading American universities. So just in the area of competitiveness, we have the willpower at NanoMech to grow this company, to provide incredible new technologies like very lightweight body armor that is much, much safer than what is out there today, new types of weapons that have never even been dreamed of that can be reached through nanotechnology--

Mr. {Long.} Let me interrupt you there. I know nanotechnology is extremely exciting and there are a lot of tremendous benefits from it. I know that in my home State of Missouri that Brewer Science has partnered with Missouri State University in my hometown and have a very, very good partnership with the development of nanotechnologies, so I think that some of these public/private partnerships are starting to take root, and I hope to see them expand, so good luck to you on your ventures.

Mr. Binek, can you tell me is Nebraska in the SEC?

Mr. {Terry.} That is a cheap shot.

Mr. {Long.} Well, I know they are not but I just love hearing it. I yield back.

Mr. {Terry.} We are united in being former members of the Big 12 with you.

Recognize the gentleman from the SEC, Mr. Bilirakis.

Mr. {Bilirakis.} Absolutely, best team in the SEC, University of Florida Gators. Go Gators.

Thank you, Mr. Chairman, for holding this hearing on a growing sector of America's innovation economy.

Nanotechnology is a sector that holds exciting prospects for the United States with its continued position at the forefront of technological advancement and economic growth. Nanotechnology is the perfect demonstration of how the private marketplace continues to innovate to solve economic and societal problems.

For example, in my district, Dais Analytic, which was named to the Forbes magazine's top energy projects to watch in 2012, has developed technologies and programs to clean dirty air and dirty water. Because nanotechnology is still a relatively new phenomenon, it is important that the Federal Government not stifle innovation and growth with burdensome and unnecessary regulations and red tape.

Here is my question. I currently serve as the co-chair of the Congressional Technology Transfer Caucus, and I am interested in how we economically capitalize upon the investments made in technology research. I understand that it may be difficult to transition from research to licensing to commercial development. Can you walk us through--and this is for the panel--can you walk us through the challenges that are faced in the stages of development, from patenting new research and technology to licensing it to companies to commercializing it, please? Whoever would like to start.

Mr. {Mrksich.} I can begin. I have done this a number of times, and having advances in my university lab lead to something interesting. Within the universities, we disclose that, apply for patents, and at the same time start to form a small company. That is sometimes done by raising seed or angle money. Sometimes it is done by going straight to venture capitalists, if that is the scale of the investment required. Then from there it gets a start, and runs on the treadmill and hits milestones and raise more capital.

One comment I want to make about nano, though, this is a new area. If you look at biotechnology, there are many repeat entrepreneurs that really are quite effective at getting new technologies out. There are venture capital firms and angels who specialize in that space, and so they are very sophisticated in recognizing opportunities and aggressively pursuing them.

Ten years ago, there was just a handful of nanotechnology companies that got started. We didn't have the capital infrastructure, the sophisticated investors that made it more--and the repeat entrepreneurs that made it more straightforward to get started. So as I look back, I think

I--and in my case, this is true as well--the SBIR program has oftentimes been the stepping stone to get IEP out of the university into a company where you can start working on a prototype and de-risk the technology. And I think in this young field still, where many of the founders of new companies are first-time founders, they are not familiar with the process and there are many barriers to getting going. Making it more straightforward to direct SBIR funds towards those folks, I would even think about a policy that said if you have a research grant from the NSF or the NIH or the DOE and a nanospace, and you apply for a patent, that you have a streamlined access to an SBIR to get that out of the university and put it into the commercial sector where it can get going. Because I think there are a lot of things that are left on the floor because, again, this young area with first-time entrepreneurs don't have a straightforward time getting something started.

I will let the others add other perspectives.

Mr. {Bilirakis.} Yes, please. Anyone else, please?

Mr. {Tour.} I have gone through this many times. Let me just--you know, I agree with Milan and I have known Milan for a long time--is that what I am finding now is that it is international companies and entities and investors that are coming and wanting to buy up the technology.

Just recently, one of our patents was licensed to a Chinese company for the development of super capacitors, and they are going to take this on and make batteries for electric vehicles this way. Three of our technologies are currently being licensed by the Israelis to start companies in three different areas, based on the technology that was developed in our laboratory. There was a company that was going to start and the tax advisor said don't start it in the United States, start it in Singapore. And that was purely from a tax consideration standpoint.

So as no other time in my career in the last year or two I am seeing this coming of foreign entities and buying up U.S. technologies, and so the question then becomes why aren't the U.S. entrepreneurs stepping forward as aggressively as the international entities, and I am not sure that I have answer to that for you, and that is something that there is probably--you in this room have thought about this more than I have. But this is a trend that I am noticing that the biggest--the most aggressive buyers of the technology now, in my experience in the last several years, are not U.S. entities anymore.

Mr. {Terry.} Thank you.

Recognize the gentleman from Ohio, Mr. Johnson.

Mr. {Johnson.} Thank you, Mr. Chairman. I did want to come back and kind of take off on what, Dr. Tour, you were just talking about. What do you think we need to do to regain U.S. competitiveness for human talent and corporate investment as compared to what some of those other countries that are doing that are state-sponsored, subsidized countries like China and others?

Mr. {Tour.} Right. So even before coming here, I talked to this Israeli group that is licensing three of our technologies to certain companies. And I said show me the tax structure of what it would cost me to start up a company in Israel. And they sent me the links to all of that data, and the tax structure is a lot more friendly towards small companies, especially if you are going to build your manufacturing entity outside of Tel Aviv, moving it. So I am talking about tax rates that are on the order of about 7 percent.

So you look at numbers like this--and I am cognizant of the fact that the U.S. government runs on taxes, but I have started several small companies myself and I will never start another one again. It is a very difficult and arduous task, and so now I just go into the licensing and license it out to others. But the tax structure is quite aggressive here, and again, I am deferring to what the Congresswoman said, and I acknowledge that. I am just saying that when you look at the tax structure, it is very different.

My testimony here is saying that without a proper mechanism for funding, many of these very smart people that we have are now leaving. The U.K. has come with a grapheme and carbon program that is enormous--the European Union--that is enormous and funding at a very large scale. And they are trolling U.S. faculty. I had two offers, two offers in the last year from the U.K. to move my program there. My program that was 90 percent federally funded, 10 percent industrially supported in 2008 is now 80 percent industrially supported and 20 percent federally supported. Same amount of money. I have been able to make that transition, so my testimony is help me to make that transition. If the Federal Government can't step up, what can you do in the meantime to allow me to bring more money into my laboratory and my colleagues into their laboratories to maintain their programs here, rather than just having us move abroad. Because these folks are industrious folks and they are going to find out how to get their program continued. And if that means moving overseas, they will do it.

Mr. {Johnson.} So is it safe to say, then, that tax reform is critically important to retaining nanotechnology expertise in America and making us competitive?

Mr. {Tour.} I absolutely think so, sir, and I know that is not the privy--the direct privy of this committee, but I know that you have influence in that.

Mr. {Johnson.} Dr. Binek, how can research consortia such as the Semiconductor Research Corporation be encouraged in the U.S.? Have you worked with other similar organizations or know of similar organizations working with universities to support nanotechnology research?

Mr. {Binek.} In the case of the Semiconductor Research Corporation, their motivation is basically driven by the--I mean, they look at the scaling issue and they know if we don't do something drastically soon, there will be a major problem because who wants a next generation cell phone which just changes color, right, but there is no progress anymore. So--and this kind of driving force can--I think can be very strong, but--and it can probably also be very strong, although I have less experience outside the semiconductor industry. For other industries, however, my concern here is that it is mainly short-driven to some extent, you know, they have to see the abyss in front by doing their own extrapolations, seeing that scaling 2020 will--and then they say okay, we better do something, and now it is already a little late. And I think we should find ways to do something in advance.

Mr. {Johnson.} Okay. In your testimony, you discuss U.S. dependence on rare earth permanent magnets, which are predominantly mined in China. So why are these magnets important to the U.S. economy and what are the benefits of finding alternatives?

Mr. {Binek.} So you find them everywhere, from your cell phone in the modern lithium ion batteries and I was specifically referring to the important use of them in permanent magnets. There are high energy permanent magnets which enable this extremely lightweight electrical engines, which allow for this unmanned aerial vehicles, for example, or headphones even. All kinds of applications, wind turbines. For example, a 2 megawatt wind turbine has 800 pounds of rare earth minerals in it, so they are very important and the thing about rare earth, as the name may suggest, they are not that rare. You cannot just mine them as other metals like gold or copper. They are not really concentrating that much, so you have to operate with large volumes and then extract small amounts of them. And that is a very costly enterprise, and also it comes with a huge burden on the environment. I mean, there are stories about these toxic lakes in China which are a big problem.

So finding alternatives to rare earth is certainly an important thing, and nanotechnology, again, can help here. For example, in the field of permanent magnets we do that also at the University of Nebraska. We use nanostructuring of materials, bringing hard and soft materials into proximity and then get those properties without rare earth, just really metals, for example.

Mr. {Terry.} Thank you.

Mr. {Johnson.} Thank you, Mr. Chairman.

Mr. {Terry.} Recognize the gentleman from Mississippi.

Mr. {Harper.} Thank you, Mr. Chairman, and thank each of you for being here and for your insight. It is certainly amazing some of the progress that is being made and the excitement for the future of what we can do if we do this properly.

Dr. Binek, if I may ask a follow-up on Mr. Johnson's question, specifically about the rare earth materials. How far are we--how far away are we from developing alternatives at a commercially viable high volume manufacturing process?

Mr. {Binek.} I think we are still quite a step away to replace them. Certainly we will not replace them with a switch everywhere. There different field and different needs applications where we can hope to find replacements soon, but I am very certain as far as I can predict that they will still play an important role in the foreseeable future in many, many applications.

Mr. {Harper.} Thank you very much.

Mr. {Binek.} I may want to mention that there are--as a mining operation also again reopened in the United States, but it comes with its own problems.

Mr. {Harper.} Okay, and where is that?

Mr. {Binek.} To be honest, I need to pass on that.

Mr. {Harper.} Okay, that is fine. Thank you very much.

Mr. Phillips, if I could ask you a few follow-up questions. In your testimony, you discuss the U.S. permitting process for manufacturing facilities. Why is the time table for approval longer in the United States than other countries?

Mr. {Phillips.} Well, you could basically say the United States perhaps is more advanced in that area in terms of guarding safety and regulations and things like that, and to a great extent, a lot of those regulations are necessary for a good, safe country. But--

Mr. {Harper.} Okay, and how have other countries--

Mr. {Phillips.} I am up against countries that don't even know what OSHA is. They have no OSHA. They have no requirements for insurance. They have no permits, typically, and so all I do is try to make a comparison as to trying to compete against those companies and countries like that that are state-run companies. It makes it more difficult for a company like us. Albeit, we work very closely with our municipalities, our state governments, and so forth to expedite those situations to reduce the amount of paperwork, typically, that comes with it. A lot of it is incredibly redundant paperwork, committees upon committees upon committees that you have to deal with that I would say could be incredibly streamlined. Having founded a company in Mississippi, co-founded a company called Skytel in Jackson, Mississippi that became instant messaging and ushered that in on a worldwide basis. I can remember back to the days in the '90s on how easy it was to do things like that. Of course, that was in the digital space, as we moved from analog to digital and totally transformed the way business is done. I believe that the transformation that is taking place in moving from micron technology in a manufacturing scale to now nanoscale will dwarf all the benefits we saw in the digital world, moving from analog to digital. Unfortunately, as the testimony shows today, in Europe and Asia and so forth, they are taking nanotechnology tremendously more serious than the

U.S. government is in terms of advancing it with incredible speed, with developing either public/private partnerships or outright gifts to corporations to make them competitive. We have seen a couple of those in the U.S. A lot of criticism about Solyndra. Solyndra received $500 million in funding and then went bankrupt, but in China, there were four competitors to Solyndra that received $5 billion each to compete and dropped the price on a worldwide basis and took the worldwide lead in solar. And now the remains of Solyndra are owned by China, as is A123, our leading battery company, that received $500 million in funding in the U.S., but compared to China it was dwarfed.

So although--you know, I'm not, again, wanting to be a state-run company or anything like that, we have to look at the entire business model on a global basis, not on a U.S. basis, in order to compete going forward. It is something we have to get a handle around, because if we don't make things, we really cease to be a country.

Mr. {Harper.} So what you are saying is if there is a way to fast track some of this process, that is a great benefit to you. And you mentioned countries that maybe are not doing it right. Are there some countries that are, indeed, doing it well on nanotechnology R&D?

Mr. {Phillips.} Well, you know, you look to Germany and Japan and so forth and the amount of public/private partnerships that you see there are fantastic in terms of the speed, Sweden and others. And this is not to over-criticize my country which I love dearly and represent it as--in the military days. I think we are definitely trying a lot of things, but we are stymied to a certain extent in patents right now. The cost of a U.S. patent compared to overseas many times is prohibitive and in the area of nanotechnology, in order to protect gigantic investments it takes to enter into a manufacturing, as opposed to digital space, that cost is very high. I just hope 100 years from now when America looks back, we don't basically say well, we are the country that did Facebook, compared to the country that came up with new ways to manufacture that totally created new cures, whether it was for cancer or what have you, and nanotechnology and maintained a very competitive weaponization system, as weapons became smaller and easier to perhaps control those weapons in strategic and tactical applications.

Mr. {Harper.} Thank you very much, Mr. Phillips. I yield back.

Mr. {Terry.} Thank you, and the gentleman from New Jersey is recognized for 5 minutes.

Mr. {Lance.} Thank you, Mr. Chairman.

Mr. Phillips, in your testimony you referred to various policies that may be hampering business investment in nanotechnology, including the R&D tax credit. In 16 countries with a higher R&D credit than the U.S.--and I am sorry that that is the case--I believe that their corporate tax rate is different from the United States, and our corporate tax rate is among the highest, perhaps the highest in the industrialized world. Could you comment on that in a little greater detail, and any advice you might be willing to give us in that regard?

Mr. {Phillips.} Well, you know, when we have a breakthrough technology that hits like digital or like in the case of nanotechnology, maybe the Federal Government needs to perhaps look at investment tax credits on spending by companies in nanotechnology of a variety of types so that they can capitalize their manufacturing facilities faster, perhaps do more research and development faster, and through investment tax credits produce new goods that return in the purchase of those goods through sales taxes and other type taxes, including income taxes on a federal basis, actually multiply the receipts on the tax base, even though in the early stages of those companies those changes could, without question, accelerate the development, and also lead to more investments in those companies from the private sector if it favored a technology as robust and as potential as nanotechnology.

Mr. {Lance.} Thank you. I certainly agree with that.

Dr. Tour, the regulatory landscape for nanotechnology drives industries as how they look today. If you would, sir, could you expand on the regulatory process for startups and how Congress might be involved in improving the situation.

Mr. {Tour.} All right. So we don't have good standards now to make comparisons and upon which to really target ways to mitigate the problem so that the improvement of standards against which we could direct these would certainly be a help for us to be able to move these along so we generate new materials. And then sometimes our--I served for 3 years on E-Track, which is a Department of Commerce committee to rewrite some of the export control laws, and because we have a very large book of things that we can export--and it was interesting that we couldn't export many of the things that are made overseas in much larger volumes than we are even making them. So we were hampered in that way and many ways, and that even hampered the basic research of collaborating with people.

So things become archaic, and after 3 years on that committee, I stepped down because everything that was proposed I wasn't even sure if it was even read. And so I am not sure that anything ultimately changed as a result of that.

So I realize that this is a big country and lots of things have to be done, but some of these barriers that really there was no good scientific rationale for the inhibitions that were there.

Mr. {Lance.} And from your expertise, could those matters be changed by administrative rule and regulation, or would it require a statutory change, change from us here in

Congress?

Mr. {Tour.} I am sorry, I don't know that.

Mr. {Lance.} Certainly it might be easier if it were only to require some sort of change from the Department of Commerce or another agency of the Executive Branch, but obviously, we and our co-equal responsibilities are looking for statutory change as well to improve the situation.

Mr. {Tour.} Right.

Mr. {Lance.} Certainly I thank you for your service, and it may seem frustrating but I certainly think it is important that talented professionals, including academics, are involved in what you do, sir.

Thank you, Mr. Chairman. I yield back the balance of my time.

Mr. {Terry.} Thank you, Mr. Vice Chairman. And that concludes our question and answer period. I want to thank all of you for being here. I think you have enlightened us, especially on policy aspects, which is hopefully one of your goals here today. I think you have given us several things to think about how we can help improve the research and development of nanotechnologies in the United States, so I appreciate that.

So with that--did you want to say something?

Ms. {Schakowsky.} No--well, let me just thank the witnesses. I mean, I think this is a real growth area for our country if we do the right thing. We have the brains. We have an infrastructure to do this, and it would just be such a pity if we lost this to--in the global marketplace.

So thank you very much for underscoring that, and for sharing your expertise.

Mr. {Terry.} So we have up to 2 weeks to submit written questions to you. Don't know if there will be any, but we have that and if we do send you written questions, we would appreciate about a couple week timeframe to get them--your written answers back to us.

With that, thank you again. You have been a great service to us, and we are adjourned.

[Whereupon, at 11:45 a.m., the Subcommittee was adjourned.]