# The Brazilian Congress at the Frontier of Innovation

*A report on parliamentary study missions on innovation policies to the United States and the United Kingdom*

Wilson Center

BRAZIL INSTITUTE

*Washington, Cambridge, London, San Diego*
*2011 • 2012 • 2013*

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# The Brazilian Congress at the Frontier of Innovation

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*Organized by Paulo Sotero with Michael Darden and Anna Carolina Cardenas*


*Institutional support*

Interfarma
Brazilian Research-based Pharmaceutical Manufacturers Association

# Foreword

It is not due to the lack of talented people that Brazil performs poorly in innovation for an economy of its size. The country has produced first-tier scientists for more than a century. Oswaldo Cruz and Carlos Chagas are early examples. In recent decades, Brazilian scientists, including a growing number of women, have gained significant space among major universities and research centers in Europe and the United States. The number of Brazilians scientists who stand out abroad for their entrepreneurial capacity has been on the rise.

The country has an abundance of academics, business executives and government officials at various levels who are aware of the essential role that technological and innovation policy plays in economic and social progress. They have written extensively about the topic and called attention to the country's need to invest in innovation by fostering an environment where companies, universities, investors, lawmakers, and regulatory agencies work together to increase the efficiency of the economy as well as the value of the national wealth by applying new knowledge in high value production chains, processes and services demanded by the market. Carlos Américo Pacheco, dean of ITA (Technological Institute of Aeronautics) and former executive secretary of the Ministry of Science and Technology, and Carlos Henrique de Brito Cruz, scientific director of FAPESP (São Paulo Research Foundation) and former dean at Unicamp, have been leading participants in this effort, along with University of São Paulo's sociologist Glauco Arbix, current president of FINEP, the federal agency for innovation, and former head of IPEA, Brazil's federal Institute of Applied Economic Research, in the first government of President Luiz Inácio Lula da Silva. In 2010, Arbix and his colleagues at USP's Innovation and Competitiveness Observatory carried out a detailed comparative study on the

evolving institutional frameworks of innovation policies and strategies in the United States, France, Finland, Canada, Ireland, the United Kingdom and Japan. The study was conducted under the auspices of the Brazilian Agency for Industrial Development and amply debated.

Therefore, Brazil's poor performance in innovation is not caused by a lack of knowledge on competitiveness issues or a lack of knowledge of what needs to be done.

It is not, therefore, for lack of knowledge of the competitiveness issues or of what needs to be done that Brazil has had a poor performance in innovation. The problem is both cultural and political. Aware of this, the Brazil Institute at the Woodrow Wilson International Center for Scholars accepted the challenge posed by Interfarma back in 2010 to organize annual missions of Brazilian congressmen interested in studying public policies and practices that support and encourage innovation in the United States and Europe. The initiative was built on a series of six seminars the Institute hosted in 2008 and 2009 in partnership with the São Paulo strategic consultancy Prospectiva. The series, held in both Washington, D.C. and São Paulo convened American and Brazilian experts, including Arbix, Pacheco and Brito Cruz. A thorough summary of the lectures and debates – Innovation in Brazil: public policies and business strategies – prepared by the political scientist Ricardo Sennes, a director at Prospectiva, was published online both in Portuguese and English.

Thirty-two house representatives and senators, including majority and minority leaders and presidents of parliamentary committees with jurisdiction over areas that are relevant to innovation, have participated in three academic conferences held between 2011 and 2013 at the Wilson Center, the Massachusetts Institute of Technology, the London King's College Brazil Institute, and the Institute of the Americas, headquartered at the University of California San Diego. The State Department received the first mission. Brazilian ambassadors in Washington, Mauro Vieira, and London, Roberto Jaguaribe, hosted the congressmen in their respective official residences, and the consul general in Los Angeles, Bruno Bath, contributed to the work in San Diego.

Participating members of the Brazilian Congress attended around forty lectures about the complex array of themes and public policies that affect the innovation policies and strategies on both sides of the Atlantic. Lively

debates followed each session. At the end of the session at MIT in 2012, one of the members of the Brazilian congressional delegation acknowledged the value of the mission after hearing an ironic thank you note addressed to the group by MIT's Anthony Knapp for preparing excellent scientists in its public universities and sending them to Cambridge, Massachusetts, to do applied research that they find little opportunity to do in Brazil. "This discussion has helped us understand our role in Congress to help to create a more appropriate environment for innovation in Brazil." Another congressman made a revealing comment about the effects of his participation in the first mission. "These talks opened my mind to the complex issues of innovation," he said during a breakfast with Interfarma's executive president Antônio Britto. The three parliamentary missions were preceded by seminars for trade journalists and followed by visits to pharmaceutical laboratories of member companies organized by Interfarma.

This volume showcases a selection of the lectures, as well as testimonials of researchers and entrepreneurial scientists who work in the thriving space situated on the border between the two areas that are vital for innovation in the post-industrial world. They contribute to discoveries in universities' and research centers' laboratories and the practical application of such knowledge by companies and venture capitalists willing to invest in them to produce solutions for real day-to-day problems and add value to the marketplace. Effects of innovation can be seen in a myriad of devices and applications that resulted from advancements in information technology, the life sciences, and marketing strategies that have been transforming the way people organize their lives, interact, work, and have fun in all corners of an increasingly integrated planet.

The volume is organized thematically in three parts. After a historical overview of innovation in the United States by Wilson Center Senior Scholar Kent Hughes, the volume focuses on the various topics of the policy debate in the United States, the United Kingdom, and India. The second part consists of edited transcripts of the sessions held in 2013 at the University of California San Diego, in partnership with the Institute of the Americas. It offers a detailed narrative of the transformation of UC San Diego into one of the leading centers of information technology, pharmaceutical, and medical innovation in the United States, by entrepreneurial scientists who remain key actors of the innovation story in Southern Ca-

lifornia. The third part describes the efforts of cooperation on innovation by Brazilian and American government institutions as well as private companies.

The Brazil Institute hopes to continue to be of assistance to the members of the Brazilian Congress in their efforts to study the complex policy issues involved in the ongoing debate on innovation.

**Paulo Sotero**

Director, Brazil Institute, Woodrow Wilson International Center for Scholars

# Brazil Wastes Opportunities in Innovation

Look into Brazil's general condition as a country and you will see some reasons to be upbeat. Democracy, institutional stability, and rule of law are the framework that provides a measure of legal security. The nation has a reasonably organized economy, an extraordinary domestic market, and more importantly, accelerating growth in the generation of knowledge, measured by the publications of papers, graduation rates of PhDs in STEM, academic participation at the global level, all evolving very strongly.

Now we look into the outcomes of innovation and you will see a mediocre position in generating patents, poor placement in innovation rankings, loss of space in pharmaceutical research, increasing dependence on technology of medical equipment and health care products.

Why did Brazil not leverage its potential? Why, as former Minister of Science and Technology, Marco Raupp, says, did Brazil not transform knowledge into wealth? And what are the consequences of this lost opportunity in a moment where change in the country has created an older population, prone to more complex illnesses, and at the same time, more conscientious and informed, demanding more access to better treatments and services?

The root of the problem, we believe, is primarily cultural. Brazil sees innovation just as an option, not as an imperative for growth. Five centuries of commodities exports and economic expansion based on a powerful domestic market have created the idea that innovation is good but not essential. In universities, researchers have neither the prestige nor the encouragement they enjoy in other countries to work in the development of new knowledge and its application in products and processes valued by

consumers. Positive examples of innovation capacity in the business world are generally a repetition of the same companies' names and cases, with Embrapa and Embraer on top. At the government level, where progress has undoubtedly been made, efforts to advance innovation are diluted and jeopardized by the intervention of way too many agents, programs and projects.

In this scenario, three years ago Interfarma reached out to the prestigious Woodrow Wilson Center with a challenge: to plan and carry out annual study missions aimed at congressmen and journalists willing to learn, assess and discuss public policies on innovation in other countries and look for leads and lessons that may be applicable in Brazil.

Working with a team led by Paulo Sotero, director of the Wilson Center's Brazil Institute, the study missions developed into useful exercises to exchange information and views between members of the Brazilian Chamber of Deputies and Senate, leading academics, and practitioners in the innovation field. Highly reputable academic institutions such as the Massachusetts Institute of Technology, King's College of London and the University of California San Diego welcomed the members of the Brazilian parliament with meaningful lectures and debates on innovation policies and strategies. A plurality of views was presented by representatives of both the public and private sectors, illustrating the presentations made by academic experts on the challenges posed by innovation.

The result of the missions was very positive, as this publication attests.

Participants observed that when facing challenges posed by innovation, some countries promote aggressive programs to attract research by streamlining bureaucratic proceedings, reducing taxes, and coordinating government actions. Participants in the missions had the opportunity to note that Brazil is going against the world's conventional wisdom on innovation. Research in our country seems to be regarded almost as a sin. Bureaucracy establishes processes that take three times longer to complete than the world's average, exposing the country's academic and scientific community to a culture of waste of resources and opportunities.

Certainly, Brazil has some islands of excellence in innovation in the health field, both in public and private settings. Examples are the National Institute for Cancer (Inca), Fundação Oswaldo Cruz Foundation (Fiocruz), Hospital Israelita Albert Einstein and Hospital Sírio Libanês. But even in those places innovation could be producing better and faster results if they did not face the obstacles of bureaucracy and an extraordinarily

high tax burden. To overcome this vicious circle, sooner or later the country will need to take the innovation game more seriously. The alternative is to be satisfied with being in the second or third division of innovation.

In order to move forward on innovation policies and strategies, Brazil will need to accomplish three pressing tasks. The first is to change the mentality within universities in order to drive them closer to the private sector. Secondly, a change of mentality is also required within the private sector in order to drive it closer to academia while accepting higher risks, which is inherit in investment in innovation. Last but not least, governments of all levels must work to foster the country's development by reducing bureaucracy, taxes and eliminating counterproductive regulations. Improvement of education, in particular STEM, also has to be a priority. This is a strategy for the next 20 years if we start now and work consistently to overcome the paradoxical position in which we find ourselves, of a country that graduates thousands of PhDs and produces tens of thousands of papers yet few patents.

The alternative is to remain where we are: in an incongruent position of being the world's 6th largest pharmaceutical market but the 19th in clinical research and the 156th in ranking of investments for innovation. This translates into a mere US$ 200 million in an annual investment market of US$ 150 billion– a reality reflected in excessive imports of technology and ideas. The country has consolidated a powerful generics industry, but 86% of them are manufactured with active ingredients brought in from India and China.

Interfarma firmly believes that the Brazilian creative capacity, continued improvements in the academic field, and increasing demand for services and products will bring a fundamental change to the relationship between Brazil and innovation. This dynamic is a necessary part of the nation's development in the twenty first century and a challenge we can tackle.

There is no successful innovation policy in the world that cannot be applied in Brazil. The speed of global changes and the difficulties of our development model tell us it is time to rethink our approach to innovation. It is our hope that this publication will contribute to this goal.

**Antônio Britto**

Executive President of Interfarma

# Summary

# Congressional Delegations

## 2011

Senator Aloysio Nunes
*Brazilian Social Democratic Party – São Paulo*

Representative Arnaldo Jardim
*Popular Socialist Party – São Paulo*

Representative Arnon Bezerra
*Workers' Party - Ceará*

Representative Bruno Araújo
*Brazilian Social Democratic Party – Pernambuco*

Representative Cândido Vaccarezza
*Workers' Party – São Paulo*

Representative Darcísio Perondi
*Brazilian Democratic Movement Party – Rio Grande do Sul*

Representative Duarte Nogueira
*Brazilian Social Democratic Party - São Paulo*

Representative Geraldo Resende
*Brazilian Democratic Movement Party – Mato Grosso do Sul*

Representative Josias Gomes
*Workers' Party – Bahia*

Senator Luiz Henrique da Silveira
*Brazilian Democratic Movement Party- Santa Catarina*

Representative Manuela D'Avila
*Communist Party of Brazil – Rio Grande do Sul*

Federal Representative Maurício Rands
*Workers' Party - Pernambuco (now affiliated with the Brazilian Socialist Party)*

Representative Moreira Mendes
*Social Democratic Party – Rondônia*

Representative Nelson Marquezelli
*Workers' Party – São Paulo*

Representative Onyx Lorenzoni
*DEM (Democrats) – Rio Grando do Sul*

Representative Renato Molling
*Socialist People's Party –Rio Grande do Sul*

Representative Saraiva Felipe
*Brazilian Democratic Movement Party - Minas Gerais*

Representative Walter Feldman
*Socialist Party of Brazil – São Paulo*

## 2012

Representative Bruno Araújo
*Brazilian Social Democratic Party – Pernambuco*

Representative Eduardo Azeredo
*Brazilian Social Democratic Party – Minas Gerais*

Representative Rogério Carvalho
*Workers' Party – Sergipe*

Senator Wellington Dias
*Workers' Party– Piauí*

Senator Casildo Maldaner
*Brazilian Democratic Movement Party – Santa Catarina*

Representative Eleuses Paiva
*Social Democratic Party – São Paulo*

Representative Darcísio Perondi
*Brazilian Democratic Movement Party – Rio Grande do Sul*

Representative Alexandre Roso
*Social Democratic Party – Rio Grande do Sul*

Representative Amauri Teixeira
*Workers' Party – Bahia*

Representative Osmar Terra
*Brazilian Democratic Movement Party – Porto Alegre*

Representative Cândido Vaccarezza
*Workers' Party – São Paulo*

## 2013

Senator Jorge Viana
*Workers' Party – Acre*

Senator Paulo Bauer
*Brazilian Social Democratic Party – Santa Catarina*

Representative Bruno Araújo
*Brazilian Social Democratic Party – Pernambuco*

Representative Cândido Vaccarezza
*Workers' Party – São Paulo*

Representative Darcisio Perondi
*Brazilian Democratic Movement Party – Rio Grande do Sul*

Representative Moreira Mendes
*Social Democratic Party – Roraima*

Representative Walter Ihoshi
*Social Democratic Party – São Paulo*

## INTRODUCTION

# Innovation in the United States: The Interplay of History, Institutions, and American Culture

**KENT HUGHES**
*Director, Program on America and the Global Economy*

I want to congratulate the members of the Brazilian Congressional Mission for your focus on innovation. If you look at the challenges that the world, Brazil and America, faces -- food security, energy security, flu pandemics, supply chains -- the answers to the key questions about the future require a good deal of innovation, technology, and science. I think you have picked a very important path to the future.

I would like to give a brief overview of the American innovation system and how it has evolved. It has evolved in terms of the basic structure of the American economy. It has responded to crises. Sometimes it has responded to opportunities. We never had a group that sat down and said, "Here's what the 21st century innovation system is going to look like." It evolved over time to be what remains one of the world's powerhouses of innovation. It's interesting to see how the approach to innovation did change as the American economy itself developed and became more outward looking and more globally competitive.

One of the striking features of the American Constitution is how little it says about the economy. But one of the few specific economic aspects

of the Constitution deals, in fact, with innovation. If you look at Article I Section 8, you will find that Congress was explicitly given the power to promote the progress of science and useful arts by securing, for a limited time, to authors and inventors the exclusive right to their respective writings and discoveries. In other words, the idea of patents and copyrights was actually embedded in the American Constitution. Most Americans don't know that the very first patent was issued by future President Thomas Jefferson, when he was our Secretary of State and also served as one of three commissioners of patents.

Abraham Lincoln was also a champion of innovation. He is often quoted as saying that patents "added the fuel of interest to the fire of genius." In the middle of the Civil War, Abraham Lincoln took a historic step of signing the Morrill Act, which established the land-grant colleges in the United States. Many of the very prominent universities that are top research universities today had their start as land-grant colleges; that is, the government gave federal lands to the states to establish universities.

From the start, they had a practical orientation. This is quite a distinction between the land-grant college and the European tradition. You see echoes of the focus on agriculture and mechanical in the names of some of today's top universities. One example is Texas A&M (Texas Agricultural and Mechanical), one of the two major university systems in the state of Texas. The American Civil War, a brutal civil war, drove many improvements in manufacturing. This pattern would be repeated as America entered into other wars, World War I, and World War II.

In the first half of the 20th century, innovation, again, was partly opportunity, partly driven by a sense of necessity. You saw American innovation definitely influenced by World War I. In part, it was opportunistic that being at war with Germany, the United States confiscated the patents of the German pharmaceutical and chemical industries, which gave American industries a significant leg up in future competition.

The military also felt in World War I that the United States had lagged behind in terms of radio communications. The government stepped in, pulled together some of the key patents, which led to the founding of what became the Radio Corporation of America (RCA), which, for many years, was a very prominent electronics company in the United States. When RCA was founded, I believe, the U.S. Navy, held 30 plus percent of its stock. This was something that was not a long-term plan. It was driven by that exigency of World War I.

The United States was different from Europe, in that instead of founding a public post, a telegraph system, and telephone system, we created a regulated monopoly: the famous AT&T; the Bell system.

A&T founded the Bell Laboratories in 1925. If you talk to leaders in today's electronic world in the United States, you would find that Bell Labs played a very significant role in many aspects of the evolution of electronics. It wasn't exactly a public entity, but nor was it a typical private entity.

At the same time, we had an evolving system of public health. It started at the very end of the 19th century with a public health service that evolved over time in what is today the National Institute of Health. There were National Institutes of Health. There were several separate institutes that were founded along the way and then were put together under one broad heading. That has become a major source of funding for innovation, and, in many cases, of innovation itself.

World War II was another benchmark in terms of the evolution of the American innovation system. As President Roosevelt famously said, "Dr. New Deal gave way to Dr. Win the War." And then looking back at the winning of that war -- in which I want to recognize that Brazil was one of our allies and played an important role in the Italian invasion and liberation -- led to an understanding of how critical science and technology were, in terms of giving the Allies a real military edge. One of Roosevelt's science advisors became a prominent advisor to President Truman: Vannevar Bush, who wrote a seminal proposal under the title of "Science: The Endless Frontier." That thinking gave birth to what became the National Science Foundation, which then and today became a major source of funding for research in the physical sciences.

At the same time, there was an awareness that, as I said, that science and technology played a critical role in actually giving the Allies an edge. That led to the Department of Defense also being a major source of funding for research in the physical sciences.

Venture capital started to emerge as an institution shortly after the end of World War II. The first venture capital fund was founded in Massachusetts, but it has continued to spread and has been one of the sources, not always the most important source, but one of the sources for funding smaller startup innovative companies that have been a distinctive feature of America's innovation system.

Let me jump forward now to 1957. Most of you will remember Sputnik, the Soviet success in launching the first human satellite to circle the

Earth. This was quite a shock to the United States. It was viewed, in part, as a challenge to our national security, but it also was a major blow to American pride. The response to Sputnik was nationwide. It included not only the national government, but also local governments and local school boards all across the country. Every one of them thought it was critical that they emphasized mathematics, science, and foreign languages because they saw this as a global struggle with regard to the Soviet Union.

There were, of course, other changes at the federal level that had significant impact on the innovation system in the U.S. The institution that had been established to promote civilian air power switched to becoming the National Aeronautics and Space Administration, and it was that group that helped fulfill President Kennedy's commitment to have a man on the moon by the end of the 1960s.

Then, the administration established a new institution in the Department of Defense. It's now known as the Defense Advanced Research Projects Administration (DARPA). With an assignment to take chances on cutting-edge technologies that would support the national security mission of the United States, it has also had an enormous impact on our innovation system here and around the world. At one point, DARPA felt it was important to facilitate communication between military research laboratories. The National Science Foundation thought, "That's really a good idea. Let's see if we can't link civilian research authorities." At some point, this became a functioning institution better known today as the Internet. You see the enormous impact that has had here, in Brazil, Europe, China -- everywhere in the world. DARPA continues to do that kind of cutting-edge research with the distinction that their customer is well defined. Their customer is the Department of Defense, even though the impact of what it invents has had much wider applications.

Let me give you a recent example: Dean Kamen, a Manchester-based, New Hampshire-based inventor, was asked by DARPA to develop an artificial arm that would be of use to so many American soldiers who were coming home with having lost a limb. Dean was successful in developing an arm that has almost all the functions of a human arm: it is sensitive enough; and it could actually pick up a grape without crushing it. Although this was targeted at soldiers returning from the battlefields of Iraq or Afghanistan, clearly, it has enormous applications in the civilian world.

The response to Sputnik also led to what may seem surprising now but was unprecedented at the time. As you may know, the U.S. has a very diffe-

rent kind of education system than most countries. We have some 16,000 local school boards that have a lot of influence on what is done and what isn't done. We have thousands of universities that set their own standards. The federal government really had not been involved in education at all up to Sputnik. But in the wake of Sputnik, they established the National Defense Education Act, which was targeted at scientists, engineers, and economists for graduate study. I benefited from that myself, so I think that was a good idea.

One of the things that also started to emerge -- and, again, there was a spin-off in some ways from the defense activity -- is innovative clusters, groupings of firms in Silicon Valley and in Route 128, in greater Boston. An element of this idea of clusters has been written about a good deal by Professor Michael Porter at the Harvard Business School. He has more recently looked at clusters of innovation and would certainly point to Austin, Texas, as one of those centers. Michigan has an Automation Alley. Oregon has Silicon Forest. There's a whole series of these innovation clusters that have emerged. What is different and interesting today is these clusters also have, in many cases, an international link as research and innovation becomes more and more of a global activity.

The next real evolution in America's innovation system came from the Japanese challenge in the 1980s that you may remember. Many popular books were highlighting Japan as number one. There was a sense that Japan was marching from one industry to the next. This led to a real look at some of the Japanese strengths. One was process. The Toyota lean production technique certainly gave a number of Japanese industries an edge. Process technology was adopted and adapted in the U.S. And there were a whole series of efforts to bring our research institutions, universities, and national laboratories closer to the market. A series of acts were adopted over the late 1970s and 1980s that allowed national laboratories or created incentives for universities to work more closely with business as a way of speeding innovations from the laboratory to the living room. In part, this was in response to Japan's success at rapid commercialization.

You can see this kind of collaboration still taking place at a state level, where most governors would view their Tier 1, or top research university, as very much part of their own growth, development, and employment strategy.

The Japanese success also triggered the beginning of a rethinking of America's education system. There was a famous publication that came

out in 1983 under Secretary Terrence Bell, President Reagan's Secretary of Education. It was called "A Nation at Risk." One of the famous quotes from that publication was: "Had a foreign power imposed America's education system on the United States, it would have been viewed as a hostile act." Despite the rhetoric and the national attention, nothing really much happened.

President George H. W. Bush, the first President Bush, wanted to be the education president. He pulled together all the governors. It was only the third time in U.S. history that a president had held a summit with the nation's governors, and the focus was education. The governors chose, a then-obscure governor from Arkansas to be their key representative in education. That young, obscure governor from Arkansas was Bill Clinton. He went on to be president of the United States. Clinton built on what George H. W. Bush had started. George W. Bush did the same and only now, after that long period of time since 1983, have we developed a system of national standards in mathematics. It's an example of how we responded to a challenge, but not necessarily in the kind of expeditious way that you would like.

The 1980s gave birth here to what I would call the "competitiveness movement." Part of that was the making research more available to the private sector that I mentioned. There were also some specifically public innovations: the Advanced Technology Program, manufacturing extension partnership -- something like our agricultural extension -- that has grown to the point where there is now a manufacturing extension facility within two hours of every small manufacturer in the United States.

There was a period where, I think, America was tempted to rest on its laurels. At the end of the 1990s, the Soviet Empire had disappeared and the Soviet Union itself collapsed. Germany had an initial struggle to absorb the German Democratic Republic. Japan was wrestling with the bursting of a double bubble, and there was a sense that this really was the American moment. Well, America has reawakened to see that, in fact, the world has changed dramatically.

One of the responses has been led by a bipartisan coalition in the U.S. Congress and by the private sector. A report done by the National Academies, "Rising Above the Gathering Storm," is now in its second edition. This led, eventually, to an America Competes Act that, again, focused on aspects of education, science, engineering, and mathematics, as well as emphasizing the importance of research in the physical sciences.

Before I conclude, let me just say a word about American culture. I think there is something different about America. In many ways, the difference here is similar to the difference in Brazil, in terms of the rest of the world. Both of us are major immigrant societies. When I lived in São Paulo, it would remind me of America in Chicago, where there were people from all over the world as well as internal immigrants who were building, industrializing, and creating.

In the U.S., we have always had an emphasis on the individual and a kind of self-reliance. And that continues to be a reality today. You heard an echo of how the frontier continues to be an element in our thinking when Vannevar Bush chose to say, "Science: The Endless Frontier," not the frontier that had closed because of land was exhausted, but the frontier that was always open to innovation.

The cowboy is still an icon in American thinking and he was a proxy for mobility here. For much of our history, we've been a very mobile and adaptable people. We started totally freed of any traditional, hereditary monarchy, and a cast of nobles. I think former Governor Huey Long of Louisiana expressed America's sensibility very well, when in the 1930s he said, "Every man, a king, but no man wears a crown." We have been open to talent from everywhere. We've had our own troubled past, with racism and clashes of ethnic groups and so forth. But by and large, we have been welcoming to talent and individuals from around the world, and that has paid enormous dividends.

AnnaLee Saxenian, who is something of a Boswell of Silicon Valley, has noted that about a third of the businesses in Silicon Valley had been started by Indian or Chinese immigrants. And that doesn't include immigrants from the rest of the world. Andy Grove, an immigrant from Hungary who headed Intel, is a fine example.

I think America, like Brazil, doesn't really define itself by a particular ethnicity. As I traveled around Brazil, I met Russians, Germans, Portuguese, of course, and a whole host of people from around the world. I think that will be an enduring strength of Brazil.

In the U.S., we have a particular attitude toward risk. You will often hear that Joe or Jane in Silicon Valley have earned their fortune in their seventh start-up. Failure, in some parts of the country, is defined as "not trying again." I think that has been a strength.

Finally, I want to point to the lemonade stand. I don't know if any of you have been here in the summer. If you drive through any American

neighborhood, you'll see small children selling lemonade. You'll see the parents proudly standing behind them. Neighbors come over and will say, "John" or "Jenny, this is terrific. You're on your way. You're going to be a great business success." So I think we're one of the few countries that, right from the start, emphasize not only democracy -- first grades will have election to get the president of the first grade -- but the sense that business is a good thing. Entrepreneurial activity is a good thing.

## POLICY DEBATES

# Patent Reform: The Patent Reform Debate

**JAY THOMAS**
*Professor, Georgetown University Law Center*

It's been a tumultuous time for Brazil in terms of patents. When Brazil entered the World Trade Organization, it adopted a stance of going to pharmaceutical patents immediately; the controversial topic of revalidation patents came up as well. Let me tell you more about what's going on in the States in patent reform and take a look at what that means potentially for Brazil and its practices.

I've heard a lot about great inventions coming every 50 years and long waves and infrastructure and universities and a bit about financial markets. But from the perspective of the private sector, the number one government intervention that leads to innovation is patents. I'm not talking about inventions that come out every 50 years; I'm talking about new medicines, new telecommunications techniques, new devices that come out every week. The patent system is the primary mechanism that supports that kind of continuous investment in R&D. The patent system is a centuries old technique. Brazil has been a long investor in the patent system. There are patent laws that date back into 1809, and Brazil was an original signatory of the leading international agreement about patents, the Paris Convention in the 19th century. It costs the government very little to run as compared to a prize system. Essentially, you just administer it into intellectual property office. It promotes investment in R&D, which leads to innovation. It leads to disclosure of technologies. Alternatively, companies might keep

their products and processes secret. Through the patent system, the patent instrument is published, and anyone's able to make use of it. The one thing I have to do before I go to Rio every time is stop at the Apple Store, and others are obviously doing the same. Intellectual property is also seen as benefiting commercialization technology. Finally, patents only last a limited period of time. When they expire, that technology goes into the public domain and everyone can use it.

Now the popularity of the U.S. patent system is evident. You've seen some impressive statistics about increases in technology; so it is for patents. The rate of filings in the United States in 2010 exceeded 500,000 applications. It's a remarkable growth of confidence of industry in the patent system in the United States. The year 2010 is the first time in the history of this country we've had more applications from foreigners than U.S. citizens. We're supporting the inventive efforts of our foreign colleagues, and we're seeing more growth from foreign system.

Now having said all of that, the last significant update to U.S. patent law was in 1952. Technologies change and the laws can adapt to grow with them. Significant reports, both by our Federal Trade Commission and by our National Academies of Science, suggested reforms to adapt the U.S. patent system to modern conditions. Serious discussion began in our legislature in 2005 and the Bill has changed; the potential reforms have moved and shifted, but we seem to be near the end of the line. The America Invents Act passed the Senate by pretty wide margin. If you follow news about Washington recently it's pretty hard to get a vote of 95 to five on just about anything, and it's also moved out of our lower tribunal of the House of Representatives with a solid vote so far.

What are the goals specifically? To modernize the patent system. Technology has changed; it's continuing to change, but the patent system has remained relatively static. The notion is it needs to be modernized. We need to improve an environment for innovation and keep United States industrial competitiveness as high. The last time we really thought about some changes to our patent system was in the late 1970s. That's an era when the United States was extremely concerned about its industrial competitiveness, particularly in respect to Germany and Japan. Those changes were made. It seems time to try it one more time. We're looking to adapt best practices from pure patent systems. Actually, U.S. law is going to look a little bit more like Brazilian Patent Law -- a little bit more like European practices that the U.S. has examined and conceded to adopt for

itself. Some of what that we would do is move to a first inventor priority system.

As you know, it's amazing who invented the airplane. We think it's the Wright Brothers; other countries have their own inventors. It's just common that some people invent the same technology at about the same time. In most countries, including Brazil, it's the first person to file -- the first to get to the office -- who succeeds in getting the patent. The U.S. currently undergoes a much more laborious, intensive inquiry as to who is the first to invent. We've decided to move to the global norm. That will impact the practices of our companies, which will find it easier to file in Brazil and vice versa: Brazilian firms will find it easier to approach the U.S. office. Our foreign trading partners were concerned that this first--to-invent system was a form of discrimination against them because U.S. companies were more facile and skillful at using the system. That appears now to be gone.

We're also talking about improving the patent office. These are some lessons, sadly, I could convey to your own intellectual property office in Rio. The USPTO faces extraordinary challenges. You can't have that much of an upscale in number of applications filed without encountering a serious backlog. The bill would allow the U.S. patent office a greater flexibility of practice to reduce its backlog, to have more interaction with affected industry, and also to set up satellite offices. Right now, as with the Brazilian office in Rio, the U.S. office is concentrated in Washington. Not everyone wants to live here, so we're thinking about offices that are high technology centers. This would allow interaction between the technological community and the government at an increased level. It would also allow our examiners not necessarily have to work in one particular city. They could telecommute and move, checking in once in a while at the office. We're also thinking about decreasing our litigation costs. As a common law system that features a jury, we have often very expensive and time-consuming litigations. They take a lot of time; they cost a lot of money; and they involve a lot of principals that aren't found in the patent systems of other jurisdictions like Brazil. So we're getting rid of them -- we're cleaning out our system to make them more compatible with global norms. These are all things for Brazil to think about, as the U.S. has looked inward to try to improve its patent system.

What are the implications for Brazil? Right now, your intellectual property office has a tremendous backlog. The term of patent protection in

Brazil is 20 years from the date of filing. What that means is you don't get any rights until that patent is actually approved. Every day at the office is a lost day in term. The average pendency for patent applications in Brazil is about 10 years. The U.S. thinks we have a crisis with a three-and-a-half-year delay. There simply isn't any way that electronic companies are going to file a patent application, and 10 years later that patent will actually be effective on the market. In 10 years technologies completely change. Similarly, what is the worth in getting a patent in other areas like life sciences with such a delay? Remember, 10 years is the average. The more complex biotechnologies, vaccines, and medicines are on the bad side of that average.

The Brazilian patent office has the honor of being a patent cooperation treaty office, so you can accept applications under a certain treaty. Not so many offices get that. But try to figure out where a Brazilian patent is, who has it, and the location of its publication – that information just isn't available. In our modern era where technology is supposed to be disclosed in shares, you're missing that big benefit. You're missing the benefit of technology disclosure. You're paying the price in terms of government fees for medications, but you're not getting the benefit. That's something I think that ought to change.

Experience with revalidation patents has proven to be a constant battle for pharmaceutical companies. It seems every mechanism available to the government has been used to challenge these patents, such as a rather feisty patent office and the Attorney General. It has been a real struggle for companies that are trying to market innovative medicines in Brazil.

Pharmaceutical data package protection is our last issue that's fallen under scrutiny as the U.S. has reviewed its patent system and tried to clean house. Once that's done, it's going to start looking abroad. Pharmaceutical data packages consist of the clinical data, the trials that are done to approve medicines. Right now, that can be used without any consequences in Brazil. You simply fill out the application at your food and drug administration and use it without any kind of review. That's arguably inconsistent with the TRIPS agreement and the WTO. Counterfeit medicines remain a big problem in Brazil. But perhaps even worse are similar medications. Ones with a close bioavailability and absorption rate, even though they have the same active ingredient. Those two have been a big problem in terms of proprietary rights. These are all things for Brazil to think about, as the U.S. has looked inward to try to improve its patent system.

Surely, the relations between our countries have not been improved by different attitudes toward compulsory license and patents, with the U.S. bringing its concerns to the World Trade Organization, leading to reprisal arguments that the U.S. Patent Law is discriminatory. From the perspective of the U.S. and European pharmaceutical innovators, the compulsory licenses that are granted will delay the introduction of the most advance medicine in Brazil. They are worried that they'll simply be copied once a marketing approval is obtained. Now we were talking about the Food and Drug Administration and all the different points of contact. But the Brazilian food and drug administration doesn't have a point of contact with the patent office. In the U.S., when there's a Food and Drug Administration approval of a generic, the patent owner is notified. In Brazilian law, there is no linkage provision. That leads pharmaceutical innovators to have to police the streets themselves to look for similars, compounding pharmacies, and generics.

The USTR sees the WTO and the TRIPS agreement as a very hard won concession. They will be loath to retreat from that. They have retreated. There is only one WTO agreement that has ever been amended since the WTO was formed, and that's TRIPS agreement. After the Doha Round, the United States and other developed countries yielded and added a new ability to declare compulsory licenses to patents. So there's a sense we've already had some slippage over the original deal. The TRIPS agreement gives Brazil and other WTO members very substantial ability to declare compulsory licenses.

# Intellectual Property: The Politics of Intellectual Property

**BILL RUSSEL**
*Head of Bilateral Relations Team, Intellectual Property Office*

I would like to start off by telling you a little bit about the Intellectual Property Office and what we do. The UK IPO is set up differently from many intellectual property offices across the world, in that we have trademarks, patents, designs, copyright, trade secrets, and nondisclosure agreements all under one roof, whereas in Brazil and other countries I know you have a department that deals with patents and trademarks, etc. The UK government made that decision because it seemed to make sense to have all the intellectual property under one department, which is the department for business innovation and skills. Within that office my job is to lead up the bilateral relations team, which has essentially two roles. First, it's about building one-to-one relationships with our key IP partners across the world, and they are China, India, the United States, and of course Brazil. The other thing that my team does is to look for ways in which we can support business. And what that means is about how we can support British business getting out into Brazil, but also about how Brazilian business can get better access into the UK system and via our IP system.

Why is IP important to innovation and what does the IPO of the UKIPO do? We believe that IP is critical to the UK's innovative knowledge--intensive economy. Let me give you a few facts and figures to try and justify that. In the UK our IP exports each year, in 2009, were worth 113 billion pounds. That's about 320 billion reais. So it's quite a lot of money

that the UKIPO and IP exports. Globally it's estimated that patents and trademarks account for about 600 billion pounds, or about five percent of the world's trade. Here in the UK about half of our productivity is due to innovation, and of course, intellectual property plays a key part in that. If you look at the UK's economy, the value of the things that we make is probably about the same as the value of the things that we create. So, for us, creation, ideas, and innovation are about half of our business. But the UKIP system does have its challenges and its opportunities. Things like climate change, access to medicine, and limited natural resources all have an impact both globally and within the IP system. IP systems across the entire world have increasing backloads of patterns and designs. We have the new digital innovation that is outstripping the ability of national governments and laws to keep pace, and we have increasing global markets that make the separate national regimes for intellectual property more and more difficult for businesses to deal with.

The IP system can therefore be seen by some businesses as a limiting factor or a restricting factor to business. We don't believe that should be the case. Here in the UKIPO we believe that IP actually helps to drive innovation, if it's done properly. That's the important point. We believe that IP enables entrepreneurs to bring new ideas to market. It encourages innovative people to do more. It helps universities and colleges to commercialize their ideas and capture their creativity and bring it to market. It helps the spread of new technologies, and it brings new drugs and medicines online quicker than would otherwise be the case. Here in the UKIPO we have one overarching policy for our international work, and that is to have an effective, respected IP system that encourages innovation and creativity, but also enables economy and society to benefit from that knowledge and those ideas, and that's the important part. It's not all about making money. It's about having an economy and society that benefit from the ideas and the innovation that's brought by it. We have set ourselves three goals within the IPO. One is to have a well-functioning international IP system, and that's about working with the world intellectual property organization and tackling some of those traditional historical issues about governance and finance that we find there. Within Europe we're working with our European partners to try and get an EU-wide patent system and an EU patent court system. We also work to try and find good national regimes, and this is what my team does. We work to push for more effective and consistent enforcement of IP laws across our key markets, but we also provide prac-

tical support for businesses that look to work overseas. Lastly, we look to further economic and technological development, which is about trying to tackle some of the fusions of medicines and climate change technologies and working with the least developed countries across the world. So what's the UKIPO doing to help this? First of all, we've been working with UK trade and investment, with businesses and universities, and all those international institutions to try and increase IP awareness. The UK counted its first patent in 1470, quite a long time ago. You'll be surprised to learn how little has changed since then.

What percentage of UK businesses do you think have an IP policy? How many people?

It's 4%. Four percent of UK businesses have an IP policy. That's quite remarkable. In the UK, something like 96 percent of businesses do not understand the value of their intellectual property. They don't understand the value of their patents, their designs, or their trademark. That's quite extraordinary. So, we've been working with WIPO and the G8 and the G20 and the World Trade Organization to raise awareness of IP. You may think that we're a long way ahead of you in trying to get an IP system that works, but clearly we're not that far ahead of you. So, one idea that we like to talk about is the Lambeth Toolkit, which is a system for collective working and collective agreement. Why do we talk about this? People tell us that innovative people are increasingly mobile; they're not tied to one country and nor is the money. Science and technology is an increasingly international thing, so IP systems that work well for one country don't necessarily work particularly well in others. So in 2003 a group of universities, businesses, and IP lawyers got together to try to find a way that they could reduce the cost of working together, reduce the time that was involved in delicate negotiations, and increase access for universities and SMEs, small and medium size employers, to bring their ideas to market. What they came up with is this Lambeth toolkit. The Lambeth toolkit is a one size doesn't fit all idea. If I talked about a pick-and-mix, would you know what I mean? This is where you go into the sweets shop and you can have a little bit of this and a little bit of that and lot of this, if you like that bit, and little bit of this. That's how the Lambeth toolkit works. There are around 70 different variations in the agreements and models that it comes up with. Some are for one-to-one negotiations, some are for multinational, and some are for multi-partner agreements. The idea is that there's a tool kit in which you can pick and find the little bit that works for you in this type of agreement

and that little bit that works in this type of agreement, and hopefully between you, you can bring a contract which works for universities, for businesses, for schools, et cetera. We believe that this actually does work, and the evidence is from a survey in 2009. Sixty-two percent of those who had used the toolkit said that it simplified the process, 57 percent of them said that it saved time, and 33 percent of them said it produced better contracts.

UKIPO has been working with universities in Brazil, in China, in South Korea and elsewhere, to get them interested in the toolkit. We think this is a good way of bringing innovation to market quicker. We believe this is a good way of getting universities and businesses to work well together. UK businesses say the Brazilian IP system appears to them to be difficult to navigate, that enforcement of rights is not easy or quick; but then they say the same about the UK system too. However, one thing that is different between the UK system and the Brazilian system is something called the Madrid Protocol, which is the recognition and respect for trademarks internationally. This is something we were very keen for the Brazilian government to consider signing. It's something we've talked about with the Brazilian government and with Brazilian businesses. They think it's a good idea. We would encourage you to think about it. So how can the UKIPO help, if indeed we can help? One of the things that we're doing is having something called an IP attaché. China, where we already have an attaché; India, where we have an attaché just going out in the next couple of weeks; Brazil, where we're looking to recruit an attaché for now; and Southeast Asia. The attaché is there to have the expertise and the resources to spread good ideas and good practices between the UK IP system and our Brazilian and international counterparts. They will have the technical expertise to help tackle enforcement issues and spread good practices. We're also looking to spread that collaborative agreement with Brazilian universities and businesses. We spend quite a lot of time and quite a lot of effort with UK businesses telling them about the wonderful opportunities that Brazil can offer. We also have provided the opportunity, which we offer again now, for technical assistance. If there are things which the Brazilian system needs that we have and we can offer, we're willing to share. We've been in this game for quite a long time, we know quite a few things, and we're prepared to share. So the offer of technical assistance with IMPI and others is there if you want it. In conclusion, from the UK government perspective, we believe that IP and innovation need each other. If there is no innovation, there is no need to have an IP system. If there's no IP system,

there is no drive to innovate. And if there's no drive to innovate, there's no innovation, and the spiral goes down. I look forward to working more and more with our Brazilian counterparts.

# Broadband Deployment: The Federal Communication Commission Broadband Deployment Plan

**JOHN HORRIGAN**
*Vice President for Policy Research, Technet*

The National Broadband Plan was mandated by the stimulus legislation that Congress passed shortly after President Obama was inaugurated. It directed the FCC to produce, within a year, the National Broadband Plan. We asked for a one-month extension so it was not delivered on the one-year anniversary of the stimulus legislation but rather on March 17, 2010.

Why do a National Broadband Plan? First, there's been a sense in this country that the United States trails other countries in broadband. According to the Organization for Economic Cooperation and Development (OECD), we ranked fourth in broadband penetration per hundred people in the population in the year 2001-2002. About a decade ago, the U.S. was ranked near the top by that metric of broadband progress, and it's been a steady downhill story since. Today, we're ranked at about 14th in the world in terms of broadband penetration per hundred population. In terms of network quality, there's a study done by Cisco and the Oxford Business School that puts the U.S. 15th in speed of network. So there's a sense that the U.S. is not doing as well as it should in broadband and that was one strong motivation for developing the plan.

Other motivation is the general belief that better broadband is better for the economy. That can have two effects: one is a direct economic benefit. If there is public investment in broadband, that's an opportunity for job creation given that people will be hired to run infrastructure and provide service. An indirect benefit, and arguably a bigger benefit, is with better broadband you have a better innovation platform in your country. Faster speeds, more ubiquitous deployment, higher rates of adoption, it is hoped, will stimulate people's entrepreneurial instincts, create new businesses, and also enable existing businesses to deliver services more effectively and efficiently.

The third important pillar of developing the broadband plan was the notion that broadband is a tool for addressing key societal challenges such as healthcare and the delivery of education. In developing the Broadband Plan, we were always clear in saying that better broadband is not going to solve the healthcare problem in the United States. Better broadband in itself will not improve educational outcomes in the United States. But as comprehensive solutions are developed in those and other areas, broadband can be a very useful part of the solution.

Let's talk about what the plan found and recommended. First, how do we go about tackling the problem when we actually did the plan at the FCC? A phrase that was repeated often in the plans development was "data driven." The National Broadband Plan itself, which is a document of about 376 pages, is very data driven, heavy in providing information that supported the various recommendations made.

At a high level, we set out a broad goal that we call the "100 by 100" goal, which is to say by 2020 the plan ambitiously forecasts and hopes that there will be 100 megabit connections to 100 million homes in the United States. That 100 million homes comes to about 90 percent of all households in the U.S. From a level today of about 65 or 67 percent of people with broadband at home in the United States, the goal is to not only increase broadband adoption to 90 percent but to dramatically increase the speed of infrastructure going to people's homes to 100 megabits from the typical speed today of about six megabits per second.

What can you do at 100 megabits per second that you can't do today? Often times when that question is asked, particularly of broadband carriers in the United States, the response will be "consumer demand is not that far along yet." The typical use case for the typical consumer requires about six megabits per second today -- meaning that the typical Internet surfer

in the United States is someone doing e-mail, Facebook, some video, and some uploading of content. Uploading speeds are typically about half the rate of download speeds.

The notion that there's a huge demand for 100 megabits today is not supported when you look at the typical use cases for Americans. The response you might get from an engineer, somebody who has long history in the internet business, is that it's historically been the case that when you provide greater speeds you will get innovators at the high end, having their imaginations quickened by this extra speed to develop more innovative applications. So it's this aspirational notion that more speed will spark innovators to do more things that will help draw demand toward uses that take advantage of 100 megabits per second. And you will find people in the United States that find that the 100 megabits per second is a conservative goal. They call it a conservative ambitious goal. Some people think we should get to one gigabit per second to people's homes. And, just as an aside, Google is pledging to do that for Kansas City with the Google fiber--to-the-home competition that Google recently concluded.

We set out this ambitious goal and tried to characterize where we are today across three dimensions: the deployment of infrastructure; the adoption of broadband among consumers; and how broadband can be used for these national purposes that I've alluded to already. So let's talk about infrastructure. What did we find in trying to benchmark where infrastructure is today in the United States? We found that approximately 95 percent of U.S. households have at least one wireline broadband provider to their home. In most cases that would be either DSL or cable modem service. We found 80 percent have access to two wireline providers; again, that's going to be DSL or cable.

In the United States, the company Verizon provides FIOS, a fiber-to-the-home service. That probably only reaches 2 or 3 percent of American broadband users. About two or three percent will not all be Verizon, but the incidence of fiber-to-the-home to the U.S. is fairly small. Our analysis showed that if you wanted to wire the final 5 percent of the geographic land mass of the U.S. -- or the final 5 percent of households, I should say -- it will cost about $24 billion to reach what are typically remote, rural areas, where there is not presently wireline broadband access. That would cost, we estimated in the broadband plan, $24 billion. In terms of what happens in other environments, in terms of broadband infrastructure, the stimulus bill funded $7.2 billion of infrastructure. How does that compare with

private sector infrastructure investment in broadband? About $30 billion annually is invested in broadband in the United States by the private sector. That's the story on wireline infrastructure.

In terms of spectrum, the National Broadband Plan spends a good deal of time talking about what we saw as the looming spectrum crisis. There is increasing demand for spectrum in the U.S. that is driven largely by the devices that many of us have in our pockets or in front of us right at this moment, smart phones, which take up a lot more band width than traditional cell phones. Do we have very many I-Pad users in the audience? Those people with I-Pads are even heavier users of data services using the spectrum and there's an upward trend in adoption of tablets, whether I--Pads or other products these days. Wireless data traffic is projected to grow 35 times by the year 2014 so this huge projected increase in demand for wireless data is the basis for the claim in the National Broadband Plan that we have to do more to get more spectrum into the market place over the next 10 years. The Broadband Plan calls for 500 megahertz of spectrum to be made available in the market within the next 10 years.

The key mechanism to do that is something called incentive auctions, which is a fairly hot topic of debate in the U.S. in telecom policy circles. So what are incentive auctions? In the United States television broadcasters have been granted spectrum to broadcast their television programs. The broadcasters were granted a lot of spectrum years ago when it did require lots of spectrum to broadcast television signals. Advances in technology has made it possible for TV broadcasts to be made with a fraction of the spectrum that broadcasters were granted and other licensed by the FCC many years ago.

The National Broadband Plan said that as much as 120 megahertz of spectrum could be freed up if we could reclaim some of that spectrum from broadcasters. The idea is to get some of that spectrum back from broadcasters without really harming their ability to broadcast their existing programming. The trouble is broadcasters aren't a big fan of this idea. They have the spectrum; they would like to keep it. The idea behind incentive options is to say to a broadcaster: if you choose to put your broadcast back into the public domain, we, the U.S. government, will sell the spectrum at auction to the private sector and some of the proceeds from that spectrum will go back to you, the broadcaster. That's the incentive for the broadcasters to participate in the auction. When the spectrum is eventually sold in the commercial marketplace, they get a cut of the proceeds from that. As I

said, that is a subject of controversy. It requires Congress to pass legislation authorizing the FCC to conduct these kinds of auctions. The FCC is, in fact, in favor of this approach; yet it can't move without congressional authorization and that's pending before Congress in the United States.

Let's talk a little bit about adoption. I said that 95 percent of homes in the United States have access to at least one wireline broadband provider. This means that 95 percent of homes could get broadband service if they choose to. The question is, how many choose to get broadband service at home? The answer is from surveys conducted by the FCC, the U.S. Department of Commerce, under my guidance when I was at the Pew Internet Project: about two-thirds of Americans have broadband at home. That data nugget is often a head scratcher in some of the audiences I talk to. People say, "You mean people have the infrastructure coming to their home, yet they choose not to have broadband?" And the answer is yes. Around that 28-percentage point gap represents a sizeable slice of the American population who, for whatever reason, chooses not to get broadband service where they live.

In the Broadband Plan, we were charged with trying to figure out why Americans without broadband do not have broadband, and we conducted a survey that found that there are several different barriers that people face to broadband adoption.

Americans pay about $40 per month for broadband. Among non-broadband adopters, 15 percent are saying that that typical price of $40 is too much for them. Another 10 percent of non-adopters say the computer is too expensive so they can't afford the hardware to get online. But then you get about 22 percent of non-adopters saying they lack computer skills. You can see, in the first instance cost, whether it's the monthly fee or the cost of a computer, looms large; but people have other challenges to getting online. Lack of computer skills is one and the final bullet is lack of awareness of broadband's utility. People just say, "It's not for me, I don't understand what I would do with broadband if I were to have it."

The other key point is when you ask people why they don't have broadband, these several different reasons I've listed here for not having broadband tend to travel in groups. If you're somebody who says it costs too much, you're also very likely to cite the fact that you don't have computer skills. So to readdress the broadband adoption gap, you're not going to employ one policy lever such as simply subsidies to lower the cost; you're going to have to give people a comprehensive approach: training, subsidy,

as well as some good old-fashioned marketing as to why broadband is a nifty and useful thing to them. The last third of adopters are the hardest set of customers to get and the private sector finds it very expensive and time consuming to go after those customers.

What are the solutions that have been proposed to try to close this broadband adoption gap? If you can partner with the public sector, with existing non-profit efforts that are aimed already at promoting broadband adoption for the private sector, it can effectively reduce your cost of acquiring those hard to reach customers. One idea is to create a digital literacy corp. Basically, hire people to go out and train those who don't have broadband on how to use it. Mobilize young people looking for a job opportunity to go train people who don't have the skills to use broadband. Secondly, develop public-private partnerships to train non-users on how to use computers and the Internet. This idea came about through discussions with members of the private sector when we were developing the Broadband Plan. We held 40 public workshops in the process of developing the National Broadband Plan, where we got input from members of non-profit organizations, the private sector, and other actors. The public workshop as a mechanism to gather private sector support as well as support from other sectors of society was key.

Comcast is one good example of a company that has devised what is called an A Plus program to try to give subsidies to eligible school children to have computers in the home and cut-rate broadband service. Then third, share best practices on adoption promotion programs around the country. In scanning the landscape in the United States of initiatives to close the broadband adoption gap, we found a lot of unevenness around the country. There are some places where the community has gotten behind developing training programs to train people to use broadband. Other places are behind the curve looking for a way to accelerate their programs to close the broadband adoption gap. If there were a forum by which best practice could be shared, we felt that this would be a useful mechanism to close the broadband adoption gap. Comcast had some difficulty getting a hardware company to participate in the program to give a sufficient cut rate on computer hardware to get online. But if they can clear that hurdle, Comcast pledged, I think, to provide broadband service to eligible homes. Eligible homes typically mean school-age children eligible for benefits programs like school lunch programs. I think the figure would be $15 per

month for broadband -- well below that average number that I quoted of $40 per month.

However, in terms of priority, do you want broadband reaching the widest number of subscribers or do you want to upgrade the network in strategic areas in such a way that might spur innovation and economic growth? Unfortunately, the U.S. Congress did not provide us guidance on that because they basically recommended that we look for ways to promote universal adoption of broadband. From my perspective, if I had to prioritize, I would say it's important for overall welfare and economic growth to invest strategically in network speed, so you get very high speeds to the areas where you're going to grow the most entrepreneurs and have the most job creating potential. One could spend a lot of money to get the highest speeds to rural America, yet there are relatively few entrepreneurs in rural America waiting to get higher network speeds to invent the next job creating business. They tend to be in urban areas, clusters of talent around universities and so forth.

With respect to national purposes, the areas that Congress directed the FCC to look into as to how broadband could improve are: energy and the environment, government performance, healthcare, education, economic opportunity, and public safety. What the Broadband Plan did was to highlight good examples from around the nation, where broadband was being used to help people manage their energy usage at home, for instance, or for the delivery of healthcare.

After about a year, how is Broadband Plan doing and what has been done? In terms of infrastructure, these are some initiatives that have come about since the release of the Broadband Plan that were either highlighted in the Broadband Plan or given more momentum because of the Broadband Plan. In a State of the Union Address, the president set this goal of covering 98 percent of the country with fourth generation high-speed wireless infrastructure within five years. That ambitious goal set forth by the president has a number of components to it. One is freeing up 500 megahertz of spectrum, something pulled directly from the Broadband Plan incentive auctions, which I did touch upon as to what they are.

The Office of Management and Budget estimates that incentive auctions could bring $28 billion in revenue into the treasury if implemented correctly. The president's plan actually has some ideas for spending some of that $28 billion but also giving back the money to the treasury. Three billion dollars is proposed for a wireless innovation fund to develop mobile

applications aimed mostly at some of those national purposes that I listed; $5 billion for a 'one dime' spending for rural high-speed infrastructure; and $10 billion for a public safety network. That involves giving a very valuable section of the electromagnetic spectrum -- the so-called D Block in the 700-megahertz portion of the spectrum -- to public safety agencies around the country. Then, they will be able to build a national interoperable public safety network, so that firefighters in one part of your city could easily not only talk to but also communicate with video or data. It would cost $10 billion to build that infrastructure to put up the towers and develop the hardware to make that work. That leaves, if I'm doing the math correctly, close to $10 billion that would go to the Federal Treasury.

Then comes from the stimulus bill, the $7.2 billion in grants for infrastructure. A lot of that from the Commerce Department is for the so-called middle mile of fiber optic networks. The middle mile is the portion of the fiber optic network that takes traffic from your neighborhood to the high-speed trunk lines that distribute data traffic around the world. The Commerce Department identified that as an infrastructure gap in the United States. Typically, there's a decent wireline broadband infrastructure in even rural areas, in a reasonably densely populated rural area. The trouble is getting that traffic from that rural spot of density to the main portion of the broadband infrastructure. That's the so-called middle mile. So the ARRA grants have helped deal with that. But the president's wireless initiative is a goal. To attain that goal, those specific elements -- the wireless innovation fund and the $5 billion for rural high speed -- are things that have to happen.

On how to increase broadband adoption, there's been somewhat less action in the ensuing year. There are programs under the stimulus program within the Commerce Department. They are on the order of $500 billion collectively that go toward sustainable broadband initiatives that fund community groups who are all about training people who don't have broadband on how to use them. There's $250 million for public computing centers to help libraries and anchor institutions like police or fire departments to provide public access to people who don't have broadband. And there have been some nascent efforts to develop the public and private partnerships that I mentioned before.

The FCC has just begun a proceeding in reforming the universal service fund to try to channel some funds from the U.S. Universal Service Fund -- which is a $9 billion per year fund aimed at both infrastructure

and adoption, but mostly aimed at old-line telephone infrastructure and adoption of telephone service. It's not oriented towards high-speed uses. Reforming that $9 billion fund and letting some of those funds be used to promote either broadband adoption or infrastructure development is underway and in the early stages at the FCC. So the adoption issue has probably gotten less traction in the ensuing year since the Broadband Plan than some other issues. Other people will actually probably say that some of the issues on spectrum have gone entirely too slowly as well. People's mileage may vary.

On national purposes, this is an instance where the Broadband Plan laid out some goals for different corners of government to take action. Since the Broadband Plan was delivered, some efforts have gotten underway around different departments. In the Education Department, for instance, there's been the development of a national educational technology plan on how to use information technology more effectively in schools. The National Institutes of Standards and Technology in the United States (NIST) is working on standards for smart grid developments, so that the energy grid in the United States can be managed more effectively and consumers have an opportunity to manage their energy consumption at home. With public safety, I mentioned this issue of the D-Block auction of spectrum to help develop a public safety broadband network. That is slowly getting underway but again; the wheels of government often turn slowly.

Let me just conclude with some ideas on the question of will the Broadband Plan deliver. On the one hand, it's a fairly weighty government document of nearly 400 pages that lays out a lot of detail. I've just given you a flavor for how some of those specific recommendations are being implemented over the past year. But the final chapter of the Broadband Plan starts out with that sentence, "This plan is in beta and always will be." Meaning the plan itself has to be constantly under review, scrutiny, and revision if necessary, as technology changes and as other things change in the climate. You have to update your goals and your processes for meeting those goals as situation changes in the world economy. I would just recommend that you set up a process by which the bar can be moved to higher goals if you need to as the situation changes.

Will it deliver? Well, there has to be better metrics to measure progress. One thing that we ran in to again and again in the Broadband Plan is the dearth of metrics on how to measure phenomenon in the broadband space. As U.S. government statistical collection practices are by and large still

anchored in the industrial age, we have to do more to try to understand how to measure things in a broadband age. Secondly, institutional change: there has been an incredible interest among state and local officials in the United States on how to use broadband. I think that has been in part, not exclusively, but in part a result of the National Broadband Plan.

I spoke at several events in the aftermath of the delivery of the Broadband Plan, where there would be city officials, state officials, coming up afterwards and being really excited on how to use broadband to run their governments more efficiently and promote economic development. Lots of cities have task forces in the U.S. trying to better use broadband and better understand broadband infrastructure. That kind of institutional change has to take place in order for the broadband plan to become real. At least, I have witnessed some of that in its early stages in the immediate aftermath of the Broadband Plan, but more has to be done to sustain that.

You undertake a National Broadband Plan so that you have a robust platform for innovation. How to measure outcomes in innovation from inputs in broadband is another challenge that we have to understand better. It's something that we have to have an ongoing discussion about. Then finally, if the Broadband Plan is to have a real impact, you want to see accelerated outcomes in terms of learning for school kids and entrepreneurship at the state and regional level. Those are important indicators. It's not something you're going to measure well a year after the Broadband Plan is delivered, but it's something to keep in mind as we go forward.

I would add that too many countries in this world believe that the core focal area of their growth should be their export-traded sectors of their economy. The message of my presentation is that while that's important, raising the productivity of domestic, non-traded sectors of your economy is equally, if not more important.

# Competitiveness: International Information Technology Competitiveness and U.S. Innovation Policies

**STEPHEN EZELL**
*Senior Analyst, Information Technology and Innovation Foundation*

General Purpose Technologies (GPT's) drive transformations and economic growth. Most innovations come incrementally with modest changes and improvements in products, processes and business models. But, approximately every half century, a new technology system emerges that changes everything. In the history of the human race, we've had about 35 of these General Purpose Technologies. The wheel, the printing press, the three-masted sailing ship, steam power, the railroad, steel, electricity, and, today, information and communications technology. The point about GPT's is that they impact and change virtually everything: what and how we produce it; how we organize and manage production in our society; the location of productive activity; the infrastructure needed to support it; and fundamentally the laws and regulations needed to support the General Purpose Technology.

GPT's also have three main characteristics. First they become pervasive and all encompassing. That means they become a part of almost all industries, products, and functions. They enable innovation in products, processes, business models and models of business organization. Finally they undergo rapid price declines and performance improvements. Take, for instance, the little thumb drive, a two-gigabit thumb drive. This is part

of our everyday lives today, right? In 1995, how much would five gigabytes worth of storage capacity have cost? Five gigabytes cost $5,500 in 1995. So we have incredibly steep declines in price, while we have incredibly steep improvements in performance at the same time. Of course, this is simply for storage capacity. I imagine we'll find the same thing for processing power of computers.

I'm sure you're familiar with Moore's Law, which of course says that the number of transistors that can be fit onto a microchip doubles every two years. In fact, when we look at the cost of one million computer operating instructions per second, that's how we measure the speed of microprocessors. In 1960, the cost of asking a computer to do one million instructions per second was $1.1 trillion; today it is 13 cents.

To illustrate that point, I have my wife's birthday coming up, so I picked up a greeting card for her. It's a nice little greeting card with an embedded microprocessor inside that plays "Unchained Melody" by the Righteous Brothers, a classic American tune. I bought this card for $4.99. Now imagine how much I would have had to pay in 1946 to buy my wife this greeting card. This would have cost me $4.6 billion in 1946. The very first computer was the ENIAC Computer created at the Pennsylvania University in Philadelphia. The ENIAC computer was developed at a cost of $5.5 million at that time. This little greeting card is 800 times more powerful than the very first ENIAC computer. This greeting card has more computing power than existed in all the world in 1955, and we're just getting started.

We see similar trends in the increases in Internet connectivity speeds. We can look back to 1992, 1996, and, for those of us who were online then, we were dealing with very slow dial-up modems. By the early 2000s, we started to get into DSL lines, Digital Subscriber Lines in the United States, 1.28 megabytes per second. Maybe by the mid 2000s, we were up to 2.5 megabytes per second. Today, we are at about to 6 megabytes per second, but we expect to go to 100 megabytes per second by 2020. In fact, Verizon and Comcast are now starting to roll out 40 and 50 megabyte per second offerings. This means that, over the past three decades, the average speed of Internet connectivity to the home has increased by 117,000 times. The speed of the network backbone has increased by 18 million times. This means that the world is becoming alive and bathed in real time access to information in all times and in all places.

By the end of 2013, it's estimated that there will be 5.5 billion devices or sensors around the world connected to the Internet. Every oil rig, oil platform every air plane, every piece of livestock will be connected to a real time Web of information, and we'll know everything we need to know about it instantly. That will enable the creation of new business models never before conceived in human history. Think about what firms like Match.com or eHarmony have done for dating or Priceline or Orbitz, for the airline industry. We can now simultaneously aggregate supply and demand for any product or service on a global basis in real time and price it. Information and Communications Technology is super capital that drives the productivity and growth of an economy.

A study from Nathan Associates found that IT capital has seven times the impact on GDP and productivity than non-IT capital in nations with low levels of IT usage, and around three times more in developed nations. We also find very clearly that the application of information technology within enterprises drives their productivity growth and therefore the profitability. Another study found that in large U.S. firms every dollar of IT capital is associated with $25 of market value. However, every dollar of non-IT capital, buildings, cars, forklifts, is associated with only one dollar of value. In fact, in a study that analyzed 80,000 U.S. firms between 1987 and 2006, each additional IT worker in a U.S. large corporation contributed about $338,000 of total value to the firm. Moreover, a study found that the doubling of IT capital stock within U.S. firms is associated with a 4 percent increase in their productivity growth. So the application of ICT is driving productivity growth and profitability in U.S. companies. We find this for the economy at large.

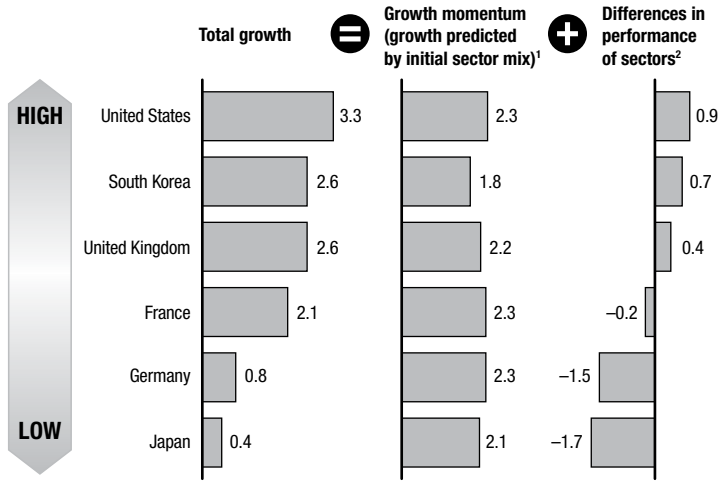
In March 2010, ITIF released a report called "The Internet Economy after 25 Years." It was on March 15, 1985 that the very first commercial Internet website ever came into being. We've only been on the commercial Internet for 25 years. But how much do you think in those 25 short years that the commercial Internet adds annually to the global economy? The commercial Internet adds $1.5 trillion each year to the global economy. Because of the IT revolution the U.S. economy is $2 trillion larger than it would be otherwise each year. In fact, a 2008 study by Eric Bergelson found that it was ICT that contributed one-third to one-half of overall U.S. productivity growth, which increased the U.S. economy by $150 billion in 2008 alone.

What are the implications of this from an economic perspective? Ultimately, we know that economies grow by increasing their productivity. How do economies increase their productivity? There are two ways. The first is by what we call "across the board productivity growth." This means raising the productivity of all the firms in all the industries within an economy. All your banks, retail establishments, hotels, hospitals, traded sector, manufacturing, autos, and airplanes; raising all of their productivity. The second way economies can grow is by changing the composition of your economy: the shift effect. This is by replacing lower value-added industries, like call centers, with higher value-added industries like semi-conductors or a pharmaceutical center. Both are important to driving growth. However, when McKinsey looked at this question, he found that the sector performance matters much more than the mix of sectors within an economy.

In his report, called "How to Compete and Grow," McKinsey looked at six developed countries [U.S., South Korea, UK, France, Germany and Japan,] and their economic growth -- their increase in GDP between 1995 and 2005 [see below].

**Sector performance has mattered more than the mix of sectors for overall GDP growth in developed countries**

Contribution to total value added, 1995-2005
Compound annual growth rate, %




1 Country growth rate calculated as if all sectors would have grown with sector-specific growth rate average across all developed countries.
2 Actual country growth minus growth momentum of initial sector mix.

SOURCE: Global Insight; McKinsey Global Institute analysis

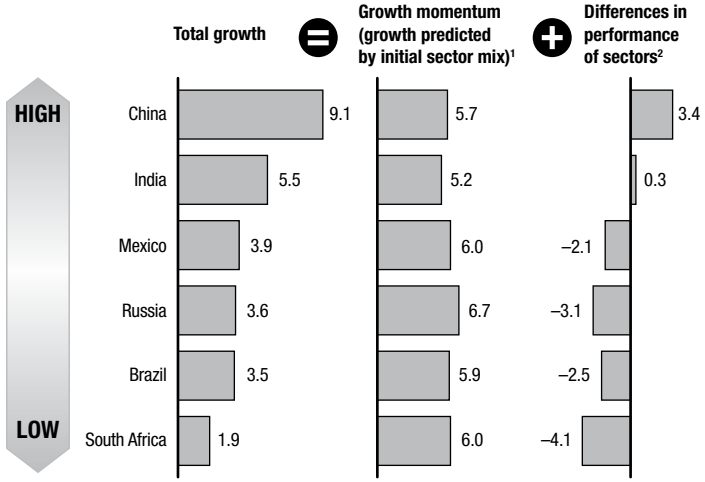
If we took the average growth rate for all the sectors across those six developed countries in 1995, what would their expected growth improvement have been? If the productivity levels of all U.S. industries grew at the average of the developing world's, what would we expect their increase in GDP growth to be over a 10-year period? For the U.S., the expected increase in GDP was 2.3 percent a year. But U.S. growth ended up being 3.3 percent per year; while Japan expected 2.1 GDP increase over 10 years, but they actually gained .4 percent annualized. Essentially, the reason why was because the U.S. did a far better job than its competitors of raising the productivity of all sectors of its economy across the board than its competitors did.

McKinsey found that the exact same trends held for developing countries as well [see below].

When they looked at China, India, Russia, Brazil and South Africa, they said, "If all the sectors of Brazil's economy grow at the average rates of these other developing nations, then we would expect between 1995 and 2005, Brazil's economy to have grown at a 5.9 percent annualized rate." In the end, Brazil grew but only at a 3.5 annualized rate -- in fact, 2.5 percent

**Sector performance matters more than sector mix in developing countries as well**

Contribution to total value added, 1995-2005
Compound annual growth rate, %




1 Country growth rate calculated as if all sectors would have grown with sector-specific growth rate average across all developed countries.
2 Actual country growth minus growth momentum of initial sector mix.

SOURCE: Global Insight; McKinsey Global Institute analysis

less than the sectoral composition of your economy in 1995 would have suggested. What accounts for this kind of underperformance of expected growth? The answer that the McKinsey study finds is that Brazil has not done as good a job as some other countries at raising the productivity of all your sectors across the board. This is the real way that economies should be focused on growing.

What are the insights on economic growth from ICT? First, that across the board productivity growth is more important than changing the sectoral mix of your economy. So Brazil's moves to grow your aerospace, airplane, pharmaceutical, and biotech industry, your machine tolls; that's all great. You're doing the right things. You need that. But you also have to be focusing on leveraging information and communications technology to raise the productivity of all your firms across your entire economy. Because the fact is that when you look at where the value of information technology comes from, you find that 80 percent of the benefit of ICT comes from its usage and only 20 percent of the benefit of ICT comes from its production. Therefore, the real power of ICT is using it to boost the productivity of all your sectors in your economy and, in particular, its usage of ICT by enterprises that matters.

ITIF did a study that looked at rates of productivity growth between the United States and Europe from 1945 to 2010. We found that in the post-war period from 1945 to 1995, European productivity and improvements were superior to the United States. But after 1995 the U.S. accelerated ahead of Europe in productivity improvements by about 1 percent a year. The difference was 85 percent explained by how much more effectively U.S. enterprises were using ICT than European ones. It should be clear from this analysis that barriers to ICT flows can only damage an economy.

The economists Kaushik and Singh did a study of the impacts of India's IC tariffs on its economy from 1970 to 1995. What they found was that for every dollar in tariffs that India applied on its ICT industry, the economy suffered a loss of one dollar and 30 cents. Why? In India's attempts to develop a domestic, indigenous ICT industry by imposing tariffs on imports of foreign ICT products, firms throughout the rest of the Indian economy were left to use inferior ICT products. So their banks, insurance companies, and airlines didn't have the benefit of world leading information and communications technologies, and their economy suffered.

Your neighbors in Argentina have placed a 33 percent tariff on imports of assembled computers in an attempt to spur the creation of an indigenous Argentinean computer industry. Essentially, they place a 33 percent tariff on assembled computers, but there are very small tariffs on the imports of computer components like the hard-disk drives and the circuit boards, et cetera. But what that's meant is that 33 percent of computers sold in Argentina are assembled by hand to get around these tariffs on imports of assembled computers. What does this leave Argentine consumers and firms with? Inferior IT products that inhibit their ability to use ICT to drive innovation throughout the rest of their economy. So, the message is that tariffs on ICT products and equipment are bad for an economy.

A few thoughts on ICT and innovation policy: ITIF has done a lot of work trying to explain international leadership across critical information technology application areas, such as health IT, e-government, intelligent transportation systems, and mobile payments. We have released a series of four reports on explaining international IT leadership in intelligence transportation systems, health IT, mobile payments, and e-government. Intelligent transportation systems is bringing real time information to your traffic system, having cars being able to communicate with the infrastructure, bringing real time traffic flow information into the vehicle. Health IT is, of course, electronic health records; and mobile payments means using your mobile phone to do financial transfers, mobile banking, and e-government.

We find the same set of countries keep coming up as world leaders: in intelligent transportation systems, Japan, South Korea, and Singapore; the same for mobile payments; in e-government, South Korea, Denmark; and the Netherlands; health IT leaders are Denmark, Finland, and Sweden. Who are these leaders that we find across these different IT application areas, and what do they all have in common? The answer is they've had national IT strategies or National Broadband Plans that go back about a decade. Japan introduced its e-Japan Strategy One in 2000, updated it with e-Japan Strategy Two in 2003, and came out with a new IT Reform Strategy in 2007. South Korea had a ubiquitous society kind of master plan for information technology. The point is that these countries have national strategies to think about how information technology can be applied for the transformation of their society and their economy across different industry verticals. I think we are coming to this discovery now in the United States that we need to do this. But we're maybe a little bit behind the cur-

ve, and that explains why we aren't finding ourselves as the world leaders in some of these IT application areas, like this set of countries.

We find that a number of countries around the world have increasingly made the recognition that innovation-based economic growth is the path forward. The UK, for example, has made a conscientious decision to place innovation at the center of their nation's economic growth strategy. In the past decade, three-dozen countries have introduced National Innovation Plans and National Innovation Strategies to guide innovation in the transformation of their economy. Countries that wish to lead the world in innovation-based economic growth must think about it strategically and must develop the institutional capability to understand how innovation drives their economy through different verticals like healthcare, education, government, transportation, et cetera.

# Innovation Policy Debate In The U.K.: Open Innovation and Drug Discovery

**WEN HWA LEE**
*Scientific Coordinator, Structural Genomics Consortium, University of Oxford*

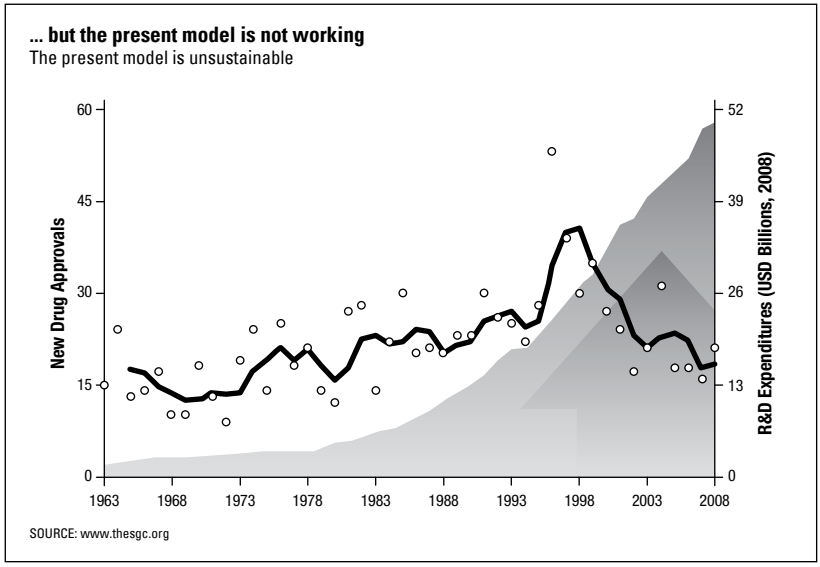
Dear members of the Brazilian parliament, I would like to tell you about the SGC (Structural Genomics Consortium), a public private partnerships for which I am the Scientific Coordinator. Today we will be taking a look at open innovation and how it can create a revolution in drug discovery from a scientist's point of view. Firstly, we know very well what the problem is: we are facing an unprecedented crisis in the creation and discovery of new medicines. How can we identify and tackle the bottlenecks leading to this problem? Once we have identified where we believe the bottlenecks are, I would like to show you the model that we have been using to address the problem. To end, I would like to share with you what the SGC has been doing together with Brazil in this area.

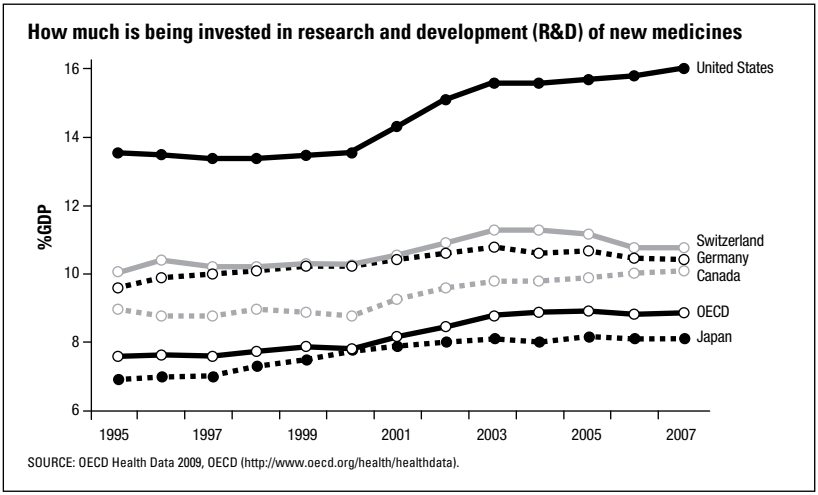
Innovation is not simply coming up with new ideas and discoveries – that happens every day. We have to think of innovation as transforming these ideas into products, into something that is going to affect our daily lives. At this moment, our field works in the following way: academics are responsible for most of the scientific discoveries. The universities hosting the academics will then file for a patent for that idea and then sell or license the patent to a pharmaceutical company, who has the expertise and

capability to bring those discoveries to the market. Before it can reach the shelves, any new medicine has to undergo clinical trials and then if successful, go through the regulatory processes that will ultimately say "yes, it is a real drug/medicine so it can be sold in our market". Once it reaches this stage, the general public can finally access the end of this cycle in the form of something they can relate to – a real drug.

However, the current model that I described just now is not working. This is how much is spent globally in research and technology for the development of new drugs (graph below). This graph is from 2008 and accounts for the nine major pharmaceutical companies.

This is how much is being invested in research and development (R&D) of new medicines, as reported by those major companies. In 2010, private companies spent $100 billion per year in R&D. But how many new real medications are being discovered/ developed per year? You can see from the graph that it is an immense bottleneck. How are industry and academia addressing this bottleneck? By pumping even more money into this field in the hope that innovation is easily scalable: $100 billion per year by private companies which is enhanced by further $100 billion globally, by foundations and charities funding biomedical research. So the total amount of money now is reaching about $200 billion per year in total. Considering the previous years, we are seeing an exponential growth



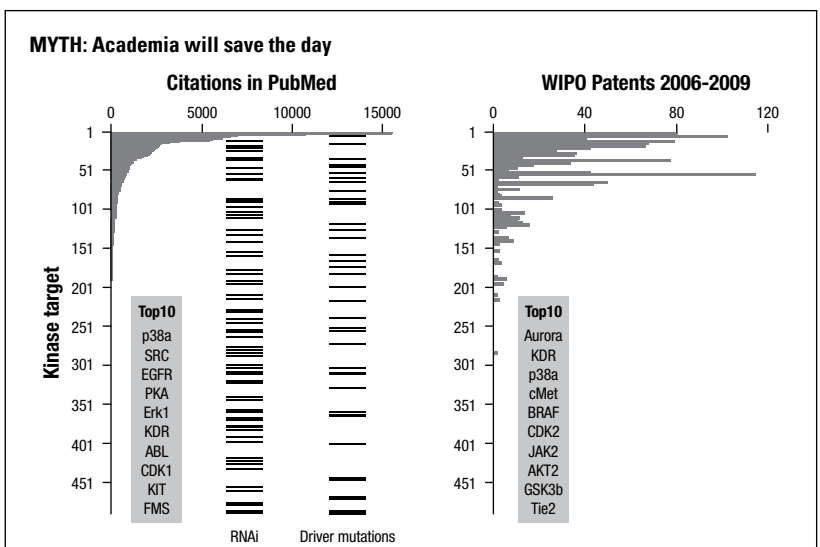



in investment. And what is happening with new drugs discovered? It is flat lining. In 2010 the FDA has approved only 21 new drugs. Conservative estimates put the price tag per every new drug that is developed at $1 to 2 billion, but the numbers above suggest that it might be more. What's happening is that many of these companies, although they're investing heavily, will lose on average 25 percent of their revenues with the loss of patents. To make the ends meet, pharmaceutical companies are closing R&D sites in a staggering manner. Since 2010, about 300,000 people lost their jobs in the pharmaceutical industry. This is not simply about restructuring and bright people moving to another company - this is actually killing generations of excellent researchers trained within the industry and academia. Once they lose their jobs, they will not have any other place to go, as all the pharmaceuticals are slimming their R&D and there are very few new companies opening up. The highly skilled people will end up opening a shop in eBay, migrating to the financial sector or a small proportion will be absorbed by academia. We are actually killing the creative minds that are bringing these innovations and these new drugs to us. The so called "Financial analysts" from investment banks are now advising their investors to stop investing in pharmaceutical companies that are doing research because they are going to lose money; it is like advising a butcher to stop selling meat. We are undergoing a great crisis, and obviously, the companies

are all saying "we need a solution, we need innovation!" But where can they find innovation? "Of course, in academia."

Well, let me tell you that this is a huge myth. Academia is NOT going to save the day. This is an interesting graph created by one of our scientists from the SGC – Prof. Stefan Knapp.

We all know that the genome project has given us the 'manual' of life. We also know that it contains information for the body to make several different types of highly specialized molecular machines which carry out all the functions sustaining life in a living organism – these are proteins. Of all these proteins, there is a class called the 'kinases' that are implicated in several cancers. In fact these kinases are so important that most of the modern drugs to cure cancer act upon kinases. There are about 500 different types of kinases in humans and MOST of them are known to be implicated in cancers and other biological processes. When scientists work on something, they write about their findings in scientific journals so other colleagues can use that finding to move the work to new directions. When Stefan and colleagues trawled the journals to count how much work had been published on each of those 500 types of kinases, he found – surprisingly – that almost the absolute majority of the research done on kinases covers only 40 or 50 of types – this is less than 10% of everything. This has




SOURCE: The (un)targeted cancer kinome. Fedorov O, Müller S, Knapp S. Nat Chem Biol. 2010 Mar; 6(3): 166-169. Too many roads not taken. Edwards AM, Isserlin R, Bader GD, Frye SV, Wilson TM, Yu FH. Nature. 2011 Feb 10; 470(7333): 163-5.

been dubbed the 'Harlow-Knapp' effect: no one is expanding; no one is trying to research new things. Why is this happening? Several reasons – one is because in academia when we send a project to an evaluation committee, the first thing they are going to say is, "Where is the data? I cannot invest in research that is not going to achieve anything." So if I am going to work on research, I will need to be backed by a funder, say FAPESP for instance – it could be NIH or MRC – it does not matter – the behavior is the same: If I am submitting a proposal about a well-known kinase – call it 'kinase 1', the reviewers will receive a huge proposal, with a very thorough literature revision, citing all that is known about kinase 1. The reviewers will say: "Great – there is a lot of information and it all makes sense because this is indeed a very comprehensive analysis". As they all work on the same kinase 1, reviewers will even probably say: "Let me see if they are citing my work. Oh, it is here and they are agreeing with (my) previous findings; it is a great proposal, so I am going to finance this research."

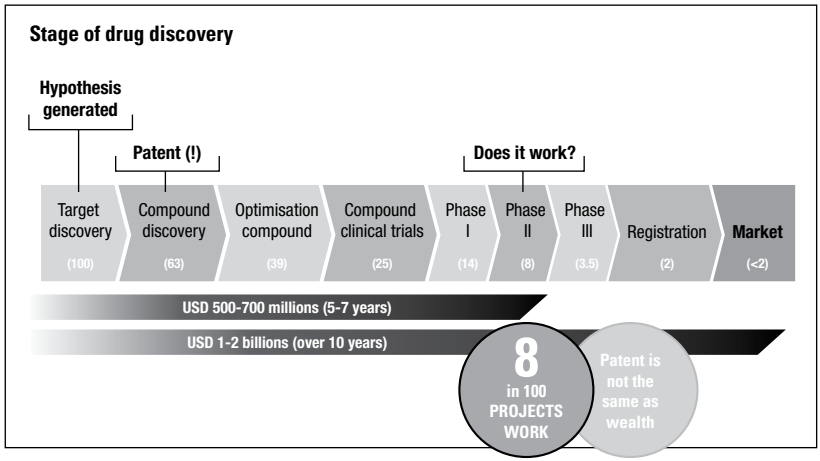
However, if a colleague of mine is brave enough to say "I want to do something different, so this obscure kinase 435 has been reported to be involved in a cancer that we do not have yet the cure for." My colleague will look at previous work about this publication and how many articles will there be? Only two. So his project will be based on a small amount of data, but that might be critical and his project is going to be only a few A4 pages long. What are the reviewers going to say? They are not going to invest in this research as it is too 'risky.' Risk is at the center of discoveries ad innovation, but alas the funders see 'risky projects' as a lost fund.

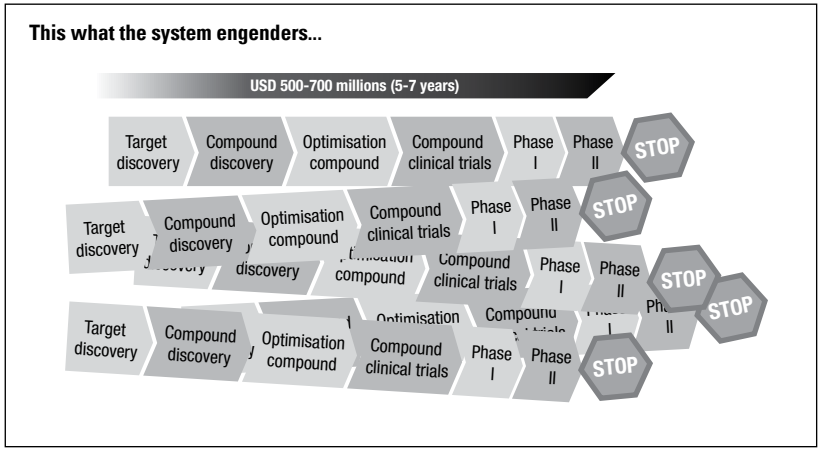
One might think this happens only in academia. Careful. Have a look at the patents put forward by the pharmaceutical industry in recent years which covers kinases. The patents follow the same 'innovative' trend in academia and cover EXACTLY the same meager 10% of the kinase space. The 'innovation' model is kind of inherently flawed: only work with things that they know already, that are 'safe-bets' and 'sure-wins.' This stifles real innovation and is systemic. It is intra- and international, so one can imagine in Brazil, everyone wants to work with all these usual 'safe-bet' kinases here, like p38a. So I write a project, my other colleague writes a project, someone else writes a project about the very same thing. Now imagine that a bus full of scientists attending a kinase conference crashes and everybody dies: the impact in scientific productivity in this area would be zero, because everybody else in the entire world is reading the same scientific articles, they are doing the same experiments on p38a so there is

a huge duplication of work on something we do not even know whether it is going to work or not.

Changing the focus a bit, let us take a look at the stages of how drugs are developed.

We start with a target, the kinases, for instance, it is a therapeutic target. I now know which is the molecule that I want to target within my body. Any drug you take is a small chemical molecule that is going to bind to a protein – a target. First, you need to define a target, then a chemical compound to modulate the activity of the target, then an optimization because sometimes the chemical compounds are toxic or not yet suitable as a drug,



so you have to tweak it to improve it and finally, you optimize the chemical compound to be used in a clinical trial, which should be safe enough to test on patients. You have then three clinical trial phases and need to pass the regulators and then finally a new drug reaches the market.

From 100 projects that start, only two are successful and reach the market. Starting with 100 projects only 8 goes beyond the phase two clinical trials, which is the most critical phase in which you are testing if the medication is really going to work (or not!) on a sick patient.

Looking at the timeline, here is where you have the generation of the hypothesis, where we publish the articles. Then the industry says, "Oh, cool, let's work on that." And here in our timeline they patent these ideas. So at this stage in the timeline (the patent stage), 63 percent of projects have been successful, but here the real question is, does the drug cure a disease/condition? This is answered at Phase IIa stage and only 8 percent of projects get to this point – and yet the patent was filed right there at the beginning of the timeline. From the patent stage to phase IIa takes five to seven years. Each company spends between $500 to $700 million to take a project all the way to phase IIa – only to find out that 92 out of 100 of such timelines will fail!

And now we have this conundrum: A patent does not translate directly into wealth generation, it is just a protection. Here what we see is that everyone sees patents as if they were direct equivalents to profits. People are rushing and saying, "Oh, I need to patent all these compounds because maybe one might become a goldmine." So they spend a lot of time and a lot of effort in filing for protection. What for? So this is what the present system engenders: spending $500 to $700 million, after five to seven years, to finally realize that the drug does not work - for 92% of the projects.

But it is even worse: because each company uses patents to protect their initial research, the information is not being shared. So everyone is reading the same article, "new scientific findings," and saying, "I am going to do this in my own company and no one is going to see it!" Because the projects are treated like secrets, everyone will take five to seven years (and $500-700 million) to finally find out that it is not going to be successful. This is the picture that I think represents what is happening.

All of us here in the pharmaceutical developments are saying, "Oh, if we have the lights, we can see the way in the dark." But not for someone who is blind. The technology and the science, they work, but not unless the way we do science is revised.

In conclusion, our model is not working and one of the fundamental reasons for this failure is the lack of comprehension of human biology. Many naively think that it is very easy to fix a human being by looking at only one protein, but human beings are very complex. And we know it is not possible to find drugs in isolation. Pharmaceutical companies and academia are very good at different things, so we have to create a way for everyone to work together. Patents that are filed too early actually harm innovation because if you do not share information and efforts, everyone is going to end up with negative results, so it will be the blind leading the blind. We need to break this cycle of not sharing and duplication. I would like to very quickly tell you about our model, the SGC model. We are a nonprofit PPP (public-private partnership). We were established in 2003 and up to now we have received more than $180 million in investments from the Wellcome Trust, the Canadian government, Genome Canada, and NIHR in Canada. We have global pharmaceutical industries, supporting Open Access Research for the public. That in itself is unprecedented. The SGC is the largest PPP for drug discovery in the world. No one else has so many parties working together and doing everything using open access model.

We (the SGC) publish everything we do, the results and the knowledge in the public domain without restriction of use. You can use it any way you want. If you want to use our data and try to secure a patent you can; if you would like to build on our results you can – there is no limit to what you can do with our data! What we really want to achieve is to promote the understanding of biology in the entire world, because it is from there that new developments will come and that is what is missing at the moment. Our main ethos is that we will not file patent protection for any of our outputs. Our scientific and economic and social impact: The SGC alone publishes on average 1.4 peer-reviewed articles per week. I can hear you say – "but you must be a huge organization with an army of scientists." I can tell you that we have about 160 scientists who are responsible for 25 percent of the world production of novel human protein structures (which is the mapping of all the atoms building a protein, a vital first step in one of the most important methods to design a new drug).

In addition to the structures, we produce chemical probes. These are not medicines yet, but one can use these to test in cancer cells, for instance, allowing scientists to experiment and leverage research in new areas. With these two outputs, we have been unveiling new therapeutic targets.

As we do not patent anything, we have now become a scientific convergence point, enabling collaborations to be established very quickly. Any scientist can say 'oh, this is a very interesting target and project, so let's work together on an article'. Not a problem, we do not need to waste time with patent lawyers and can get straight to the point and start collaborating.

To reach our deliverables, we have also developed parallel technology, which is also in the public domain. As a consequence we are generating jobs, because there are several companies that are already using technology that we have developed and launching start-up businesses. Generating jobs and sharing knowledge, all in the absence of Patents.

I will give you one example of our latest success, which is a chemical probe, which is a tool molecule that researchers are going to use in their experiments. In July 2009 we started and we told our partner we wanted to start a project in a new area, in which most pharmaceutical companies have said, "I do not think this is going to work. But the SGC have autonomy and we are funding you exactly to explore the unknown." In January 2010, we gathered initial data and asked ourselves "what is the best academic group to work with to make progresses quickly?" We identified a group at Harvard and called them over the phone to discuss a possible collaboration. As we were not restricted by patents or lawyers, we started work the following day. That was 2010. In less than 12 months, we have shown that that target, that protein, could be used in therapy and we were published in Nature, which is arguably the most respected scientific journal.

As we initiated the project, one of our pharmaceutical partners also began examining the same target, using our open data together with their own internal information. Surprisingly, very exciting results came from our labs and from the GSK labs almost at the same time, addressing the same target. The findings were published in two separate articles, in the same issue of Nature: one from the SGC showing that our probe was active against a rare form of human cancer and a GSK article showing their own compound for the same target, but showing encouraging results against inflammation.

A month later we began to distribute our probe compound to whoever wants to carry out an experiment. In seven months we had distributed the probe to more than 100 labs in the world which were used by other scientists to implicate this same target with two new types of cancer.

In October 2012, academic and industrial groups across the world are working in this new area. Our original article was cited by 66 other articles, at least two pharmaceutical companies have projects on this field and two biotechs are exploiting the technology developed by us. One biotech has been created and attracted an investment of $15 million, using the results from only one of our projects.

All this has been made possible in a very short time from a molecule that does not have any patents. Obviously, there are big advantages of our non-patents model for the companies, for the industry. The companies can share knowledge. They can share risks and they do not need to be worried about solicitors, lawyers. One of the barriers that exists within the industry is that when the scientists say I'd like to write an article and share good information, the lawyers will come in and say no, we have to protect this, that, and etc. So, that shows to you the waste of time and money which is also important for the industry.

The main advantage of our model for government and charitable funding agencies is that it allows them to invest in open source creation of knowledge. The risk and costs is shared with the industry and it ultimately seeds the reinvigoration of academia with new tools, reagents and data generated by the SGC. The additional technology can also help creating jobs and 'raising the waters' for all the scientists.

Can we imagine the impact that it will have for the Brazilian government once it is involved in a project that has found a new medication that will cure cancer?

I will conclude by telling you a bit about what we are doing in Brazil. The SGC was the first institution to team up with the project Science without Borders announced by President Dilma Rousseff to host Brazilian scientists at a post-graduate level. On December 19 we opened up calls for proposals to bring researchers to Brazil and we already have a list of scientists that we want to bring here to initiate our joint research projects. All of this happened within only six months. Again, that was possible because there are no lawyers involved. There are no patents involved. So the whole idea is a transfer of knowledge in the network between us and Brazil and this includes bringing scientists that are based here to Brazil to help to develop our model upon their return. And at the same time we are also meeting more Brazilian scientists from several research institutes. For instance we have so far hosted seven Brazilian scientists who have

been training at the SGC Oxford Laboratories and have already achieved incredible progress.

So, my personal goal as a scientist is to make sure that society can reap the benefits of science more directly, more quickly. I have a brother who has autism and I know that this condition occurs within my family. As a scientist and as a relative of somebody with a condition for which there is still no cure, I want to know that the so necessary innovation can really happen. Every one of us have or will have relatives and close ones who will be diagnosed with an incurable disease such as cancer or neurodegenerative disease, and as a scientist I do not want to wait for lawyers or anyone else making decisions on what we can or cannot do research on to find cures based only on imaginary profitability.

To finish, I think about us the Brazilians as creative people. We are creative and energetic and generous and these are great tenets for Innovation. Brazil has this excellent opportunity of taking this big leap, have the benefit of avoiding the trotted paths and proclaim that we do not want to run into the same pitfalls stifling invention. We want to innovate. Brazil has already done so in agriculture and in airspace, and Brazil is now really well positioned to create this innovation in the Pharmaceutical and biological research industries

In my opinion there is no better partner than the U.K. to develop this innovation. The British society, academia and industry are all very open to this new concept. This creates something really unique - the openness that will allow partners to build trust and aim for the higher goal of improving our lives, through science. Brazil has this opportunity, this one-off opportunity to change her own progress to innovation.

# Innovation Policy Debate in India: Innovation in Comparative Perspective

**SUNIL KHILNANI**
*Professor and Director of the India Institute, King's College London*

To talk to you about this subject, I'm a poor impersonation for my colleague, Jahnavi Phalkey, who is an expert on this, but she is in India, so you have been warned. First of all, it's very, very nice to be able to have you here at King's. We at the India Institute have just been established this year, and are now colleagues with Anthony Pereira's Brazil Institute here, and we indeed hope to collaborate within King's over the next while on a number of different projects, so it's very nice to be able to meet and speak to you here. I'll try and talk about some very general points concerning what's been happening in India in the economy and broadly in the field of research and sort of human capital if you like, and then maybe just make a couple of suggestive remarks about where there may be some areas of collaboration. As you know, India has been the second fastest growing economy in the past decade. It has slowed down at the moment, and its growth rates are expected to be lower than they have been for the next couple of years at around 6 percent, but for much of the last decade it was around 8 percent, and higher. This has been a rather peculiar pattern of growth in India. It's not followed the kind of standard path that most other economies have taken, which is to move from the

primary to the secondary sector, to see an expansion in manufacturing, and then to services. That's the sort of standard trajectory for economies. That is not been the case in India. India's growth has been driven by an expansion of the service sector which is an oddity, and it has led some to refer to India as experiencing a kind of precocious growth. Thatis to say, the sector which is supposed to grow last in the normal pattern is the one that has actually been the most dynamic in India over the last 20 years or so. That has been the IT industry, the information technology industry. One result, or one byproduct, of this peculiar shape of India's growth is that there's been largely what economies call jobless growth. So, there has not been a sufficient creation of employment, given India's employment needs, and given the growth rates that it's experiencing. So there is, in India, a huge surplus of labor and the need for capital and investment to gainfully employ that. That is just one general point to make about this peculiar character of India's growth. The second thing I would say is that in recent years there has been recognition on the part of Indian leadership of the need to expand the knowledge base of India's society, to expand education and to distribute skills amongst various sectors of the economy.

Now that's a huge task. At the moment, there's a fair amount of investment in India in higher education that is still relatively small, compared to other countries. India has about 370 universities. To achieve the government stated goal of 30 percent of the population with higher education in 2025, about 1,500 universities need to be created in in the next 12 to 13 years. So it's a massive task, a lot of money is being put into it, but whether or not India will be able to generate the kinds of faculty needed to populate these universities is a very big question. And at the moment, it is the case that even in India's existing universities, there are many, many positions which are unfilled because they cannot find the sufficiently qualified faculty to take these positions. It is also the case that Indian universities are very much regulated by the state. There's a reluctance to allow the private universities to really expand. That is going to have to change now given the goals that India's setting, but it means that there's a lot of regulation around universities.

One of the things that they have to abide by is India's affirmative action policies, reservations policies, and that means that a number of faculty positions are defined by affirmative action criteria, so not all can be filled, necessarily. That's a side issue, but one can come back to it.

Coming back to the role of science and technology and indeed innovation; India's first Prime Minister Nehru was someone who was always very interested in the sciences. He studied natural sciences at Cambridge, well before India's independence in 1947, well before there was a serious attempt to create a kind of national scientific and industrial base in India. That went back, I think, to the national movement's commitment to self--reliance. It was of course a Gandhian notion of self-reliance in a different way, that India should be self-reliant in its basic needs, but there was also that principle, or ethic if you like, extended into the more modernizing vision of people like Nehru as well. So self-reliance, the notion that India had to create its own base of science and industry in order not least to have its own defense capability, was a very important part of Nehru's commitment. It's also the case that if you look at the history of 20th century science in India, as early as the 1930s some Indian scientists were engaging quite high levels research in various sectors, particularly in nuclear physics, and in other fields.

You heard, for instance, a scientist like Bhabha, Homi Bhabha, the founder of the Indian civilian nuclear program, and also Saha, another scientist very involved in that, who were already building their labs in India in the '30s. In the 1940s, India imported a cyclotron during the middle of the Second World War into India. Now it was the only non-Western country, the only country outside the sort of core nuclear powers that actually did this, and it's just an indication of this intellectual commitment, as well as the political commitment to engage in basic research in India. After independence, India, through Nehru's government, and many of the policy decisions they made, invested very heavily in basic research in a number of fields, and in establishing high level research and teaching institutions. The most famous of these was of course the Indian Institutes of Technology, which were created in the 1950s.

India also created the Atomic Energy Commission, under Bhabha in the late '50s and early '60s, and, the a space agency under Vikram Sarabhai. Space, nuclear, and these other areas were very important early areas of activity.

This had many very interesting and beneficial effects early on. It began to lose some of its steam in the 1980s when some of it became a bit ossified for a number of reasons, which we don't need to go into. One instance of these early investments was the creation of a dense network of institutions in the city of Bangalore. Now, of course, we think of Bangalore

as a success story in terms of India's private capital and entrepreneurship because it took off in the late '80s. Indeed, the IT boom wasn't directly choreographed by the state; it was the creation of private entrepreneurship. Indeed, one of the explanations for why it did so well is perhaps that the state had nothing to do with it in India. However, what's interesting to note is what made it possible in a city like Bangalore? How did it come about? Why did it happen there?

For that explanation, you do have to go back and understand the big investments that were made in the 1950s in that city. So you had the creation of Hindustan Aeronautics, you had the creation of a whole series of precision engineering industries in Bangalore, you had the National Institute of Science, you had the National Institute of Advanced Study, the IIT, a number of different research, and technology, and scientific institutions were setup in Bangalore in the 1950s, which created this environment for innovation. I think there was earlier reference to this notion of clusters, and indeed there's a lot of talk in India about this clustering of expertise. Bangalore was a perfect example of that. It was created early on by the Indian state, and the benefits really kicked in much later. So I think when one looks at what allowed a city like Bangalore to innovate so interestingly, you have to actually understand the history of it. It wasn't just a few policy changes at the top.

It was actually rooted in some very core commitments and choices made by the government, some way down the road, and by others way back in the road. I think that this happened over time. Why? India has been an open society where ideas do circulate freely. They're not directed so much by the state, there is a very open and vibrant intellectual culture, and it has been that way for 60 years. I think that's a long term investment in democracy, in the pluralism of ideas which starts to have benefits down the road, and that's very hard to kind of create out nowhere. And you know, it seems to me that in the end, that's one of the most fertile climates for a long-term viable innovation - the fact that you do see Indian scientists, social scientists, economists, et cetera, in all of the big international organizations and so on. There's a kind of openness of flow of ideas as well that is not only within India, but between India and the world. I think that's an important fact, that India's an open society in itself, but it's an open society to the world, it always has been, certainly at the intellectual level, at the level of the circulation of ideas. And I think that's, again, a kind of long-term investment.

Now, in terms of the more recent wake up that the government has had about the peculiar character of the Indian economy, the need to be able to create a more job-rich growth and so on. Various initiatives have been taken. The National Knowledge Commission was created some six or seven years ago and came out with its own controversies and so on, but came out with a report that really did emphasize the need for India to invest in knowledge creation. Last year a National Innovation Council was created, headed by a man called Sam Pitroda, who pioneered the spread of telephones in India in the 1980s. He worked with Rajiv Gandhi. I don't know if any of you had ever traveled to India before the late 1980s, but making telephone calls was a nightmare. First of all, it was very difficult to get a telephone. If you needed to make a long distance call, you had to book it, et cetera. That was revolutionized in the late '80s by Sam Pitroda, by policies that had to do with his ideas, which brought phone booths all over India, and which inculcated the habit of speaking on the phone, which is one of the things that has made Indians so readily avid for the mobile phone.

As you know, the mobile phone sector is growing at a huge pace in India, and is a very innovative one. There have been a number of these government commissions and councils which have been created. Now, whether or not they've actually had any direct effect at the moment is not clear. However, I think that the great challenge India's going to face, if it's going to be a producer of primary science and primary innovation, rather than simply a destination for outsourcing, the great challenge is going to be the educational one, it can create the higher education needs that have been identified. At the moment, India does a lot of outsourced research. Companies like Boeing, like HP, like IBM, all have important research investments and research offices in India. Much of that is being done to order, as it were, but this comes back to the needs of a country. Companies like HP and Microsoft also have big research operations in India.

The research is beginning to be tailored to more specific Indian needs, and interests, and of course, one area that India has become known for is this notion of frugal innovation of low tech. Not the high tech kind of innovation, but low tech innovation in relation to very specific needs. Particularly the needs of a large, poor population, which is still what the vast majority of Indians are, and here you are. You are seeing some very interesting developments, both very much at the lower end, individuals, small companies, workshops, highly localized solutions which are someti-

mes recognized as being scaled up, but often just remain local still, but also have the possibility of being scaled up. You are also getting big companies. India's biggest companies are beginning to invest in research for this kind of low tech innovation. So, the best example of this is Tata's Nano car. It's had a slightly bumpy start, but that was really an attempt to do the opposite of what Mercedes Benz does. To strip down a car to its very bare basics, to make the doors light as possible, everything as light as possible not to have that big clunky sound when you shut the door, and so it really minimized the technology in the car, which seems to me a very interesting kind of innovation, if you're a big company who wants to reach a big market.

Another area that Tata has been doing some research in is on trying to develop very cheap water purifiers. One of the great problems of health in India is the absence of clean water. Can you create a cheap, popular, easily usable, water purifier that doesn't need instructions, that doesn't need particular timings, et cetera, but is just a straightforward thing? Another area that's been very interesting in terms of innovation is in the financial sector in India. The emergence of micro insurance and microfinance in India was pioneered in the last 20 years. But how do you get an extensive credit and risk insurance system to a largely poor, non-literate society who live in the countryside? How do you do it when you don't have the kind of the infrastructure to do it? This led to the invention of innovative forms of financial practice. So, there's quite an interesting amount of policy innovation which is going on in India.

We see innovation not just in the some of the kind of product-related things, or in the pure kind of science and technology area, but also in other areas. That's something worth looking at. I know in Brazil there's a lot of this happening as well, and I think there could be a very interesting dialogue there because it is, in a sense, about learning lessons and transferring them quite simply. There are several locations where innovation is taking place. These tend to be corridors between cities. Bangalore-Mysore, for example, is a very interesting corridor where there's a lot of clustering of these kinds of institutions and companies, Infosys, et cetera. Delhi-Jaipur is another one where this is happening, Mumbai-Pune is yet another, so there are these locations where there are twin cities a couple of hours apart that are seeing very interesting communication paths where there's a lot going on. That's where small companies are setting up, that's where big companies are investing, and there's a kind of architecture and geography of information, and I think India's seeing some of this happening.

Let me just end by stating some areas where I think there may be complementarities. Agriculture was mentioned, and India has a lot to learn. It seems to me that that is one area where Brazil could actually very creatively and constructively engage with India. The agricultural sector in India is way behind where it should be. Another area to consider would be this business of how does one manage biodiversity, which both Brazil and India have, in a way that's sustainable, and provides a sustainable kind of profitability from it in both domestic and global terms. It seems to me that there could be some interesting dialogue there. A third area would be innovations to do with urbanization. Again, some of the biggest cities in the world are in our two countries, similar kinds of problems with very different contexts. Regardless of whether it's innovations in forms of governance, or policy delivery, or infrastructure, et cetera; I'm suggesting a broader picture of how one might think about this as innovation not just in the way that it's usually used.

To conclude, I was informed the other day that on the professional network LinkedIn, the two most popular phrases that people use to describe themselves are "innovative" and "with extensive experience." I'm not sure how much extensive experience one can have in being innovative, but they do seem to be popular in the personal domain as well. I will end with one more thought: there is much to be taken from the notion of innovation in India, which extends across a whole set of different fields, not just in science and technology. There's a plan to create a national university on innovation in the liberal arts. I will be flying off to Delhi to take part in a committee to look at this, and so there is this attempt to kick start a number of areas that are

## PRACTICAL APPLICATIONS: THE ROLE OF UNIVERSITIES AND THE PRIVATE SECTOR IN INNOVATION

# Innovation at King's College

**DENISE LIEVESLEY**

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Let me tell you a little bit about King's College London, and I will focus particularly on my school because I think my school has a lot of relevance to today's topics. King's College recognizes the importance and has invested very heavily in emerging powers such as Brazil, not only with the creation of the Brazil, China, and India institutes, but with the internationalization of the whole college, with our emphasis on research on global issues. We are a college of some 25,000 students; two thirds of those staff and students are in health and medicine, so we have schools of dentistry, medicine, biomedicine, psychiatry, and nursing. And then one third are in what we call non-health, my own school, a school of arts and humanities, a school of law, and a school of natural and mathematical sciences.

When we were established as a university, the mission statement was academia at the service of society, and I think that ethos still informs a lot of what we do today. I have the great honor to be the head of a school of social science and public policy that is very vibrant and interdisciplinary.

Sometimes we even say it's post disciplinary, and we work on really important themes for society, and we have some very particular specialisms that you don't see in other universities. The school comprises seven departments, and something called King's Policy Institute. Five departments are fairly longstanding ones: a department of war studies, which studies war in

order to understand how wars begin, in order to build a more peaceful and sustainable society; a department of management with a particular focus on public sector management; a department of education and professional studies, with a focus on school education particularly, but also on the relationships with the professions; a department of geography that spans everything from physical to human geography, and works particularly on adaptation to climate change, risk, and resilience; and a very unusual department of defense studies, a model that doesn't exist elsewhere in the world, I think, and that is that this department actually does the continuing professional development for all of the military in the United Kingdom. So we have a major contract, and some 50 academic staff based at the joint services college for all of our military, so at the stage of about lieutenant colonel or equivalent in the other services, the military go and do a master's degree with us on leadership, management, and strategy.

And then we have two new departments, and I thought you might be interested in these because they are an example of how universities can adapt to changing needs, and these departments have been set up because of a sense of the importance of these particular topics in society. So a department of political economy that has existed not yet for two years, and was founded as the only one of its kind in the United Kingdom. Our new department isn't a department of economics, nor is it a department of politics, and still less is it a joint department of those two disciplines. Instead, what we're seeking to do is to build a new foundation where the subjects converge and overlap in the study of relationships amongst institutions, markets, and behavior. The issues that we're confronting in Europe in respect to Greece and Portugal have demonstrated the need for a department of political economy and more academics studying that topic.

The other brand new department that has existed for only three months is on social science, health, and medicine. This is because the change in character of the health professions in the context of new global patterns of training and migration of health and social care workers needs to be studied. We need to study the efficiency and the value for money in developing health and social care policy, the challenges of rationing health care, particularly in an aging society, and the promises and the peril of advanced biomedicine. So how do we support responsible innovation in biomedicine, and the problems of translation from the laboratory to clinical application in respect to genomics, stem cells, neuroscience, et cetera? I think this is a very exciting new department.

The expansion isn't just of new departments. We're also expanding in the school and across the college, and in our existing departments, and one thing I particularly want to mention is the expansion in our education department in relation to STEM subjects: science, technology, engineering, and mathematics. We have a huge shortage in this country of good, quantitatively trained teachers at school and university levels, and so we're aiming to try to cover that gap.

Before I come on to UNESCO and innovation in a UNESCO context, let me say a word or two about King's Policy Institute, which is set up by my school, but actually works across the college, and works increasingly with institutes such as the Brazil Institute. It's at the interface between high quality academic research, and making a difference to the world. So it's about what we're currently calling impact. It's about understanding what academic expertise we have where we can make a difference; whether our problems in policy need to be addressed, in policy and practice, and then bringing the academics together with policy makers, people in industry, in non-governmental organizations, and so on. Trying to develop fruitful relationships.

Your meeting is of great interest to me; I previously worked at UNESCO. I was director of statistics for UNESCO, and of course, UNESCO is the U.N. agency that works at the interface between education, science, culture, and communication. As director of statistics, one of the things that I had responsibility for was developing good statistical systems to monitor and measure performance with respect to education, research and development, including innovation. So I had responsibility for the development of the Oslo Manual, which is the manual that is used for measuring innovation, and we had particular interest in doing that with the emerging economies. So we worked alongside the OECD in order to try to ensure that the statistical systems that were developed met the needs of all countries from the cutting edge, the leading countries, through to the developing countries, but with a particular focus on emerging economies. One of the things that we're very interested in is the whole issue of innovation, not just in terms of the development of new technologies, but their application. I think application was a particular priority, and also looking for partnership amongst government, universities, and industry through things like the MOST program, which was the program for social transformation in societies.

Over the last few decades, many different agencies have produced different data sets and analysis on the development of knowledge and technological innovation. At the national level, countries have produced science and technology indicators, and science and technology and innovation policies. Internationally, OECD has produced important manuals, analyses, and recommendations based on the concept of national innovation systems. Additionally, the United Nations Development Program, UNDP, has developed a technological achievement index as a corollary to its human development index. UNESCO has produced science reports that present the evolution of science at a global level, and the latest edition came out in 2010. I gather that they're currently working on the one for 2012. A framework for understanding innovation has to take account of instability, inequalities, and heterogeneities present when innovation takes place in emerging and developing economies. The cross-cutting nature of innovation requires coherence amongst policies that are expected to influence innovation, and they have to get the balance right between the international, the national, and the local levels. This is always a challenge for the international agencies.

Today I think there's general consensus on the importance of knowledge in economic growth and social development, but there are still debates surrounding the forms of knowledge and how you measure them, and how you translate knowledge into innovation, into practice. One of the problems that I encountered at UNESCO is that a lot of innovation measurement focuses exclusively on science developed in formal institutions such as academies and research laboratories. And knowledge existing and generated outside of those facilities, and through exciting new relationships, hasn't been properly addressed. Let me just quickly mention three initiatives of UNESCO that might be of interest. The first is UNESCO's university-industry science partnership, UNISPAR. It was launched in 1993, and it was launched in order to improve the quality of universities, and to encourage them to become more involved in the process of industrialization of their countries. Today the program helps to forge partnerships between universities and industry, and to strengthen the capacity for innovation.

The second initiative is the Regional Center for Studies for the Development of the Information Society, which was established in Brazil as a center of UNESCO, established in São Paulo, and that supports Latin America and Portuguese-speaking African countries with studies on the

progress and impact of building exclusive knowledge societies through information and communication. The ambassador of Brazil to UNESCO said that the Center will become a center of reference for capacity building, research, and networking of specialists and developing countries, and that it will also contribute to UNESCO's programs to support the creation, access, preservation, and sharing of information and knowledge. So I look forward to looking for opportunities in which we at King's might work with that center, especially as we're in the process of setting up a new Africa institute here in King's, so I think there are opportunities there.

And then the last initiative is an initiative of a center that's been set up to support south-south cooperation, and this is a center in Kuala Lumpur in Malaysia, and again, I think there are great opportunities for working with the center. When I was at UNESCO, I worked very intensively with Brazil to help Brazil improve and share knowledge in terms of its education developments with Paraguay and Uruguay through a program called Work Education Indicators with Maria Helena de Magalhães Castro. She worked very closely with us in the UNESCO at that time. So I'm looking forward also to looking at how this new center in Kuala Lumpur for south-south cooperation, how we might facilitate its work. Thank you very much for the invitation to come and speak to you.

# Innovation at UCSD: Historical Overview and Role of Universities and Research Institutions

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## MARY WALSHOK:

My remarks will be short as an introduction, and then the panel will be short because, as I understand it, you are very sophisticated about the history of science policy in the United States. You have learned about the importance of the post-war federal investment in research that came with the Vannevar Bush report and the growth of the National Science Foundation (NSF) and the National Institutes of Health (NIH) and all of the federal funders, which changed the landscape

of American universities forever and made them, across the United States, centers of research and development with potential value to their regional economies. The second major federal initiative was told the Bayh-Dole of 1980. It allowed research universities to retain the rights to commercialize intellectual property.

As a sociologist, I always emphasize the importance of culture. The fact that people recognized in the 1980s that technology development and commercialization could have economic value across the United States was a huge step for this country. People began to understand that science and technology are not just men in white coats but products and processes that can benefit jobs and the economy.

Sweden is a very good example, I think, for Brazil. They have been enormously successful in changing their policies, including tax policies, to support innovation and entrepreneurship and also to create university mechanisms like at the Karolinska Institute in Stockholm, which has a foundation through which they do technology transfer and a big investment fund. A different model than the United States, but an interesting model.

Now the interesting question that we as a panel are going to address is since the 1980s there have been very different outcomes in terms of companies, innovation, entrepreneurship, new wealth creation, new job creation, across America.

Ivor Royston, who will speak first, comes from a city, Baltimore, which has not done as well as San Diego. Back in 1969, San Diego was considered to have nothing other than the military, the zoo, and a five-year-old university campus, which is the one you are visiting today. My life history as an adult has paralleled the transformation of this place over a 50-year period. It is an extraordinary story of innovation and entrepreneurship but also of a community that made land use decisions and regional - not state or federal - investments in building capacity to create research enterprises and commercialization entities which, combined with our success in federal research funding and the increasing activity of venture capital in the region, has given rise to a wonderful, interesting success story. We are like the kid that nobody thought could make it. And as you can saw in our video, much has happened.

The culture of innovation and entrepreneurship is hugely important when you have good federal policy, as we have had, and access to significant federal funds for research. Then it becomes the job of the region to build the ecosystem. And what I think you are going to discover this

morning is the diverse ways in which the region has gone about building that ecosystem.

I have three wonderful colleagues here who represent complimentary perspectives; we will start with Ivor and then move to David and then conclude with Jeff. Ivor, what I am hoping you will describe is why you came here when you could have been anywhere else in the country and what your early experiences were like as a member of the medical school and then as the inventor behind the technology that Hybritech was able to commercialize.

## IVOR ROYSTON:

Thank you, Mary. It is an honor to be here with you today. I have had the pleasure of being a guest in Brazil in January where I visited a number of people in Rio de Janeiro and São Paulo to learn more about the potentials there, which I think are many. I will restrict my remarks to the biotech industry which I have been part of.

San Diego today is a world leader in wireless technology and in biotechnology. I grew up in Washington, D.C. but it was in Baltimore where I went to school. Baltimore has Johns Hopkins University, which gets more federal research dollars than any university in the country, but is on the bottom of entrepreneurship and biotechnology industry. We will come to that later.

The reason I came to San Diego after I finished my post-doctorate at Stanford was that I was offered a job by the director of the UCSD Cancer Center and there was hardly anybody here. That was Dr. Mendelsohn, who went on to become the director of MD Anderson Hospital, one of the top cancer centers in the country. He started a brand new cancer center with only one additional faculty member, and invited me to be number two. At that point, I did not know that I was an entrepreneur or a start-up person, but there was something about me that always wanted to be on the ground floor, on the bottom of building something, and I knew that my entire life. I was offered jobs in well-established institutions on the East coast, but the opportunity here in San Diego was an opportunity to build something. I did not know at the time that I was also going to be contributing to building a biotechnology cluster.

When I started my research at the UCSD Cancer Center in 1977, we began to work on this new technology of making monoclonal antibodies (genetically engineered pure antibodies) that we thought could revolutionize how we treat disease, especially cancer, which was my area of interest. When we made those antibodies I began to reflect on how we were going to manufacture them and treat patients, since my goal was to take discovery from the laboratory into the clinic. I was a board-certified medical oncologist and I had experience in research. That led me to a venture capitalist in San Francisco, Kleiner Perkins Caufield and Byers. They had just started Genentech in the Bay Area, and I was able to convince them that they should start a company down here to develop these monoclonal antibodies, which is what they ended up doing.

The company, of course, was successful and went on to do many wonderful things. You will hear more about that from David Hale who became CEO of Hybritech. He was initially the head of marketing, but then became the CEO of the company and can talk a little bit more about it. The company's major claim to fame at the time was their development of a PSA test which led to the early diagnosis of prostate cancer in men and revolutionized the medical care of prostate cancer. So this is one of the major contributions it made.

I think Brazil has many opportunities to be in the same situation that San Diego has. First of all, when I went to Rio, I thought the city was just like another, larger version of San Diego in terms of landscape and weather. Additionally, you have great technology at the Federal University of Rio as well as institutions like the Fiocruz Institute. I was very impressed and think there is a lot of potential there. The reason I am saying that is because we had that potential here in San Diego in 1977, but if it was not for access to venture capital –which is the industry I work in now - there would be no industry here in biotech. Biotech requires tremendous amounts of capital and people who know how to start companies, like the venture capitalists.

Access to venture capital is extremely important. The Bayh-Dole Act that Mary referred to, the ability of the federal government to grant to the universities all the responsibility for licensing the patents, to own the patents, and license the patents, was extremely important. Another thing I would like to mention is the ability for university professors like myself to go out and start a company while they are still teaching. This is very important. At the University of California and nearly all the universities and

research institutes in the United States, a professor can spend 20 percent of his time on outside activities, which include consulting for and, in my case, starting companies. And that is what is going on, and that is another reason why the United States has excelled in this area. That leads to the whole entrepreneurial culture that we now have in many of our universities, such as UCSD and of course famous places like Stanford, MIT and Harvard. There are still a few universities that do not have that entrepreneurial culture, and unfortunately my alma mater, Johns Hopkins, was one of them, and that is why, in my opinion, they have not established the kind of biotech cluster that we have here. We are now considered number two in the world in biotechnology and it is amazing what we have accomplished over 25 to 30 years as a group of people.

One of the major catalysts for the growth of the industry here in San Diego was when Hybritech was acquired by Eli Lilly. At that point in time, virtually all of the managers and directors, including David, who did not want to be in a large bureaucracy over the next year, left Eli Lilly, and each of them started a biotech company, of which many were very successful. So a major catalyst for the growth of an industry is that success of the first company and then, actually, its acquisition. The same thing took place in San Francisco when Genentech was acquired by Roche, so we see a trend here.

All you need is one success, and that success will breed an entire industry of serial entrepreneurs who want to repeat the excitement of being in an early-stage startup company, to build something new and make a big contribution to new technologies. So, I eventually left academic medicine and decided I wanted to go into venture capital. Now that I have been around for 20 years I have learned a bit about it. I never went to business school myself, but I have really wanted to use my time to work with other entrepreneurs to help them build their business in medicine, and especially in the cancer area.

## DAVID HALE:

My undergraduate background was in biology and chemistry. I always focused on the business side of healthcare and life sciences; the development, marketing, and sales of products like biotech, medical device, pharmaceutical products - so not actually the

science as much as the development. As you can see from my biography, I worked at Johnson & Johnson, the major worldwide company, and then another worldwide company called Becton Dickinson. However, in 1981 I was called by a recruiter. I was living in Baltimore, Maryland, running a company there and he asked me to visit a company in San Diego called Hybritech that was focused on monoclonal antibody technology which actually had been discovered in England a few years before. And so I said yes.

Hybritech at the time consisted of a few people in a trailer in a parking lot up on Torrey Pines Mesa, so it was not a big institute. My objective was to take the technology being developed by the scientists at Hybritech and turn it into a business because I believe that the creation of knowledge is very important, but I also believe very strongly that taking that science, knowledge and innovation and turning it into products is very important for society, the growth of industry, and certainly for job growth.

Hybritech became a successful company focused on monoclonal antibodies for diagnostics, and within a few years, we were selling products in the U.S. and Europe. Then, along came Lilly, the big, large pharmaceutical company and they bought Hybritech. As Ivor said, what happened is that most of the senior management team left Hybritech and went out and started new companies. Since the sale of Hybritech to Lilly, there have been over 150 companies created by the senior management team at Hybritech. That has had a significant contribution to what Mary has talked about in terms of the life science cluster in San Diego.

San Diego has this large cluster of life science companies, diagnostics companies, pharmaceutical companies, and medical device companies - that began in the late 70s and today has over 500 companies. So, I would like to quickly talk about what I think is important in terms of creating a cluster. Obviously science and innovation is the cornerstone. We had that in San Diego with Scripps, Salk, USC, USCD and Burnham. The second part is having the ability and the attitude in order to transfer that technology into companies. A place like Johns Hopkins does not have this, and so Baltimore has not been successful. A lot of it is because they do not have that culture of entrepreneurial transfer of technology to industry. Along with that is the protection of intellectual property. We were very successful early on in convincing the university how important it was to protect intellectual property. Ivor has already talked about venture capital and the fact that without it, there would be no industry here.

The third thing I want to talk about is this support system. You have to have the support system, the law firms and the accounting firms that understand your business and how to help you build that business. One of the things we did very early on that had a tremendous impact on San Diego was the development of an organization called CONNECT. When we conceived that organization, it was to support technology and entrepreneurship and the transfer of technology out of research into companies. The mission has been broadened significantly since then, but it is still to support innovation, technology transfer, entrepreneurship, and the building of companies based on technology.

In the early 90s we also took a second step and we created an organization called BIOCOM, and you are going to hear more about it from Joe Panetta a little bit later, but BIOCOM's purpose in life was to support the interests of the biotechnology industry with our government officials, whether they be city, state, or national. They have done a great job of doing that because a lot of times the issues that affect our industry are not specific company issues but industry issues.

CONNECT sponsors a number of programs, and I gave a talk about how to create a successful biotechnology company and the factors that were important in creating such a company. There were two scientists from UCSD in the audience who had some technology that they thought was important in the cardiovascular area. After the meeting, amongst other people that I talked with, they approached me and indicated that they were interested in starting a company based on that technology. We talked right after the CONNECT program and ended up starting two companies; one called Gensia that ended being successful over a long period of time, and another, called Vigene, which was sold to Chiron, a big company in the Bay Area. That happened as a result of the CONNECT meeting. In addition, CONNECT over the years sponsored a number of meetings with venture capital groups that ended up investing in the companies that I was involved in.

The final thing that I think is very important if you are looking to build a cluster of companies is entrepreneurs. You have to have people who have some background in understanding how companies are built. When you have very scarce resources like you do in a small company, it is very important that people understand how to get things done with a very small amount of resource. The transition for me from big company to small company was major. I had no staff. It was just me and a couple of other

people. So having a culture of entrepreneurship has been very important in San Diego. In conclusion, putting all of these things together is what leads to a successful cluster of innovation. Thank you.

## JEFFREY STEINDORF:

I know that Brazil is an extraordinary country. The UNESCO data indicated over the last few years that your GDP has grown at a rate that is eclipsed only by China. I believe it was 33 percent from 2009 to 2011, currently ranked sixth in the world, projected to have the fourth largest GDP in 25 years. I am astonished, and in many respects I think what is happening in Brazil mirrors what happened here but on a much greater scale. Hence, I am really delighted to share some of our experiences.

I headed up campus planning at UCSD for about 30 years, I came out as a post-doc in 1977. Some of the skills that I developed along the way were generalizable in terms of doing analysis and just being a good, organized administrator. So I have applied those skills to help build an infrastructure at UCSD, but in doing so, the group of people that I worked with was composed of individuals who had as their core a desire to reflect the entrepreneurialism of the faculty. And what I would like to do is just spend a few minutes talking about the leadership that created UCSD, its entrepreneurial ethos, and then some of the capital planning strategies that we have used over the years.

As you saw in the film, San Diego developed very rapidly after World War II as a function of the Manhattan Project and the federal-university partnership that emerged. After the war, it was clear that the national welfare economy and national defense could all be advanced by solidifying that federal-university partnership, and at institutions like Johns Hopkins, Stanford, MIT, the University of Chicago, and University of California there was increasing development of federally-funded research activities and federally-funded facilities for research. Over that period of time in San Diego, Salk Institution of Oceanography also benefitted. SIO, which is the precursor to UCSD, was established in 1912, and during World War II, some of the researchers at SIO had been involved in doing wave action research that supported the invasion of the Normandy Beachs on D-Day. It was very clear that there was a center of scientific excellence here that had applicability.

In the years that followed, Roger Revelle, who had come from Harvard to head up SIO, was also involved in developing the United States Office of Naval Research. He was extremely well-positioned to take advantage of the federally-funded infrastructure that was developing over those late years. I think the leadership of San Diego has continuously reflected that central positioning in the federal scientific funding network. The first CEO was Revelle and the first chancellor was Herb York, who had worked in the Eisenhower administration. He was a physicist who had also worked on the Manhattan Project. He was the first director of the Livermore National Energy Lab. He had been one of the founders of the Advanced Research Project Administration in Washington. Other chancellors included Bill McElroy, who was the director of the National Science Foundation under President Nixon. McElroy was succeeded by Dick Atkinson, who was the director of the National Science Foundation under Presidents Ford and Carter. And the other chancellors all were equally well-positioned individuals who are either members of National Academy of Sciences or had all been recognized. For example, our previous chancellor received the Presidential Medal of Science a couple of years ago.

All of these people are well-positioned in the national network and knew what the national priorities were. During the beginning years, the notion was: "Let's not just build a university- let's build a university that is focused on research." What was developed at UCSD was building from the top down; bringing in great scientists who would attract great faculty, great post-docs and great graduate students. That research ethos was established before bringing in the undergraduates. The facilities for research were built and used as the core that provided the impetus to the development of that area. It all succeeded amazingly well.

Along with the federal funds that helped build facilities, San Diego obviously benefitted by the baby boom era, the post-World War II demographics that supported the significant expansion of higher education in California that led to the development of San Diego. And, again, this campus built off of Scripps, so there was already an established center of excellence here and a focus on interdisciplinary subjects with multidisciplinary involvement. There was always a very creative mode that was reflected in the initiation of the medical school in San Diego. It was not only a medical school, but it was a medical school working with the basic researchers in biology and chemistry and physics so that San Diego was not only training physicians but training physician researchers and imbuing in them an ethos

to go from bench to bedside to the marketplace. And, again, that entrepreneurialism that Dr. Royston mentioned has been continuous throughout these years.

The campus benefitted by having ample state funds at its initiation; however, that period ended with the Vietnam War. We went into a period of about 10 years in which there was no state funding, and at that point we needed to be a little more creative in terms of identifying other funds. That is when we started to engage in external financing. There was a good robust funding base, so we took some chances there. But over the years we developed a couple of techniques, and despite them not being extraordinarily creative, I think there are a few good lessons here. We passed that year of simple state funding where we had a single funding source and built a large part of the initial infrastructure to an era in which we needed to cobble together funds from different funding sources. It was as a combination of mixing funds and also leveraging funds. For example, the bioengineering building that was developed a few years ago was initiated as a foundation support grant from the Whitaker Foundation. At that point, UC San Diego's bioengineering program was ranked either one or two by the National Academy of Sciences, either just behind Johns Hopkins or just in front of Johns Hopkins. A group had attracted this funding, but not quite enough to build a building.

Bioengineering is a subject that should have been funded by the state. Despite it being the era in which the economy had slowed down, we were able to leverage that foundation funding for bioengineering by telling the state, "We have an opportunity here. This foundation will provide roughly half the funds to build a building if you will give us the other half." And, as a matter of fact, we actually did the same thing with the foundation. We told the foundation we can get half the funding from the state if you will solidify the other half from your group. We were able to build the building. In the initial years, the state was providing funds for research for the university. Its ability to do that diminished as there were other calls against state of California funding. Consequently, there was an agreement reached between the University of California and the state to change the funding mechanism a little bit. Because the state was providing funding for research and the federal government was also providing funding for research, for many years the university used to return some of its money from the feds to the state in recognition of the support that it was getting from the state. But when the state was no longer able to maintain that same high level of

funding, they agreed to allow us to keep all of the funding that we were getting from the feds instead of returning some, and in fact they would give us a credit to use those funds to build buildings. It was something called the Garamendi Act. John Garamendi, who's now a Congressman from northern California, was a state legislator and the insurance commissioner who viewed this as an opportunity to enable us to build facilities. So, we have been using those indirect funds to help build buildings and it has enabled us to construct seven major science and engineering buildings over the last few years.

I do not think there is any substitute for leadership and building that infrastructure, even if the facilities in place are not completely built. Above all, try and bring together the very, very best people. Cluster them. Let those great minds interact.

## DAVID HALE:

In the late 1970s and early 1980s it was very difficult to license technology from most universities in the U.S. We used to say it was almost impossible. One of the things that changed and really helped that process was the creation of offices of technology transfer in universities, which were responsible for understanding what technology was being developed and had the primary responsibility for the interface with companies on potentially licensing that technology for development. Today, most major universities around the country have one of those offices of technology transfer. The establishment of these offices really facilitate the process because back in the day, universities were very insulated and the faculty was only interested in publishing, not in making their technology available for development.

## MARY WALSHOK:

I would like to add an example. The two most important research professors at UCSD to the economy here, Ivor Royston and Irwin Jacobs, both left the university in the 1970s because it was so difficult at that time to be both a traditional academic and run a company. Perhaps you would like to comment.

## IVOR ROYSTON:

I left the university because it was, and still is, very bureaucratic, and after seeing what we could do at Hybritech, I felt that we could do things much faster in the private sector. Following up on what David said, I am certain you all have technology transfer offices in your universities, and that is very important. However, the issue arises when you have to negotiate with the government. Negotiating with the Brazilian government cannot be any better than negotiating with the government of the United States. Before, it was nearly impossible to get any significant licensing quickly, because negotiating for a startup venture with the U.S. government was extremely difficult – and I assume the same thing is true in Brazil. What made the Bayh-Dole Act possible was the leadership that President Reagan gave. President Reagan made a speech in 1981 and said the government is not good at licensing technology – "It is not our business to license technology. Let's give it to the universities, where they can set up tech transfer offices to do that." I think you need leadership in Brazil from your president. If she could get behind this, I would assume like President Reagan, maybe everybody would be inspired to make the change. I would be interested in your opinion.

## JEFFREY STEINDORF:

I would like to make a comment. Having a different role now at the Sanford Consortium for Regenerative Medicine, where there is no staff or bureaucracy. We have a consortium that includes UC San Diego, the Salk Institute for Biological Studies, the Sanford-Burnham Biomedical Research Institute, the Scripps Research Institute, and the La Jolla Institute for Allergy & Immunology. These are five world-class institutions. The agreement among the members of the consortium is that the consortium will not act as an institution and utilize staff to process tech transfer and intellectual property. As a result of that, each principle investigator has agreed to abide by the rules that are in place at his or her home institution. We are still dealing with problems of bureaucracy, even given what is a relatively facilitated structure as a function of law. For example, we have two principle investigators who are working with firms that are well known, Fluidyne and Becton-Dickinson, who want to bring people in to work with the investigators. And on both sides of the house, on the private sector from

these companies and from the institutions, there is a legalistic disposition to try and dot the i's and cross the t's of every potential legal issue that may arise in conjunction with intellectual property, even though the likelihood of intellectual property happening in the near term is relatively low.

Consequently, what we are trying to do is move the paradigm a bit and have the institutions on both sides, the research institutions and the private sector, agree that we will hold in advance specific legal considerations and detailing of intellectual property prerogatives and rights until those become reasonably foreseeable. It remains to be seen whether that approach is going to be satisfactory to the legal counsel in the respective institutions, but what we are trying to do is get the work done, get the science done, and then deal with the potential IP.

I would like to make just one other comment. It is essential that there be a supportive governmental structure, and, to my eye, I think that exists to a large extent already in Brazil. My understanding is that the gross economic R&D portion of the GNP is roughly comparable to that of the United States. What is different, however, is that in Brazil I think about 70 percent of the support for R&D comes from the government. In the United States it's about 30 percent. So what has developed here is an understanding among the private sector of how critically important it is to invest in an ongoing, continuous nature in R&D to ensure its long--term competitiveness. So, to the extent that you can create either laws or tax benefits that encourage that activity, I think you would be well served.

In 2012, UCSD received approximately $18 million in licensing income and technology transfer income. The university has $3billion dollar budget in total for teaching and research.

# Discussion

## DARCÍSIO PAULO PERONDI:

I will begin with what Mary just mentioned. It is a Swedish saying that you should never feel hate towards profit and wealth. Wealth creates business, research, products, and jobs. I believe our government is finally, although distantly, listening to this Swedish proverb. We must believe

in profit. This is one of the main issues Brazil faces today. The government sometimes believes in the private sector, but sometimes detaches from it. In the realm of research, we are increasingly seeing a coupling between the government and the private sector. We have a National Development Bank with a budget larger than that of Argentina and many other countries. Brazil has two problems it must tackle: the first is to believe in profit and wealth, and the second, is to achieve convergence between the government and the private sector.

However, in terms of research, Brazil is doing relatively well. We have Embrapa- The Brazilian Agricultural Research Corporation, established in 1970. We are the second largest agricultural country in the world, and will soon surpass the United States.

Undoubtedly, we still have basic difficulties to tackle. The most pressing of these is the lack of quality in basic education – at the primary level. However, we are a rich country with so much potential. We are blessed with fertile soil, good climate, rivers, ocean, and we are the sixth largest economy in the world. You must believe more in us, and demonstrate your faith by taking your companies to Brazil, be it through technology transfers or establishing institutions there.

## PAULO ROBERTO BAUER:

I want to extend my applause to the success that the project you established in San Diego has achieved. What concerns me very much is the process of acquiring the knowledge for this kind of project here, and attempting to do the same in Brazil. This would mean that we would have to wait thirty to forty years before experiencing success. Although establishing a model like the one we have learned about today would be welcome and possible, we are under no condition to wait all this time to see concrete results. We undeniably need to launch some sort of initiative. Because of our political and economic background, the government would have to be involved more than it is here in the U.S. On the other hand, from what I understand, the research undertaken here in San Diego was transformed into a private sector initiative. In other words, it became business. And, if it became business in the U.S., it, by default, became business throughout the world. Hence, companies that currently use the technology created here also earn money by selling products to Brazil.

This brings me to the question of how much partnership has been established between the university, the state of California, and the institutions working here with other countries throughout the word. A second question is what can be done in Brazil, along the same lines as what has been done here, that could generate new research which would ultimately be transferred to the U.S., and vice versa. We would surely have a possibility for success in the Brazilian scenery as well as the global scenery.

## MARY WALSHOK:

I would like to respond to the university community issues that Paulo touched upon since I recently finished a book on the topic. A very small percentage of the companies are directly related to university technology. Indirectly we have graduate students, professors who are scientific advisors, licensing relations, etc. But, we found about 300 companies a year in this region in the tech space - UCSD represents only 12 or 15 of them. The strongest portion of this project lies in the larger ecosystem. Intermediary organizations like CONNECT and BIOCOM create a platform for the small number of enterprising professors, early entrepreneurs, and attorneys and accountants interested in entrepreneurship, to come together. We were 24 organizations when we started CONNECT, and now it is in the thousands. It is my belief that you must create a physical place where people go to seminars and interact socially with people from academia and the private sector.

Hence, in terms of developing this type of ecosystem, university research is important – but, in my opinion, having people who help bridge the gap between academics and commercialization is much more important.

## IVOR ROYSTON:

I would like to comment on Senator Bauer's words and to extend Mary's remarks. First, I agree that Brazil is a leader in aeronautics, agriculture, alternative energy, and even bio fuels. However, I come from a biotechnology background, and having recently returned from Brazil, I found that as far as the biotech industry, there is so much more Brazil can do. There is very little biotechnology industry in Brazil. I met some entrepreneurs there who are beginning to address this. However, what I would like

to say to all the Senators and Congressmen is that now is the ideal time for Brazil to start building its biotechnology industry.

In the U.S., the investment in biotechnology is going down, and there are a lot of reasons for that (economic, political, etc.) Biotechnology is the R&D engine for pharmaceuticals, and I know that there is a mandate in Brazil to improve healthcare and to create innovation in the medical industry. Today, it is possible to identify technologies and products in the U.S. that can be developed in Brazil.

## DAVID HALE:

There are, undoubtedly, opportunities to establish relationships between startup companies here and the appropriate startup enterprises in Brazil. This would, first of all, help technology transfers, but it would also help build the infrastructure that would eventually allow Brazil to develop the entrepreneurial culture we have here in San Diego.

## BRUNO CALVALCANTI ARAÚJO:

Many times, in Congress, we have very little perception of how or if our actions turn into something effective and useful for society. I would like to share a story that demonstrates why meeting and gatherings like this one can contribute to something important in the long run. In April, we had a conference at MIT, in Boston. Of the students attending, three were Brazilian, and 200 were from India and China. This led to a discussion about the relevance and importance of having Brazilian students studying in universities abroad. This discussion culminated in the drafting of a project to stimulate the transfer of students in Brazilian universities to top universities around the world. With all the students present here today, we can see the project was successful.

The changes that need to be brought about are many times achieved from top to bottom, through public policies. However, those thousands of Brazilian students studying elsewhere are going to help change Brazilian universities from bottom to top. Through strengthening their education, they will be able to return and contribute more. One of the conditions for our full support of this project was that Brazilians in the program could not be studying law, philosophy, history, or journalism – they had to be in

engineering, medicine, health sciences, and hard sciences. We know that we have advanced in this regard, and we know that more will be achieved when these Brazilian students sitting here today in San Diego return to Brazil and help create change from the bottom up.

## MARY WALSHOK:

There is very good data in the United States on the role of visiting students and immigrants, not only in taking an entrepreneurial culture back to their region, but in sustaining relationships for the kinds of partnerships Ivor and David are talking about. Close to 50 percent of the companies in Silicon Valley are founded by immigrants, and the largest international venture capital investment goes there. Partnerships develop because of people.

## JORGE VIANA:

I have no doubt that our country today affirms itself before the world and is determined to become a world power with its wealth, its people, and its "Brazilian way." I have no doubt, also, that the opportunities we have today to make a leap in innovation are much better than the ones you had decades ago in California. That is why it is important for us to be here – to understand how it happened here, and find a way of making the same happen in Brazil. Perhaps the biggest obstacle we face is the lack of a culture of entrepreneurship. There is an ever so present dependency on governments. In Brazil, the word "wealth" is still very much a taboo - even more so within Brazilian universities. The problem is how to solve the equation of creating a culture of entrepreneurship and transform scientific knowledge into business. This was a determining step for you – so much so that many decided to leave universities and start your own business.

We are in a room filled with congressmen from different parties, and yet we all agree on the problems we have today in Brazil. The agenda of our research centers are purely corporate. In recent years we have experienced some change, however. In fact, our government is helping break this culture with the Science Without Borders initiative. 100,000 Brazilian students will study at top universities and research center in the world, and they will return to Brazil with a different vision. This is a fundamental step.

I also think there is a second problem associated with this culture. There is always a degree of wait and expectation for the government. It is as if, for something to happen, the government has to do it. Thing are not happening outside the government like they happen here, and that is equally as problematic as the lack of entrepreneur culture. Even the investment in science shows this. In Brazil, 70 percent of investment is made by the government, while only 30 percent is done by the private sector - the exact opposite numbers as in the U.S.

I believe that our goal, as a group of congressmen, is to find our Bayh--Dole Act. Our challenge is to find a law that will help our country become competitive in the innovation sector. If we do not achieve this, we will never become a true world leader.

I would like to finish with two questions. First, would a partnership between the private sector, the center for research and the Brazilian government to conduct research on the biodiversity of the Amazon and then transform that knowledge into business be something appealing to you? Second, how can we open a pathway for future cooperation between our universities in Brazil and the University of California San Diego?

## IVOR ROYSTON:

I am in complete agreement with Senator Viana. The government must take the first step, which is the equivalent of the Bayh-Dole Act. Why? Because when the university is responsible for licensing the technology and not the government they will receive the income, the fees, the milestone payments, the royalties, the equity in the companies, and then the university will take the leadership in changing the entrepreneurial culture because it benefits everyone there.

This is what we have learned in the United States and why the technology transfer offices are so active and the university administrators so supportive of entrepreneurship. Even Johns Hopkins today has the head of tech transfer report directly to the President, because they want to make this change. The very first step is the government, and the very first step is the passing of an equivalent of the Bayh-Dole Act that puts all the responsibility into the university and the research institutes.

# Supporting Innovation: Role of the Education System and Public Research Institutions

**PRADEEP KHOSLA**
*Chancellor, University of California San Diego*

If you look at this country from 1945 until today, it is safe to say there has never been a time in history when so much wealth has been generated because of significant investments by one country. Not only has so much wealth been generated, but it has uplifted the lives of people domestically and around the world. The real defining moment for the history of this country happened at the conclusion of World War II. During the war we spent hundreds of millions of dollars trying to build weapons using technologies that allowed us not only to sense where the enemy was, but also to confront them with super-destructive power. Once the war was over, President Truman had to think of how to use this technology for the advantage of society and mankind. This redistribution of investment in technology allowed us to create what we think of as the American Research University.

In response to the quest started under President Roosevelt to make this technology development useful for society, Vannevar Bush, then director of the Office of Scientific Research and Development, wrote an essay. In it, he said that people were advancing science, in this case not for war, but for health, prosperity, and security - as a nation in the modern world. He argued that basic research is a prerequisite - someone has to do basic research, someone has to discover the laws of nature, someone has to discover how atoms, molecules and biology behave and use that information to make human life better. Even in war years the government should invest in university research to meet the demands of both industry and government.

Most countries invest in research and have a separation between government and industry that is so clean that you are not able to see economic development due to government investments. Bush went on to argue that to do all of this you need manpower which can only be developed through scholarships at colleges.

If you look at the history of federal research funding you see it go from literally non-existent, to around $10 million dollars in 1953, and to $140 billion dollars today. This research has had a very positive impact on this country and the rest of the world. If you look at the defining moment when the world started becoming richer at a faster pace, it coincides with the dot.com boom in the late 1990's. Even though the U.S. suffered an economic downturn after the dot-com bust, the rest of the world, including India and China, continued to boom.

The entire dot.com boom was based on the Internet, a Department of Defense technology funded entirely by the government. Another example is the semiconductor industry. The whole notion of semiconductors, transistors, integrated circuits, etc., came out of purely governmental research, first at AT&T Laboratories, and then across the country.

What I am trying to emphasize is that government research has had a very big impact. The Brazilians in the room may be thinking this is great because Brazil spends a lot of money on government research and on public universities. However, name one country in which there exists a Google. By Google I mean a basic research technology that was funded purely by the government, resulted from someone's PhD thesis, and went on to become a $200 plus billion dollar company. There is no such country. This is unique to the U.S. and represents the power of the American educational system and of American policy where education, technology transfer, economic development, and human development all integrate. This, however, did not happen through magic. In 1945 Google would have been unimaginable because our technology transfer laws and intellectual property laws were not viable. It was the laws added to government policies that made Google possible.

Comparing universities in 1945 to today, we see that U.S. universities have become more than just educational institutions. They are in many ways agents of change. And education is just one tool in being an agent of change. We are agents of economic development. In fact, if you look at just the U.S. and you ask yourself which cities are growing – you see that at the center of that growth is always a university. Palo Alto and Silicon Valley

would not be what they are today without Stanford on one side of the Bay and Berkeley at the other side. San Diego would not be San Diego the way it is right now without UC San Diego being the economic driver of this place. If you look at biotech industry at UC, just about every company is either directly tied to UC San Diego or one step away.

There are very few countries that think of their research universities in this comprehensive a way. Most countries will think of a university as offering education. Others will think of the research component at the university as being a separate institute that does not mix with teaching. Seven years ago I met the Prime Minister of Portugal at the time and he wanted to know what they should be doing in terms of research. They already had great universities that produce great PhD's who then come to the U.S. and work here. So, my advice was to ask what it is they should be doing so that these PhD's who are as "high quality" as American PhD's can live in the country, start companies and create economic development in a way that your investment in this program in the next twenty years should come back to you as taxes. He became very enthusiastic, and we created a partnership with six universities in Portugal. Although there were cultural barriers, we made substantial progress. We brought their people to the U.S. and taught them how to think about technology transfer, an equal system, an incubator, venture capital, the professorial person who has the ability to both teach and be an entrepreneur. In Europe, there is a tendency to see teaching and running a company as completely incompatible, which is fundamentally bad.

The lesson we should take out of this story is that being a professor at a university and being and entrepreneur of a startup company should be able to happen without conflict of interest.

Universities clearly have had a very big impact on the U.S. In Fiscal Year 2010 alone, American universities introduced 657 new products, 4,284 patents issued for inventions, and 20,642 patent disclosures. U.S. universities receive $2.4 billion of licensing income and they have spun off 650 companies. What is interesting is that 75 percent of these companies were located in the state of the university from which they were spun off, and this is what ties to economic development. Available data estimates $2.4 billion dollars in revenue. It sounds like a large number, but if you look at the total government investment in research and development that return on investment is less than 2 percent. Hence, you should not be thinking about licensing revenue as the main source of revenue. The real

revenue comes from highly educated people who work for companies and who have created new technology and new companies that generate jobs and sell products domestically and abroad.

The rule of UC San Diego system in general is no different than what I have been talking about. Without UC San Diego, San Diego would not be what it is today. There are also other contributing schools and organizations such as Sanford-Burnham, La Jolla Institute, etc, that all contribute to economic development. The big difference amongst us is that we have 30,000 students. Most other places that have as high-quality research as we do do not have a substantial student body.

We have a $1-billion dollar per year research program, ranked number six in the country in terms of federal research dollars. We are number six in the country in terms of numbers of members in the National Academy of Science, National Academy of Engineering, and Institute of Medicine. We are ranked number 15 in the world in terms of our overall impact and citations. This place is a powerhouse in more than just the university. There is no other university that I can think of in this country that proposed something like the Institute of the Americas, which is both independent and part of us simultaneously. Our role in this community and in our nation is not just to educate students but also to do research. It is about economic development. It is about bringing other diverse thinking onto our campus, and partnering with them to make a broader impact that we are not able to make because of our charter and mission.

They key conditions for innovation and economic development to take place are research, talent, and money. There undoubtedly has to be research - as in discovery; invention. There has to be talent, both in terms of doing the research and in the process of getting trained to go out and work in companies. Additionally, there has to be investment. In the U.S., besides the Bayh-Dole Act, we also have the Small Business Innovated Research Program. It is a program run by every government agency where the idea is that if you spend X amount of your budget, a small percentage of that mandatorily goes to small businesses. The SBIR program, and now the STTR, the Small Business Technology Transfer Research Program, have created companies. The government is investing in what the venture capitalists would not. So when I think about government investment, I think about government investment as mitigating or lowering the risk. As individuals, we are less likely to invest in something when the probability of losing that money is at the 90th percentile. However, the country has

the obligation to invest with public money because it is only through more investment that the risk of overall investment decreases. What remains to be calculated is how much you reduce the risk. The U.S. government has various policies and academic researchers who help shape the understanding of how much risk there is, when venture capitals come in, when the private sector comes in, and at what point you have to mitigate these risks for various technologies.

I would like to talk further about our impact. If you look at the biotechnology cluster, from 1991 until now, employment has increased by 50 percent. In communication technology, it has increased by 70 percent. In clean technology, it has nearly doubled. That is an area that was non--existent 20 years ago. In defense manufacturing, because of government policies, employment is going down, but the important part is that the total in 2010 is higher than the total in 1991. There is a new creation of jobs, which means there is a net creation of wealth and revenue in the system we have in place here.

## Q) WHAT IS THE CURRENT AGENDA UC SAN DIEGO HAS WITH REGIONAL AND FEDERAL GOVERNMENTS?

UCSD receives exactly zero dollars from the federal government, as in we cannot negotiate how much money they will give us. If we get $1 billion a year in research and we are number six on the federal government list, it is because the federal government decides to invest in biotechnology or molecular engineering, opening the Request for Proposals (RFP) to the entire country. Hence, our faculty creates proposals which are awarded the funding. This demonstrates that when you build a university with the goal of being a power player, quality has to be criteria number one – that is what defines our ability to compete and win.

We do have conversations with the state government about how much they are going to allocate to us – but it does not influence their decision very much. For example, we get $240 million from the state, which is allocated to educate 30,000 students. We take that money and multiply it by 15, generating 3.5 billion dollars, which is our entire budget.

One billion comes from the outside. We pay approximately $2 billion in salaries, which creates about $180 to $200 million in state income taxes. Hence, the net contribution of the state to us is only about $40, $50,

**ON PICKING WINNERS AND LOSERS**

In terms of not picking winners and losers, the government did and still does things to avoid favoritism. However, picking winners and losers was not in the context of technology but more in the context of two companies working on the same outcomes – one following approach A, the other following approach B. It was clear that we were not going to invest in certain technology because it was either a lot of money in the private industry or there was not enough good research available. In that sense, we were picking what investments to be made, but we were not choosing one approach over another.

$60 million dollars. With that amount, we educate 30,000 students and help build the great city of San Diego, where real estate prices are surging because of the generation of wealth. If you look at our total impact, it is humongous.

[In Washington, D.C., you hear the other side of this discussion, President Obama claiming that the U.S. is falling behind on innovation, at least in some areas. There are two or three million jobs open in the United States right now without the necessary manpower to fill them.]

All these statements are true, but we need to understand the reasons behind them. There are three million jobs that are open and 10 million people or more who are not employed. I think the reason for this is a skills mismatch. It is not that these people have the skills and instead we are going to India or Brazil to hire. These people do not have the skills, partly because as individuals they did not see the shift coming and partly because the shift happened so fast that there was no time for them to think about it. This is where President Obama's investments in community colleges and other job training programs are important. Some of these people can be trained to do other jobs.

Regarding questions about lack of innovation, I will respond with my personal view. There are two things happening. First, there might be a slowing down of innovation. Yet, I do not think it is so much the slowing down of innovation but the fact that we are losing ground. This country is not used to having a downward slope in terms of standard of living, which has taken place over the last 50 years. Right now what we are seeing is India, China, Brazil and other BRIC countries increasing the standard of living much faster than in the U.S. Hence, we are seeing a relative but not absolute reduction in the standard of living. The question is whether this will lead to an absolute reduction at some point? Will the U.S. ever down-

grade to the second best standard of living compared to these developing countries? I believe that is what President Obama means by not having enough innovation.

Today, we see so many companies and jobs being created. Perhaps not as much as during the dot-com era, but definitely more than five years ago. I am positive going forward. What will hold us back is our K-12 system, which in my belief is really not doing well. Our university system is making up for the K-12 system. Most four-year universities in this country are offering remedial education to high school graduates who come there and cannot compete with the best of the best.

I will now talk about globalization. People always ask me, "If the real strength of the U.S. is its education system and the culture and policy of integrating education with economic development, why would you not keep that as an intellectual property secret? And why would you share it with other countries and let them compete with you?" My response is: for a couple of reasons. One is that these things can be kept a secret for only so long. Second, the problem is that if you look at the world, very few countries are investing as much in basic research, discovery, and innovation as the U.S. A lot of the innovation that is happening in other countries right now is more of the applied nature, where the core of that idea came from some fundamental discovery from France, Germany, Europe, England, or the U.S. The research of developing countries is not of the caliber where they can lead to significant fundamental discoveries. Third, the U.S. does not have the ability to keep on investing in research for the rest of this century. My view is that seven billion people in this world have to have a better quality of life, and therefore, every government has an obligation to invest in research. They have an obligation to understand the success model. This is not to say that we have the only success model, but it is one that is proven. However, this model has to be adopted and adapted. You cannot simply replicate it because it needs to be modified culturally.

Globalization is going to be important. At UC San Diego we have a big interest in making sure that our thought processes, our style of learning, discovery, and teaching is propagated. I believe, nonetheless, that the U.S. higher education system, especially the graduate education system, is still untouched. As in, there is no country that comes even a close second to this system.

My hope would be for the countries not just to adopt the U.S. education system, but the holistic ecosystem that this country has developed

and really spur economic growth. The faster other countries get richer, the faster people in the world will be brought into the middle class, the better our standard of living will be, the fewer wars we will fight, the fewer difficulties we will have with our neighbors. Globalization is extremely important, and I do not just mean in terms of the U.S. exporting ideas to Brazil, but also in terms of Brazil exporting ideas to the U.S. It should be a bilateral conversation.

## Q - SENATOR PAULO BAUER

Do you believe in the possibility of the globalizations of knowledge through research in universities around the world? We know that your university has contributed to the development of this region. We know that research in Brazil assisted with improvements in agricultural production. Is it possible to integrate this so that the quality of life that American already have can be passed along to other regions in the world in the coming years?

## PRADEEP KHOSLA:

The U.S. has achieved its quality of life at the expense of consumption of significant natural resources. If everyone in the world started consuming natural resources in the way the U.S. does, the world would be dead in less than two decades. So, for starters, it is impossible for everyone to consume and live like Americans have for the last fifty to sixty years. That does not mean the future is not bright. That means the future lies with renewable technologies, recycling and sustainability. These are areas that we have not focused on, and we have to focus on inventing new technologies, inventing new ways of doing business, so that the rest of the world can consume in a responsible, sustainable manner. However, for this to happen, investment is necessary.

All of these investments are not going to come solely from the U.S. because we do not have that kind of money. This is why when I engage with other countries, I emphasize our model of ecosystem development and not our model of wasting resources. We promote investing in research and thinking in terms of a global society where we uplift one another.

In addition, I think the sharing of technology across borders is really important. What limits us are our intellectual property laws and their implementation. We have to rethink what it means to patent technology in

the U.S. and not in Brazil, or to patent something in Brazil but not in India. This is going to be difficult, but a necessary next step.

## Q- REPRESENTATIVE MOREIRA MENDES

I am here representing the state of Roraima, in the North of Brazil. What I want to share with you today is the fact that two Brazil's exist. One is a Brazil that can develop and advance, and the other is a Brazil that has a difficult time achieving this. The second Brazil is represented by the Amazon, which is very closed off, and which the world observes with protectionist eyes, forgetting that nearly 25 million Brazilians live there. Because of international pressure, a form of glass box was placed in this area. In this line of reasoning, what opportunities do you see for your university to cooperate with us in the Amazon so that it begins to be perceived not only as a coveted forest, but as a forest inhabited by citizens who have rights.

## PRADEEP KHOSLA:

The question on what opportunities UC San Diego has to respect the preservation intent in the amazon while at the same time creating opportunities for citizens is a challenging one. It is a philosophical policy debates that happens in this country all the time. The Amazon forest is one of the largest ecosystems in terms of the number of species. One of the big projects we are working on right now is called "drugs in the sea" and it involves understanding sea life, both mammalian and plant life, and figuring out what the chemical composition is and whether any of them can cure human diseases. In that sense, there is a need for research on understanding what the natural products of this forest are that can be harvested in a sustainable manner while having marginal impact on the environment and what value will these harvested products provide to humanity in general.

Q- What can be done to create greater access to those resources? It is my understanding that it is nearly impossible for the private sector to touch anything in the Amazon without having to go through bureaucracy.

## PRADEEP KHOSLA:

The public sector however, including public universities, does have access to it – providing a loophole. You can invest in public universities to understand what capabilities and products exist there that can be harvested

sustainably. You can then create a policy in which, once these products are identified, they transition immediately to the private interest, just like the U.S. government does. By doing this you are helping scientists be professors, researchers and entrepreneurs - respecting the will of your government while respecting the aspirations of the citizens in terms of leading a better quality of life.

## Q- SENATOR JORGE VIANA:

You emphasized the fact that where innovation and development succeeded in the U.S., there was always an important center of knowledge present. The model of innovation that was used here, at UC San Diego, was successful, and over the last 50 years, has become a reference to the world. However, given our growing population, the world no longer supports this model of production and consumption. If we were to try to implement the American standard around the world, the planet would cease to exist. In Brazil, with population growth, we are faced with significant challenges in terms of food production and natural resources. We have to develop while changing the production and consumption model. How is this transformation being dealt with here, in the U.S.? How much are you thinking about a new, innovative model, which will bring opportunities to the poor but not pose a risk to the planet?

## PRADEEP KHOSLA:

I agree - we need to focus on sustainability. If we cannot sustainably harvest natural resources on this earth, we are not going to be able to provide for the seven billion people that we have.

There are two things UC San Diego is doing about this. First, I believe there is great potential in what is called co-innovation. Co-innovation means taking some of the best and the brightest thinkers from a place like UC San Diego and connecting them to the best and the brightest thinkers from third-world countries, who understand the situation in the country, but who do not have access to the best possible technology to solve pressing issues. One example of such is orthopedic devices. Poor villagers in India, who understand the material they have available, in partnership with American students who understand the properties and technologies of these materials, worked together to create an artificial foot that costs $20 dollars. That is co-innovation - it explains why globalization is so impor-

tant. Bringing together middle-class and lower-middle-class children from Brazil, Argentina, India or China, with students from the U.S. and creating design teams that understand how to solve a problem by using products which are locally available is incredibly important.

A second component of this is how new technologies disrupt existing ecosystems. When you develop a $20 dollar orthopedic device, it is only a matter of time until $10,000 orthopedic device in the U.S. becomes useless. If this happens often enough and broadly enough we will see sustainable generation of knowledge, sustainable consumption of resources, and sustainable increase of standard of living.

# The Commercialization of Research: Private Sector Partnerships

**JOSEPH PANETTA**
*President, BIOCOM*

**CLAUDIO JOAZEIRO**
*Doctor & Assistant Professor, Department of Cellular Biology, The Scripps Research Institute*

**BRENT JACOBS**
*Executive Director, C&W Global Life Scineces Practice Group*

**MAGDA MARQUET**
*Chair of the Board, BIOCOM; Cofounder, Althea Technologies*

## BRENT JACOBS:

I am a real estate broker, and many times, people wonder why I am involved in the science community. Thirty five years ago I worked closely with an architect called Ken Kornberg, whose father won the Nobel Prize for Chemistry. He motivated me to pursue more education, specifically in the realms of biology and science.

The truth is - the scientific community needs to align itself with the real estate community or the science does not go from the bench to the bedside. There is a disconnect between the two worlds. In the late 1970s for example, there were about 30 companies here in San Diego – most of

which came out of academia; UCSD, Scripps, and La Jolla Cancer Institute (now Sanford-Burnham). When entrepreneurs decided to go forth with building new companies, they had to look into real estate. They knew very little about how to build these institutions, what the infrastructure was, and what the laws were. So, a small group of us who had the necessary training were kept very busy at the beginning. We began to notice that many of these buildings that were put together by scientists were a complete mess. They did not understand the laws, especially those specific to infrastructure where chemicals are being dealt with. Many of them were purchasing used equipment at Home Depot.

We actually had to overhaul, pull down, and rebuild some of these facilities. As more and more scientists and money flowed into San Diego to build up this industry, part of the real estate community was becoming interested in this area. Number one, for the most part, the scientists would pay over the market price. They needed the space right away and would sometimes allow the landlord to get stock in the companies or warrants. It was a real win for the landlords until they began to realize that many companies were specializing the structures and so, if they were to go out of business, leasing it again would be difficult. We had an insurgence of real estate that went away in the 1980s but then came up again when public companies, called REITs (Real Estate Investment Trust), based on Wall Street, stated that there was a market here, and began building facilities.

In the beginning it was very much a hurried attempt at putting something together that would pass as a laboratory.

Even with my colleagues from Hybritech, many mistakes were made along the way. Today we are finally past those issues, and a very specific field with highly trained people has developed. We have accountants, architects, and designers who specialize in laboratories. There are HAZMAT people who deal with radioactive licensing or removing licensing, people who work specifically with HVAC, which is very sophisticated and expensive, as well as different legal groups that write leases.

All these specialties came together and we now have a very sophisticated industry. In addition, because these buildings are so expensive, we have Wall Street private enterprise financing these. They are now being built in a way that we call generic. They are constructed with what a typical laboratory requires – office space, chemistry, biology, a vivarium, etc. They try to construct these in a way that is not too specialized. If it does require specialization, the tenants themselves have to pay for any modification or

addition. In total we have about 18 million square feet of laboratory space here in San Diego.

## MAGDA MARQUET:

I would like to start by telling my story because I think it is relevant as I am an immigrant entrepreneur. I am originally from Andora, a small country with very little biotechnology. I went to school in France and then moved to California with my husband, who was a post-doc at UCSD at the time. The reason we stayed here was because of the environment in which foreigners are welcomed, helped, and given opportunities.

I worked for several companies in the industry, but then decided to start a company. If you put this into context – how many countries would allow foreigners to start a new business? You come from a different background, you have very few connections, and yet you are able to find people who believe in you and will invest in you. This partnership pertains to the culture of this region.

We created Althea Technologies with the objective of helping companies in drug development take their products to the market faster. It has recently been acquired by Ajinomoto, a global Japanese company. Yet, it will keep the operations and employees intact, which is good for San Diego. In addition to Althea Technologies, we created a spinoff which is the companion diagnostics field. This idea was conceived around our belief that in order to get the best pharmaceuticals to the right patient, the realms diagnostics and pharmaceuticals have to converse. We also firmly believe that this will have a huge impact on the overall cost of healthcare.

In addition to these companies, we started a small fund a couple of years ago to be able to invest in small countries. We were able to start our company because entrepreneurs and investors gave us the mentorship and the funds to do that, and we are trying to do the same.

If you look at the landscape of companies in San Diego, there is so much diversity and convergence. For example, during the early days of BIOCOM the main focus was on drug development devices. Today, it has evolved, and ranges to bio-renewables and e-Health, a convergence between physics and biology.

One question I would like to pose is what kind of alliance we can make with Brazil. Because I am a biochemical engineer by training and because I

worked for many years in biologics, I think Brazil has a huge opportunity in this field.

In terms of reproducing what we have in San Diego, it is very important to look at connectors – the people who allowed this to happen.

## CLAUDIO JOAZEIRO:

I am originally from Bahia, Brazil, but came to the U.S. for my doctorate, after having studied biology at USP (University of São Paulo), and have remained here ever since. During this period I had professional experience in the pharmaceutical industry doing research and drug development for NOVARTIS. Currently, I am a professor at Scripps Research Institute.

One of my dreams is to transform Brazilian cities into future San Diego's. Currently, I go to Brazil four to five times a year, engaging with the federal government, state governments, and academia - sharing the experiences and knowledge I have acquired here, and helping shape public policies.

The research model at Scripps is different from what is commonly used in Brazil. Scripps is a private nonprofit institution, with over 200 professors, four of which are Nobel Prize winners. We have over 2,300 employees, and we are almost entirely dedicated to research and entrepreneurship. What this means is that, as a professor, I am not involved in undergraduate teaching, which allows me to devote more time to research and technology transfer. Another unique aspect of Scripps is that half our staff is composed of biologists, and the other half of scientists. Hence, as soon as I discover a new biological process in the cell, I am able to walk across the hall and consult with a chemist, who will help me develop a molecule or drug that can modulate this process and eventually turn it into a drug.

I would like to talk about the research and drug development environment in Brazil. Without a doubt, we have seen advancements and more investments in this sector. Yet, it is time to ask – what is missing? What elements in this infrastructure are still lacking in Brazil? Senator Bauer mentioned the difficulty in replicating the San Diego model elsewhere. I agree – I believe we need a new model; a catalyzing development model. The government has an important role to play as a catalyst, which is very different from the more spontaneous model that took place here. Within

this catalyzing development model, the government has a role in developing intellectual property laws, decreasing the bureaucracy involved in processes related to how companies function, imposing tax incentives and increasing public investment. Both federal and state governments have to help establish the infrastructure for research to take place as well as the creation of companies.

There are two elements that require special attention. First, is the scientific component. There will be no innovation within a company if there is no strong scientific presence. Brazil has advanced a lot in this regard. I am not sure if I agree that Brazilian researchers lack the entrepreneur spirit. I believe Brazilian scientists are as business oriented as my American counterparts. Aversion to wealth is not inexistent in American academia. Perhaps it has just become less frequent, and this can be attributed to examples of success. In Brazil, we are lacking some good examples of success. Another important aspect is the role of the private sector in entrepreneurship. In the U.S., when I have a product I want to take to the market, private capital is readily accessible. Many times, this private capital is of much more value because public capital has little to no follow-up.

# Multi-Disciplinary Approach and Collaboration: Future Trends

**LARRY SMARR**
*Founding Director, California Institute for Telecommunications and Information Technology*

**KRISTIINA VUORI**
*President and interim CEO, Sanford-Burnham Medical Research Institute; Pauline and Stanley Foster Presidential Chair; Professor*

**LARRY GOLDSTEIN**
*Distinguished Professor, Dept of Cellular and Molecular Medicine & Dept of Neurosciences at UCSD School of Medicine; Director, UC San Diego Stem Cell Program; Scientific Director, Sanford Consortium for Regenerative Medicine; Director, Sanford Stem Cell Clinical Center*

## LARRY GOLDSTEIN:

I moved here from Harvard University where I was a tenured professor, and one of the reasons I moved was because this environment struck me as constructively chaotic, where one could interact and work with lots of different people doing lots of different things and where there was a very free flow of ideas. This is usually not true at traditional organizations like Harvard and MIT.

Another reason why I moved to California was because it has a very lively venture capital community and I had become convinced that the systems that we had studied for a number of years that are responsible for moving materials around inside of cells would be important drug targets for cancer and neurodegenerative diseases like ALS and Alzheimer's.

I had been at the University of California San Diego for a couple of years when I heard from a colleague about an interesting collaboration that he had developed with a marine natural products chemist down at the Scripps Institute for Oceanography looking for molecules from strange marine organisms that had interesting biological effects. I thought maybe I could contact this guy and we could look for funny-looking chemicals that might be proto-drugs that target these movement systems and establish the intellectual property portfolio that would be needed to attract investment, as well as seed the kind of infrastructure that would be needed to start a company to look for drugs in that area.

So I contacted John Faulkner, a marine chemist who was very interested in the idea of working together. He had never heard of me or of my work, but he was open to discussing further. So I enlisted John, who started supplying us with molecules from the South Pacific, in particular sponges. I had an undergraduate student in my lab developing a simple screening assay, ultra-low throughput. We discovered a class of molecules that had interesting effects on the systems we were trying to analyze, which led to the establishment of an intellectual property portfolio. The small molecules we identified turned out to be reasonable synthetic targets. That is actually an important lesson: what you discover in the Amazon does not necessarily have to be harvested forever from the Amazon, because modern organic synthetic chemists are unbelievable in their ability to synthesize incredibly exotic and complicated molecules. So, it is a sustainable model in that sense. The intellectual property portfolio we put together attracted five million, 15 million, and then another 50 million in investment over a few years. The company is now a publically held company on the NASDAQ. It has at various times employed 100 or 200 people in California. The company is based in San Francisco and it has drugs in advanced clinical trials for heart failure and ALS and myasthenia gravis and I think they will hit the market at some point soon.

The point I am making is that you actually can build a model based on exotic plant and animal life that might be transferrable to the Amazon.

The question then is what are the key elements that are needed for something like that to work and why did that work here? I do not think it would have worked at Harvard or anywhere else. First, you have to get someone on the other end of the phone who is interested in talking to you. In many modern academic institutions if you call someone up in another department, you have to establish a number of things first. You

have to establish who is smartest, who has the most status, and who is more important. What makes things work around here is that people do not have wildly overinflated views of their own status and value. Second, people have to have reasonable communication skills and the ability to engage with people in different disciplines. Third, you have to have adequate concentration of diverse expertise. What makes La Jolla very special is that within a square mile the concentration of scientific talent is extraordinary. It exceeds Boston, it exceeds New York, it exceeds anywhere else in the world. That is important when coupled with the ability of people to communicate and the interest in communicating.

My fourth point is that you need institutional support to cross boundaries. Part of what John and I did was academic, part of it was tech transfer, and part of it was trying to launch the intellectual property idea. Hence, you have to work in an environment where your institution is not setting up barriers between departments and schools. John was at the Scripps Institute of Oceanography, which was a completely different academic unit than my department in the medical school.

I would like to make a couple of concluding points. In constructing the Sanford Consortium for Regenerative Medicine, we have tried to really build that kind of example on a much larger scale; interdisciplinary, multi--institutional collaborations and a framework to support them in a new building and institute. One of the things we have learned in putting this together is that you have to select the right people. It is not just enough to be brilliant, you also have to be someone who, as I just mentioned, is interested in cooperating and collaborating and communicating.

On another note, I think there is a tendency in government to think about return of tax revenues to the government as being the only financial benefit. I want to remind you of the value of the concept of indirect benefit. If your citizens are all gainfully employed in ventures that raise their standard of living, you are less interested in tax revenue. So the concept of indirect benefit in these kinds of endeavors is really important when you make government investments in social welfare or in scientific programs that will benefit the public. Another point is, when the government has a pot of money, it has to establish merit-based, competitive systems to make sure their investments are used wisely. This is something that has been very important in the history of American science.

## KRISTIINA VUORI:

I represent the Sanford-Burnham Medical Research Institute, an independent, not-for-profit medical research institute, and our goal is to study unmet medical needs. Being an independent medical research institute implies that we are not affiliated with any universities or hospital, so we do not provide undergraduate teaching or patient-care. This allows us to have a very single-minded mission of conducting medical research. We also train the next generation of scientists, the postdoctoral fellows who come to us after they have finished graduate school. We have scientists from over 30 countries in our institutes.

The fact that we are an independent research institute allows to do very high-quality research. It comes with a price, however, and that is that we are a "soft-money" institute. We need to compete for all our funding. About 80 percent of our funding comes from competitive federal or state grants or contracts, about 20 percent comes from philanthropy, and 10 percent comes from technology transfer activities. We get our license fees, royalties, or milestone payments from pharmaceutical companies. Hence, our funding model is very challenging but also very rewarding and very entrepreneurial.

Another unique capability of ours is to do drug discovery and development. We are like a hybrid between a university and a biotech or pharmaceutical company. The benefit of being in San Diego is that the environment is very collaborative in this regard. We work with the university, other research institutes, biotech and pharmaceutical companies, venture capital funding, and angel investors. San Diego provides us with this unique ecosystem. My role and the role of others who are leaders in these organizations is to remove the barriers for collaboration and keep them out of the way so that intelligent people can take their discoveries from the laboratories to the marketplace.

The model in San Diego has actually been so successful that there is an attempt to duplicate this very activity in the state of Florida. In 2006, the then governor, Jeb Bush, decided, as a result of the state of Florida having a surplus of funding, that he wanted to jumpstart the economy through something other than tourism, and so he chose biotechnology. He studied various models and he looked at us here in La Jolla and San Diego and wondered whether the same could be done in Florida in a shorter period of time, with the government boosting the funding. We were recruited

and are now a bicoastal organization to Orlando, Florida. We received a $300 million dollar startup package to establish a brand new institute with the goal of having 300 investigators in a span of 10 years, becoming self--sufficient after this initial government funding. In other words, achieve the same capability we have here to compete for grant funding, attract philanthropy and have enough discoveries going to the private sector that we get revenues in the form of royalties and down payments. In addition, our objective is to serve as an anchor for a larger medical city that would attract hospital, biotech companies, and venture capital funding to Orlando. Our efforts in Orlando began in 2007, and are still very much a work in progress.

## LARRY SMARR:

The California Institute for Telecommunications and Information Technology (CalIT2) was asked for by the governor of California. At that time we had a surplus both at the federal level and the state level, and the governor was trying to understand how to invest this money. He shifted his focus to the University of California and realized that, to some extent, we had over-invested in individual faculty member and underinvested in the ability to make collaborative teams that could attack the real world problems that California faces. He then asked the president of the University of California, Dick Atkinson, to have a competition to create what became four institutes with different themes, of which we are one. Our theme is the ongoing exponential change in information technology and nanotechnology and how that is going to transform health, environment, energy, and culture.

The model in place is structural. The verticals are the professor, the department, the school, and the campus. We create a horizontal structure to allow for partnerships to form. We find ways so that the chemist, the doctor and the mathematician can fuse together to make a team and, in particular, we try to do that in a way that engages companies, both small (startups) and large (Ericson). In our building, we have facilities for visualization, virtual reality, nanotechnology, and spaces where you execute cross-disciplinary grants.

Approximately 80 percent of the money we bring in comes from the federal government. That is the engine of the United States that makes innovation continually possible. But we have also won 600 to 800 grants,

worked with 300 companies, and worked with various departments and faculty between UC San Diego and UC Irvine. A lot of what we use is optical networks to enable that kind of collaboration at a distance.

In addition, many of our projects have international partners, among them Brazil. As an example, we put together a public-private partnership in the emergence of digital cinema. We had about 100 years of movies on film, and in the last ten years, it has all gone digital. Now, in fact, the companies that made film, such Kodak, are out of business. So, we pulled together the Hollywood studios and the universities that study cinema in a partnership we called CineGrid. Since the beginning, however, we made it an international project, including universities around the world. We put on a digital movie demonstration in Sao Paulo, Brazil, and it was premiered globally with an audience in San Diego and in Japan. It was the first tri--continent premiere of a movie over digital networks.

This notion that we live in a global innovation technology is important. We have to find ways to establish partnerships not only across our own campuses, out into the community, into industry, but also globally. Almost every large scale project CalIT2 is involved in now has international partners. This is the future.

## Q - WHEN YOU LOOK OUTSIDE THE US, ESPECIALLY TO EMERGING MARKETS, WHAT KIND OF COUNTRIES DO YOU THINK ARE WORKING WELL ON INNOVATION, SPECIFICALLY ON LIFE SCIENCES, AND WHY?

## KRISTIINA VUORI:

Very broadly, although my knowledge base is North America and Europe, I think the places where support for innovation works best is where the government understands its main role as a catalyst of innovation. Once it becomes beyond something that is a catalytic activity, it is very difficult by government resources only, to sustain innovation. There have to be other partners and participants in the process, including risk-taking in moving discoveries forward. I think Europe has done this very well, but it has been a thought process with many governments

coming together within the context of EU. Brazil is probably a country that is large enough to catalyze things on their own but, again, the question is what are the national priorities?

## Q - I HAVE A QUESTION FOR LARRY SMARR ABOUT CALIT2 AND BROADBAND NETWORKS. PRESIDENT DILMA ROUSSEFF OF BRAZIL HAS RECENTLY TALKED ABOUT ITS DESIRE FOR BROAD BAND CONNECTIONS, BUT FROM WHAT I UNDERSTAND; BRAZIL IS VERY ISOLATED FROM THE EXISTING NETWORK YOU MENTIONED EARLIER. CAN YOU EXPLAIN FURTHER?

## LARRY SMARR:

What I discussed earlier were optical networks that are dedicated to large data, not the shared Internet. In fact, the largest source of Tweets comes from Indonesia. The shared Internet is much more pervasive. But at the research level, being able to work at approximately 1,000 times the bandwidth is what I was referring to in terms of optical networks. Because these are international networks, you must have both countries on board in order for it to work. Essentially any country can participate, but they have to have a national desire to link into this big data research activity. There are no connections into Africa. That is changing because of the square kilometer array telescope, which will be partly in Australia and partly in South Africa and other Southern African Countries. Brazil has been the best Latin America country in getting involved with this optical network. I have worked for seven years to try to get the very first link into Mexico and it just recently happened, whereas Brazil has been there for a number of years. I see Brazil as one of the international leaders in understanding the importance of your researchers being able to have access to big data wherever it is generated in the world and to whatever collaborators they need, whenever they need to do it. I just encourage you to continue that leadership.

## LARRY GOLDSTEIN:

Historically, the Internet itself began as a very specialized defense, computer science, and research business, and then it became harnessed for all these other uses. One would speculate that over the course of the next five to 20 years, someone will discover a new innovative use for this kind of big data flow that we have not anticipated, and it will be socially driven.

## LARRY SMARR:

In Japan, for instance, there is somewhere between 12 and 15 million homes that have this optical fiber directly in the home, which means that they are capable of a billion bits per second, whereas most homes in America are fortunate to get more than a few million bits per second. Google, you may know, in Kansas City, has put this kind of optical fiber into all the homes so that we can begin to see this next level of innovation.

## CHARLES SHAPIRO:

I would like to follow up to your comment about optical networks. You mentioned that the country on the other side must be willing to join the network. Do you mean the government, or the research institutions, businesses, etc.?

## LARRY SMARR:

It is led by the researchers who want to join as peers in this international set of researchers, but it is typically the government that funds the optical network connection. So, if, for example, it were to come between Brazil and the U.S., Brazil would fund half and the U.S. would fund the other half of the cost of the submarine cable.

# Brazil-U.S. Cooperation in Innovation: Synthetic Biology, The New Frontier for Innovation: From Fighting Malaria to Producing the Second Generation of Biofuels

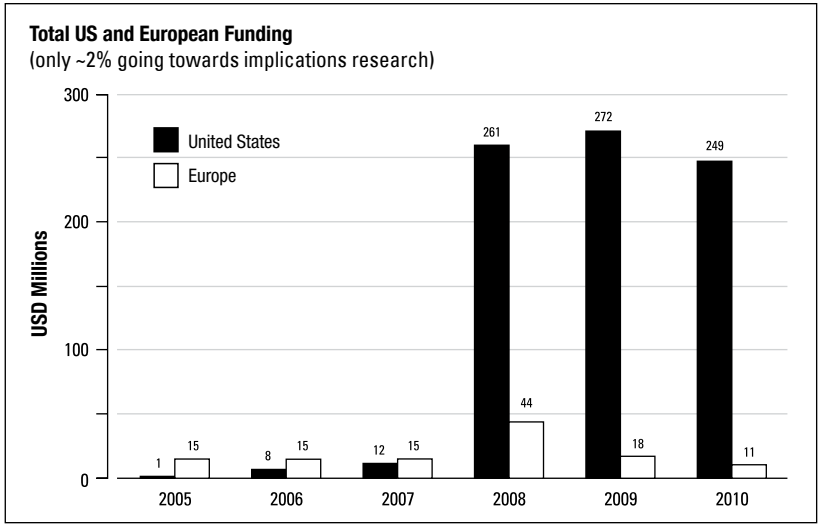
**TODD KUIKEN**

*Research Associate, Project on Emerging Nanotechnologies*

What is "synthetic biology"? That's an emerging form of bio-engineering, the design and construction of new biological parts, devices, or systems. You can think of synthetic biology as an outgrowth of genetic engineering, where you're able now to create synthetically DNA strands, take different components of DNA strands, and put them together in different ways to do certain things within a living cell. The basic tenet is that it combines science and engineering in order to design and build novel biological functions and systems. This grew out of the engineering field. A lot of the first pioneers in this field weren't biologists; they were actually computer engineers that looked at the biological systems and said, "Wow, this really operates pretty much like a computer system, and we think we can redesign these things based on those ideas."

Jay Keasling, one of the leading pioneers in the field of synthetic biology, gives a good explanation of what they're doing. He said, "My idea of synthetic biology is that it's the industrialization of biotechnology. It's doing for biology and biotechnology what other engineering disciplines have done for other fields: the development of standardized components that are well characterized, that can be assembled and put together to make a device that will accomplish some particular task… Biotechnology, as it's been practiced, has been a series of one-offs. If you look at every kind of new project that comes up in synthetic biology, they tend to be one-offs in that. We don't have standardized components that come out of that, that can be used for the next project. As a result, biotechnology is still a very expensive discipline to work in. It takes a lot of person power to do biotechnology. We have to navigate the patent landscape because biotechnology grew out of primarily the pharmaceutical industry where you patent, hold those patents exclusively, and don't share them; that isn't necessarily conducive to the kinds of sharing that we want to have. Even some of the smallest most trivial but most useful components are patented, which means that they can't be used in important applications like producing a low-cost biofuel or a low-cost drug for the developing world."

Last year, we wanted to see how much the U.S. government was actually spending from a research standpoint in the field of synthetic biology [see graph].



We went back through 2005. In 2008 the numbers jumped up pretty rapidly. Those are up to about $260 million a year that they were spending on R&D. Most of that money was actually coming from our Department of Energy, and the money was going directly into biofuels research. What was interesting, however, was that a small portion of that and only about two percent of the total was actually going into "implications research" – the environmental implications of what could potentially happen using these technologies and the social implications of what these new emerging technologies would produce.

My work at the Synthetic Biology Project at the Wilson Center involves tracking industries, universities, and other actors, such as companies that have also ventured into this field. You could say they fall into a few different categories. One of the majority ones is biofuels; the other is in DNA sequencing, which is what enabled synthetic biology to emerge, so as the costs of sequencing DNA has dropped rapidly. Another interesting note is that Monsanto, which is an agriculture company, has recently provided funding into this field as well, looking into whether or not their fertilizers and seeds can be developed using this technique.

In May 2010, Craig Venter's lab announced that they had made a bacterium that has an artificial genome, basically creating a living creature with no ancestor. This story was on the cover of The Economist, which pointed out that computers and humans are now representing God. The question is not whether or not they actually created new life; most people would say they didn't. What they did was absolutely extraordinary. For the first time, they synthetically created an entire DNA sequence. They took that sequence and inserted it into a bacterial cell. That cell then took in the new code from that DNA and started to replicate itself. So you can almost think of this as a artificial insemination, where they took the code of life, inserted it into a house and then that bacterial cell took that new DNA, started replicating, and created the new form that they had sequenced. It's an extraordinary feat. It's going to have major implications to the field.

I think the press and others were confused by the idea that they created a brand new life form, which is not exactly what they did. Based on that, the U.S. president created a bioethics commission that looks at a vast array of ethical issues. When Venter had made his announcement, he formed his bioethics commission to look directly at synthetic biology. They had about a six-month time span to come up with recommendations for the president on this new emerging field of synthetic biology. I want to focus

on a few of these: risk assessment review and field release gap analysis, monitoring containment, and risk assessments. These are important because we're starting to deal with biological entities. They may be synthetically created, but figuring out what happens to these once they're put out into the environment is going to be an important aspect as this field develops.

Some of the other issues that the commission recommended was that there be an international coordination and dialogue as this field grows. Ethics education, which we're looking at as well, is an interesting issue. One of the things that we're doing is trying to figure out how you change the curriculum in an engineering discipline to start thinking about the ethical issues involved in synthetic biology if you actually are creating or redesigning living organisms. The engineering field itself has an ethics course, but it doesn't really involve anything associated with the issues associated with biology.

Two years ago, we put out a report looking at the ethical issues of synthetic biology and concluded that there definitely will be some ethical concerns that arise with synthetic biology. They can be divided into two categories: physical harms and nonphysical harms. Physical harms are your environmental harms, health safety harms, and security harms; and the nonphysical harms are your moral and social concerns -- within that you can take a precautionary approach or the precautionary principle approach, however you want to define that, or a more proactionary approach, in whether you go after these issues beforehand or as the technology is developing.

What do we mean with these nonphysical harms? We asked a few questions that we think get raised in this issue, and one is: How do you distribute the tools that are needed to do synthetic biology? Do you need to distribute the technology across the world to countries that may not have the resources to do this technology right away? How do you distribute the benefits? Who's going to get the benefits of some of these technologies as they develop? Do you take a model, as Amyris did, where they're in a sense giving away the technology in the form of malarial drugs to the developing world, or do you patent everything so you can keep all of the money within the country or the company that developed the actual technology?

What's the appropriate attitude to adopt from us and to the rest of the world? What are the benefits that I get from this technology, and what are the benefits to the larger society? We run a bunch of focus groups looking at the issues of synthetic biology, and we ask people what's their reaction

to these technologies. What's interesting is when you ask them if they are comfortable with this technology in general, they're a little reluctant. But when you dive a little deeper and ask, "How would you feel if I told you that this technology had the potential to cure a specific disease such as cancer?" They become a lot more comfortable with the technology.

This gets into this issue of "what's the benefit to me, and what's the benefit to the rest of the natural world?" Then you have moral and religious concerns. When we start talking about creating new life or redesigning what's already out there, it definitely raises some of these moral and religious concerns. What I found interesting from the Craig Venter announcement was that the religious community in a sense took a very passive role on it and didn't find that many objections to it. Now that may change as more of this develops and you actually start seeing more synthetic life forms being created, but we're going to have to wait and see how that develops.

Some of the physical harms are largely safety and security questions, regarding the environmental health of what happens with synthetic organisms and their interactions with the natural environment. What's the [effect of this on] human health? What's the exposure to humans to these new synthetic organisms that are out there? Then you have biosecurity concerns that this technology could get into a rogue hand and they could recreate, say, an Ebola virus synthetically, or they could recreate an anthrax virus. These are all concerns that have to be addressed as the technology is developing.

I want to go a little bit deeper into the environmental implications. I'm an environmental scientist by training, so that's my area of concern mostly. One of the things we've found is that the ecological risk assessments are lacking from the synthetic biology standpoint. What do I mean by an ecological risk assessment? What are the implications of what will happen if these organisms are intentionally released or they're accidentally released? The applications of synthetic biology are far and wide, so you have to assume that a lot of these organisms are going to escape. What does that mean when they get out into the natural environment? Are they going to interact with the natural organisms that they're loosely based on? Will those organisms uptake the new DNA sequences that have been inserted into these organisms? What you hear a lot from some of the practitioners is that they've designed in what they call "kill switches." This means that

the organism has been designed to basically self-destruct once it's out of the environment that it was specifically created to live in.

This was done for two reasons. One was for the environmental implications so these things would self-destruct if they got out into the natural environment. The other is from an actual intellectual property standpoint. If you're thinking about biofuels, for instance, and you're growing up these algae in a tank; then someone just comes in, and scoops out a cup of it. They can bring it back and grow it out themselves. In essence, these are supposed to kill themselves if that were to happen. There's some concern with that because synthetic biology is different from an environmental standpoint. If you look at it from a synthetic chemistry standpoint, where we've had fertilizers and pesticides, when chemicals get out or there's a chemical spill, you can get that back because there's something you can actually take out of the water or take out of the air. What we're talking about now are actual biological organisms, and what I think history has shown us is that biological organisms tend to try to live on. They don't really want to die. Despite our best efforts to control or kill them, we're not very good at it. So it's something that has to be looked at pretty closely when you're talking about a biological organism that has the potential to escape, then enter into the natural world, and interact with other organisms.

There are a lot of ideas out there on synthetic biology, and they're not all positive. I will mention two reports: "Synthetic Solutions to the Climate Crisis: The Dangers of Synthetics Biology for Biofuels Production" from Friends of the Earth, and "The New Biomassters: Synthetic Biology and the Next Assault on Biodiversity and Livelihoods" from the Et Cetera Group. While these tend to be some of the more radical environmental groups, they actually raise some interesting ideas and concerns about synthetic biology, particularly in the realm of biofuels and using synthetic biology techniques to develop new medicines. They're concerned about land grab issues. What does it mean if we're now going to move from big oil to big agriculture? Are you going to displace farmers using these new techniques? Are you going to put other people out of work using this new technology? I wanted to put this out there so people are aware that there are other ideas and they're not all positive, and that these groups can tend to have a lot of traction.

They can derail an entire industry, an entire technology, if the public rejects it. If you look back at what happened with the genetically modified organisms debate, GMO foods and crops, a lot of that had to do with these

two organizations that convinced the public, particularly in Europe, to reject the technology. It had a huge economic impact to the U.S. farmers because they can't sell their crops in Europe, for instance. So the public and society have a big part in these new emerging technologies in whether or not they accept them. A technology can have great potential benefits, but if the public rejects it, it's worthless.

I want to move into the DIYbio movement because it's an interesting phenomenon that is growing at the same time that synthetic biology has. This is a group that was founded about two or three years ago to help organize the efforts of amateur biologists, citizen scientists, and other non-traditional practitioners of biology worldwide. On their website, you can see a map of some of the various groups. Basically they're beginning to adopt different practices like genome sequencing and biological engineering that were once only accessible in an institutional setting. A lot of this has to do with the drop in price of DNA sequencing, which has enabled people other than Ph.D. students to enter into this field. For instance, in 2008 there were two members, the two founders of this group. Two years later, there are over 2,000 people that are on their lists, calling themselves amateur or citizen scientists. There's 20 various regional groups. These are all across the world. I believe there are two located in Brazil.

Another phenomenon that's developed out of this are what are called community laboratories. The first one, a fully functioning biotechnology laboratory called Genspace, recently opened in Brooklyn in December. You can think of this almost as a gym membership where you pay a monthly fee, and you can go to this space that has various different lab equipment and run your own experiments outside of a traditional university or corporate laboratory. A woman in Boston basically sequenced her own DNA in her closet in her house to figure out if she had this promoter that was going to express this potential disease that ran in her family. You have other people that are working on engineering yogurt bacteria to tell you if you have a contaminant in your yogurt. And there is a startup company created by two Ph.D. students at the University of Michigan. They've raised money on a site called KickStarter, which is basically a crowdsourcing technique of raising money, and now send out biotechnology kits to high schools that don't have that curriculum in their high school to get them more inspired to work into this field.

As you can imagine, there's some pretty significant biosafety and biosecurity concerns with this movement. At the Wilson Center, we are par-

tnered up with DIYbio to try to put together information and set some standards for this movement so they can do these things safely. A lot of the people that are involved in this aren't trained biologists; they're not trained in lab practice; and they may not know what it is that they're actually making or throwing out when they're finished with it.

I want to end my presentation with the iGEM competition, which is the International Genetically Engineered Machine competition. This started at MIT in 2004, I believe, and basically these are undergraduate student teams that are given a kit of biological parts at the beginning of the summer. The biological parts are those pieces of DNA that we were talking about before that you can put together in different ways to make things do things, or make them do different things. They work at their schools over the summer and design new parts to build biological systems, then operate these within living cells. In 2004 there were five teams from five schools, and it was only located in the U.S. Six years later, there was 130 teams that were represented on all the continents across the globe. I'm a judge at iGEM. I judge the environmental health and safety aspects of all of the teams' projects.

The 2009 Brazil team that was there won a gold award for their project. It's important for them to be able to get funding because you're growing your future scientists in this new field of synthetic biology. Already from this competition, there has been at least two companies that have formed directly as a result of these undergraduate teams' work. They do all of the work themselves over about a three-month period. So I just wanted to leave you with that. This was in 2009. They didn't have a team in 2010, but this year they do, Brazil does have another team from the same university. They've actually partnered with a university in France. It will be interesting to see what develops out of two different countries from two different parts of the world. This competition is a way that you can grow from your own countries new scientists that can then go back into industries or into the university system and teach science again. It's something that you can look at. It's an easy thing to fund. These projects don't cost that much money, and I think have enormous returns in the future.

# The Leading Edge of Synthetic Biology in Brazil

**JOEL VELASCO**
*Senior Vice-President, Amyris*

Amyris is a renewable products company that is applying its industrial synthetic biology technology platform to provide sustainable alternatives to select petroleum-sourced products used in specialty chemical and transportation fuel markets worldwide. The Company engineers microorganisms, primarily yeast, and use them as living factories in established fermentation processes to convert plant-sourced sugars into potentially thousands of molecules. Put it simply, Amyris engineered the same yeast used to convert sugarcane into ethanol in Brazil to produce more value-add hydrocarbon molecules. It has chosen to focus its production in Brazil – primarily São Paulo – because of the country's leading edge position as a major producer of renewable and sustainable feedstock as well as it openness for innovative bioenergy technologies.

## ADDRESSING MALARIA

While Amyris commercial focus is to develop renewable fuels and chemicals, its first breakthrough of innovation came in 2005 through the development of a technology to produce Artemisinic Acid, a precursor of Artemisinin, an anti-malarial therapeutic. Artemisinin is part of a highly effective treatment for malaria patients. Patients take the artemisinin-based combination therapy, or ACTs, after they have been infected with malaria. Malaria is a preventable, curable disease that claims the lives of more than a

million people a year. In Africa alone, malaria causes 20% of all childhood deaths, killing 2,000 children every day.

Unlike a vaccine that is possibly years away, artemisinin is available today albeit not in quantities needed. The uncertainty in supplies of artemisinin, which until now has been derived from a plant-based source, artemisia annua, creates a significant public health crisis as millions are infected with malaria every year.

Recognizing this challenge, the Bill & Melinda Gates Foundation provided Amyris with a grant to leverage synthetic biology to convert plant--sugars, like those found in sugarcane, into a semi-synthetic version of artemisinin that could alleviate ACT manufacturers dependency on plant material and exposure to the associated vagaries of the growing season. In 2008, with the technology proven to work in the lab, Amyris entered into an agreement to license our artemisinic acid-producing yeast strains to Sanofi-Aventis on a royalty free basis for the purpose of manufacturing and commercializing artemisinin-based drugs for the treatment of malaria.

With the technology proven and our shared commitment with our partners to ensure that the malaria drug will be available to all who need it, Amyris had turned its focus to the production of renewable chemicals and fuels. Amyris is now applying inspired science to reduce the world's dependency on fossil fuels.

## SUSTAINABILITY = PERFORMANCE

Before Amyris, choosing a sustainable product required customers to make tradeoffs. More often than not, they compromised on performance. Levering its industrial synthetic biology platform, Amyris is optimized to deliver high performance solutions to those who seek sustainable alternatives to petroleum sources fuels and chemicals.

Amyris's first commercial focus has been in the production of farnesene. Why farnesene? Because farnesene is a 15 carbon molecule that, with minor modifications, can be flexibly adapted to serve as an alternative to fossil fuel-derived products across a number of markets. Biofene®, Amyris--brand of renewable farnesene, can be used as-is or modified to provide other renewable ingredients for the six markets upon which the Company is focusing: cosmetics, flavors and fragrances, industrial lubricants, plastics and polymers, consumer product goods and transportation fuels like diesel and jet.

Another attractive aspect of Amyris' renewable farnesene is that we can use sugarcane as a feedstock. While Amyris's platform can work with a variety of plant-sugars, the Company is focused on Brazilian sugarcane for our production efforts because of its abundance, low cost and relatively price stability. Sugarcane is the most photosynthetic efficient plant to convert sunlight, carbon and water into stored energy in the form of sugars. And finally, of course, renewable hydrocarbons provide a number of compelling advantages when compared with fossil fuels. It's biodegradable. It doesn't yield sulfur and it has significantly lower emissions than petroleum. Best of all, unlike the world's finite supply of fossil fuels, we are making renewable products from sustainable produced feedstock.

## MAKING IT HAPPEN

Amyris produces renewable hydrocarbosn by applying its proprietary industrial synthetic biology platform to genetically modify microorganism – primarily yeast – to function as living factories. After the sugar source is extracted from the sugarcane at a traditional mill, Amyris employs fermentation process that used the engineered yeast strain to convert the sugar into the target molecules – currently farnesene but eventually other hydrocarbons like isoprene.

Over the last few years, Amyris has made remarkable progress both in terms of technologies to address some of the world's challenges. The Company is currently producing at three sites in three continents. Two industrial scale sites are currently under construction in Brazil, where about a quarter of Amyris's staff and its state-of-the-art demonstration plant is located. In the coming years, the Company expects to continue its accelerated growth and innovation both in the United States and Brazil.

In a world of finite resources, we need to solve problems with solutions that are both renewable and sustainable. Amyris is committed to that challenge with solutions that don't compromise on performance, affordability and availability.

# Brazil-U.S. Collaboration: A Private Sector Perspective

**CHAD EVANS**
*Senior Vice President, Council on Competitiveness*

The Council on Competitiveness has a fairly long-standing relationship with Brazil with a couple of key partners that I'll talk about. We're a non-profit, non-partisan think tank in Washington, D.C. Our mission is very simple: the advocacy of policies and activities that promotes growth in U.S. productivity, growth in the standard of living for the average American, and the success of U.S. goods and services in the global market place.

In 2004 we were visited by Jorge Gerdau, founding chairman of a very similar organization to our own Competitiveness Council. He challenged us to think about how we could partner with MBC (Movimento Brasil Competitivo) in developing a series of engagements. The purpose of those engagements would be to deepen the bilateral innovation relationship between the two countries. In 2005 and 2006, we began a deep collaboration, participating in MBC's annual meetings. In 2007 we hosted, not only with MBC but also with ABDI (Agência Brasileira de Desenvolvimento Industrial), the world's first U.S.-Brazil Innovation Summit, which took place in Brasília. We brought a delegation of around 50 U.S. CEO's and university presidents to an event that Gerdau hosted. For all intents and purposes, it was a success from our perspective in raising the visibility of the important role that innovation plays in both of our societies. That first summit also led to a call to action that was endorsed by then Presidents Lula and Bush. That supported our contention that we needed another innovation

summit, hosted by President Jack DeGioia at Georgetown University this past September. Between those two summits, we wanted to create a more engaging conversation and dialogue among innovation stakeholders. We decided to create something new: the Innovation Learning Laboratories.

Innovation Learning Laboratories are multi-day workshops that take place both in Brazil and the United States. The purpose of which is two--fold: first of all, to focus on policy alignment between the innovation economies in both of our countries. More importantly, the second purpose is we, along with MBC and ABDI, are trying to catalyze concrete world partnerships between businesses in both countries; between universities; between businesses and universities; public and private. That has been our goal between 2008 and 2011. We've actually hosted 11 of these learning laboratories in both countries.

I want to describe the process of the Innovation Learning Lab. We kicked off in Washington, D.C. in 2008 and in Brasília in August of 2008. From there, we moved to Porto Alegre in 2009, Chicago, Research Triangle Park in North Carolina, São Paulo, Silicon Valley, Rio de Janeiro, and Golden, Colorado. We've just held our last Innovation Learning Lab in Phoenix at Arizona State University this past February. Each of these 11 Innovation Learning Labs is a multi-day workshop involving 30 to 50 people from both economies. Its purpose is to spend time together in a moderated conversation, to drive towards catalyzing these new partnerships. I just want to give you a sense of the scale of the conversation because it is about increasing innovation: we're dealing with issues, the entire spectrum of innovation from the actual innovative thought and idea, the ideation, through the development of technology, the development of product and processes. How do you get that innovation into the market place? And how do you scale that innovation into large, viable, sustainable businesses?

In dealing with all of those issues, we're looking at research and development; the role that intellectual property plays in driving entrepreneurial innovative activity; the policy environment; the regulatory environment; the administrative environment that is necessary for an innovation ecosystem to function. Out of these laboratories and these sets of issues, a series of concrete deliverables have come out. There are so many business-to--business opportunities that have developed, but also some larger systemic partnerships that I want to give some attention to.

One of the initial ideas that came out in early 2009 led by CEMIG, the utility company in Belo Horizonte, was the desire to create a sister

city demonstration product in Smart Grid technology. We're very close to identifying the community in the United States that will be the sister city project. I think it will be Richland, Washington. What we've done with CEMIG is to identify a community of about 40 to 50,000 people in Brazil-- outside of Belo Horizonte -- a similar size community in the United States. The Sister City Smart Grid Demonstration Project is all about co-investment between the two sister city projects. It's about research exchange, people exchange, and it's about multi-sector. We're looking to not only bring in the utilities but universities and startup companies that want to be involved in this. The MBC, the Council on Competitiveness, and ABDI play a catalyst role, to try to trigger these sorts of partnerships.

Another example that's taking place in Porto Alegre is that of co-incubation. This is an effort to drive entrepreneurial innovative business development in both countries. The incubator in Porto Alegre will attract, mentor, and help small and medium size U.S. entrepreneurs who want to create a business in Brazil and vice versa. Arizona State is going to attract 10 to 12 Brazilian startup companies that want to launch in the United States but need help with business plan development and marketing. This is what we like to think of as a win-win situation for both economies. We're looking to expand that global co-incubation model to other universities in both countries.

There have been a couple other ideas that have come out: a clean-tech open concept where we would think about how you can acknowledge and reward startup entrepreneurial innovative companies in the clean tech, energy space. There are many more of these opportunities. I think what is interesting about all of the work from the two summits -- and the 11 laboratories that have spanned between the two summits -- is that we've really tried to engage a series of leaders on five mega opportunities. The first of which is this nexus of energy and water. We've posed a very simple question to all of our laboratory participants. How will our two countries together innovate to meet the growing demand for global energy? We know that in the next two decades global energy demand will increase by 50 percent. Of that growth and demand, 80 percent will take place in non-OECD countries. Brazil and the United States have a leading role to play in addressing that demand.

The second big question that we've asked all of our stakeholders and our network in both countries to address is that of food. Our two countries alone will have to help solve the issue of feeding the world when global

food demand doubles in 50 years. How will we do that? There are no two countries that are better poised to help solve that global grand challenge.

A third issue that we're all addressing together in this larger network is how our two countries will build the smartest, the most resilient, the most sustainable infrastructures for a 21st century innovation economy. The panel that was before us talked about one of those types of infrastructures in IT and cellular communications. But it's more than just physical infrastructure; this is also policy infrastructure. How do we ensure that we have the most agile, flexible, responsive innovation ecosystem that will attract and mentor and help innovators prosper?

A fourth question is how will our leaders come together to ensure that we have a culture of creativity, collaboration, mutual innovation, and entrepreneurship. Then, finally, the fifth major opportunity where we're working is this nexus of manufacturing and services: that coming together of the manufactured product and the ecosystem of services that adds value to that product, which will lead to new industry growth and new jobs in the 21st century. How can our countries understand that?

This leads me to where we are going from here. Our next lab will be November 18, 2011 in Porto Alegre. What will be particularly special about this event is we will be inviting the competitiveness councils from 40 other countries to come to Porto Alegre at the same time. It will be a real opportunity for the MBC, ABDI, and Council on Competitiveness partnership to shine. It will also be an opportunity to expose innovators from around the world to the capabilities that Brazil has in this innovation economy. Also, I'm hoping to have some best practices or guidelines on intellectual property. One of our goals this year is to do a series of global case studies that would point out best practices that could be shared and adopted in multiple countries.

On the patenting and the globalization of benefits from innovative technologies, I would note that from the perspective of the members of the Council on Competitiveness, the crown jewel for the innovative activity is the patent. Without that patent, you will not see the type of investment that is necessary to develop and scale that innovation for a large market size. Patent breaking tends to completely take away the incentive to invest in that sort of scaling. You wouldn't actually see any global sharing of the best products or the best service. I think that's a very serious concern that I know many of our members have, and this is a very frank ongoing conversation that we've had in Brazil. We hosted our first U.S.-Brazil summit

in June of 2007. Merck's HIV drug patent was broken in Brazil in May that year. The initial co-chair for our U.S. side for the Innovation Summit was the CEO of Merck. He did not come to the summit in June. Obviously, it was one month after that happened, so there was friction. But we made the decision to continue with the Innovation Summit.

It's also important to put this in a global context. Obviously, I think the United States and Brazil are the most important, but let's look at a country like China, which, five years ago, anyone would have said is a most egregious violator of intellectual property rights, which is probably still true today. But we are seeing a massive transformation take place in China with the emergence of innovative firms that are demanding respect for intellectual property, which will be driving global markets going forward. So the U.S.-Brazil debate is important, but the U.S.-Brazil debate has to take place in a global reality. We can both be left behind very quickly by China, Indonesia, Vietnam, or South Africa. In 1986 when our Council started, it was the U.S. response to Japan. There are now dozens of global competitors to the United States, or to Brazil.

Finally, we will have more summits. We were particularly gratified when President Obama met with President Rousseff just a month ago. In their final joint statement, they recognized the power of the innovation summits. They explicitly called out for more. We're hoping -- and we will be working with both administrations -- to plan for the next innovation summit in Brazil in 2012 with Gerdau, MBC, and ABDI.

# Addressing the Innovation Imperative and the Challenges of Early-Stage Financing

**CHARLES WESSNER**
*Director, Program on Technology, Innovation and Entrepreneurship*

I'm very honored to have the privilege of speaking to such a distinguished group. I am, in fact, very encouraged that you're here because one of the themes of my talk is the importance of Brazilian and U.S. interaction. There's also another premise of my talk: we have things to learn from each other. I want to stress that we in the United States have things to learn.

I am speaking in a personal capacity, not on behalf of the Center or on behalf of the National Academies.

One of the things that we have a problem with in the United States is that your colleagues [American congressmen] are extremely complacent. I once asked a senior senator, when we were talking about innovation policy, what his colleagues thought. Where did they think our innovation strength came from? This is a very intelligent man. He paused and said, "Well, I think they think it's divinely ordained that we should have a lead in technology. And they've forgotten what their fathers did."

Now, your challenge, according to your colleagues, whom I have spoken with recently in Brasilia, is that you've got a really hard task here. Why is it hard? Well, it's because you're doing well. I was just in Ottawa a week ago, and the Canadians were saying, "We have a really tough task here. The more oil we export, the harder it gets to maintain a diversified,

innovative economy." One of the questions the Canadians had was, "Are we doing as well as Saudi Arabia?" Hear this: "Are we doing as well as Saudi Arabia in capturing the value of the whole chain from the petroleum industry?" Now, I think you guys do actually better than Canada on that. But the question is: how do you do well enough?

Another premise of my talk is that nobody has a lock. No one fully understands how innovation works. There is a distinguished professor, Richard Nelson, who calls innovation the "black box of economics." There's also a cartoon I wanted to put up, where they have a guy who does a whole series of equations, and then he has a passage where a miracle occurs. That somehow is often what we talk about for innovation policy. We don't really fully understand the creative genius.

Also, in Washington, many people don't pay much attention to the innovation ecosystem. We like to call it an "innovation ecosystem" because when you talk to my colleagues at the National Academy of Engineering, when you say an "innovation system," they think it's a series of pieces, like a bridge. Each piece goes there, and if you put it together, it works. Whereas a better analogy is a garden, where changing temperatures, changing sunlight, changing fertilizer, and watering gives you different options. It's a much more dynamic model. In fact, Brazil is a good illustration of a dynamic model.

I used to work at the Treasury; and we knew that you would fail with Embraer. Actually, we also knew that Airbus would fail. The fact that you have not failed with Embraer, I think, is a powerful statement of the importance of not necessarily listening to the advice of the conventional, orthodox Washington economists.

Yes, you subsidized, but, the last I checked, we sometimes subsidize Boeing a little bit. In fact, we have actually grown our economy by very close public-private interaction, particularly in the early stages.

Now, one of the good things about our system is we know when to let go. We're not running the Internet. We let entrepreneurs do those applications. But we're pretty good at doing some of the early work and then letting the private sector take it up.

There is also serious work by Vernon Ruttan, a leading economist who, alas, is no longer with us, who argues that there is no major export sector in the U.S. economy that has not had major government support. Now, that doesn't mean that every tiny-minded trade barrier makes sense for

Brazil anymore than for us, but that the hand of the government is often there.

So let me get to my actual talk. I will talk about both U.S. and Brazilian innovation strategy, some of the myths that block our process, and some challenges we have with the "Valley of Death" – a concept that is very important to understand.

One reason we're glad you're here is because we have a lot in common; one of them is common global mega-challenges. If we're going to drive growth and employment -- which you all need to be reelected and you need for your people -- if we're going to have alternatives to oil, where you've already done very well, we need innovation. We need innovation to have a greener economy. And we need innovation for global health and for national security. That is what we call the "innovation imperative." The best definition I've ever heard of innovation is that "research converts money into knowledge, and innovation converts knowledge back into money." This is something that we sometimes forget in the U.S. and is often forgotten within our universities.

We need innovation to grow in your competitive position in addressing these global challenges. Collaboration is a key part of that. One of my main messages to you when you're dealing with your institutions at home is it is very important not to lecture them. It is very important not to tell university professors to behave differently. You have to provide them incentives to behave differently. As many CEOs in the United States have pointed out, be careful what you measure because that's what people will do.

What are the leading nations around the world doing? One is high--level focus on innovation. Another is sustained support for R&D. Support for innovation, small, and medium-sized enterprises, and partnerships between the public and the private sector.

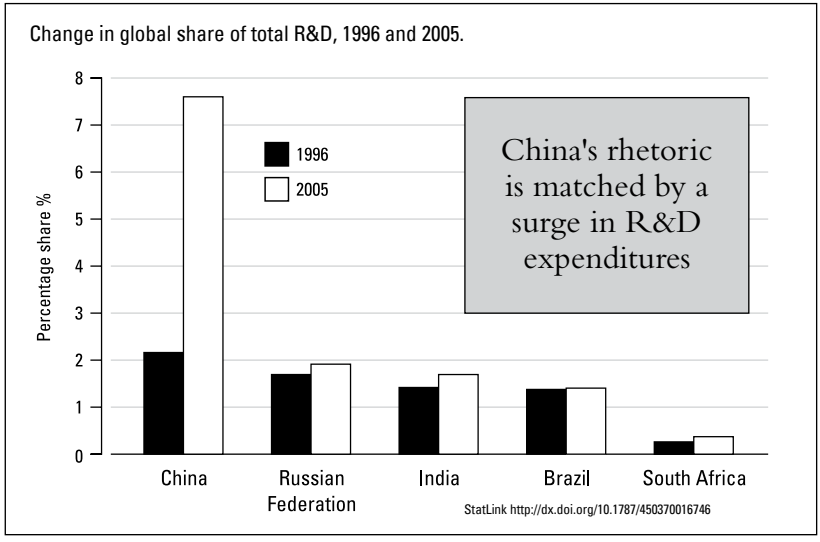
International cooperation is very real. You should also not lose sight of the fact that it's a tough world. There are many countries that are competing just as hard as they can with you. There's a great line in a wonderful play that someone says, "That's not fair." And the rejoinder throughout the whole play is, "Who said anything about fair?"

China gives us a lesson in many ways. I like to kid Americans that they seem to be cheating. How are they cheating? Well, they keep sending their children to school. They keep investing in universities. They keep building universities. They keep buying equipment for universities. And they keep training their kids as best they can. When I was out in Washington state,

I suggested that they might set up a new university. I was with a distinguished group of leaders. They looked at me like I was out of my mind. Yes, our fathers set up universities. Why would we set up universities? Our fathers built the innovation system that we have. Why do we do that? I mean, a case in point, we canceled a new tunnel into New York City. Why? Because it's too expensive and times are hard. When was the Holland Tunnel Built? That was during the Depression, when the economy was falling apart, the Nazis were running over Europe, and your other alternative was your friend's a Communist. You know, times were hard then, too. And so we built the Holland Tunnel. We built the Golden Gate Bridge.

Today, the countries that are going to win the future are focused, committed, and willing to spend. China is not just talking about it. Someone should show China's expenditure to the Parliamentarians from Brazil [see graph].

It's not just China. There is a huge surge from Asia collectively. By the way, it's a good thing. More money into research is a good thing. It's not clear that these inputs will necessarily give you innovation and inventions, but it does reflect their commitment to innovation, their commitment to investing in the future. How are you doing in the innovation imperative? Well, you have new investments, new institutions, and a new focus on science, technology, and innovation. On one level, I can only congratulate



you. You have a strategy; you're consciously trying to work on your national innovation system. You are promoting innovation and enterprises. You are providing some incentives for startups. You have - along with the rest of the world - been focusing on bio, nano, and health. And you recognize the major social benefits that are involved there.

When I was last in Rio, I was stunned by the growth of technology schools and the number of master's degrees. You're expanding out to the world intellectual stage in a very rapid fashion. This three-fold expansion is really quite impressive.

You also have - and I think it's very important for you to understand - a really high-quality innovation agency. I don't say this lightly; I don't know the new president of FINEP, but I can tell you that the last one had an international, global grasp of innovation policy. Having institutions like that is really important. Funding them is really important. And I was encouraged to hear that you have maintained the funding for FINEP. But remember: our Chinese colleagues are not just maintaining funding; they're increasing it. I'd like to talk a little bit about how you might do that.

The good news is the positive trend for your R&D investment, but there is also relatively bad news [see graph].

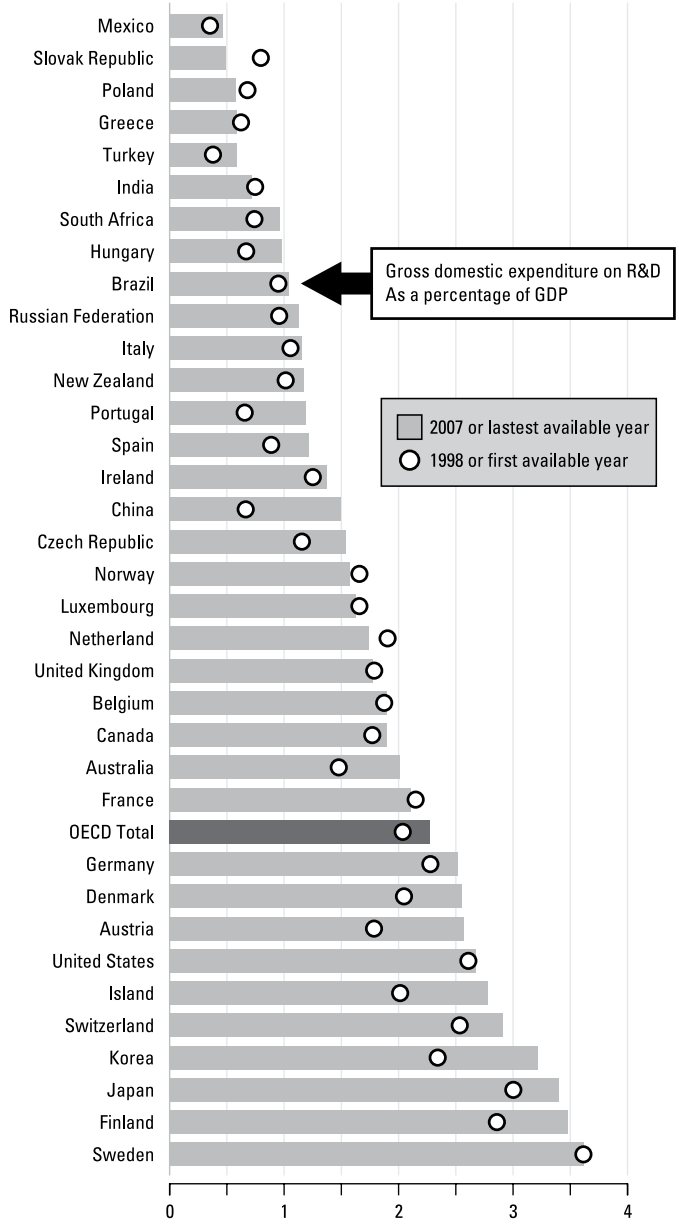
Brazil is not actually in the head of the pack. You're ahead of Mexico. But is that where you want to be? I think it's important to look at these things. And remember, these are just aggregate figures. This is not saying what are you getting out of it. I'm not saying that you should just distribute R&D all across all the universities throughout Brazil. One of the things our German colleagues and our French colleagues are wrestling with is: how do you concentrate resources to develop schools of excellence?

We have in the U.S. about 3,200 (3,600, depending how you want to count) institutions of higher learning. But only about 200 of those are really research universities. Probably only about 120 to 150 are top-quality schools. That push towards excellence is something that is worth discussing.

During our trip to Brazil we visited Minas Gerais, and we were very impressed with the system that they have in that state, impressed enough to invite State Secretary Portugal to come up here and talk to a major National Academies meeting.

What do you need to do? You've got to continue to work on strengthening the policy framework. A point that is very important is some of the cultural attitudes. We are more tolerant of risk; we're more tolerant of

The (Relatively) bad news. Brazil's position in the OECD R&D comparison.




OECD Factbook 2009: Economic, Environmental and Social Statistics

failure with a small company, but it's not in the genes. There's an old joke, but a good one: Do you know the secret to Silicon Valley? It's German capital, French engineers, and British managers.

But the real secret is what we have in the sand. Some of what we have in the sand of Silicon Valley is the network of legal firms, patent offices, and universities that make that dense cluster. The secret is also policy. If you have a company in Silicon Valley and it fails, when the entrepreneur goes home, she tells her husband that she tried really hard, but it just didn't work. And he says, "I know you tried hard. Let's go out and have dinner, and we'll talk about what you'll do next."

In Finland, when the entrepreneur comes home and says the company has failed, his wife bursts into tears, drops the dishes, and cries, "My God! Where are we going to live? How will we ever pay the debts?" What is that difference? That difference is the bankruptcy laws. If you can't start a company quickly, and you can't end a company quickly, then don't expect to have an entrepreneurial environment. Yet, I know labor laws are tough to reform. It depends a little bit how much you care about your country.

In Italy, it takes six years to close down an enterprise. So what happens? You get lots of black market enterprise because the administrative load is too heavy. I would leave that as a challenge to you. How can you reform constructively those labor laws? How can you make it easy for a firm to stop when it's not working and reallocate the capital, and the spirit, and the entrepreneurship? That's what Chapter 11 [bankruptcy law] does in the United States.

So what are we doing here? Well, we are benefiting from some of the best leadership in innovation that we've had in a long time. One of the reasons that you should be here and think about collaborating with us is the U.S. share of global R&D. You are quite literally where the money is. It's an open system. It's a cooperative system. We're not here to help poor-rich Brazil because you're not poor. You've got great academic strengths. You've got great research strengths. The trick is to have a twin-pillar approach where you're providing funds - we're providing funds - where you can train people that can collaborate here.

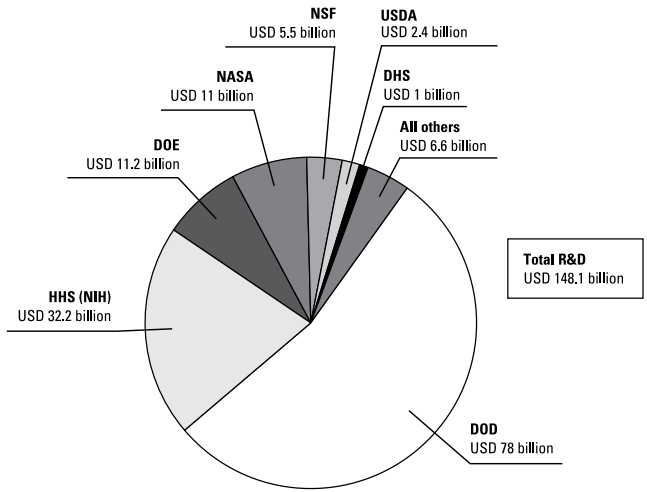
I would commend to you the Canadian Academic Chairs Program. They basically set up a whole series of well-paid positions across the country. It's actually kind of funny when you think about it. Canada complained for years and years about the brain drain, and then they finally figured out that maybe there was a brain drain because they could earn more money in

the U.S. than they could in Canada. So they started paying them better, and surprise, surprise, they came back. Not only did the Canadians come back, but also U.S. professors went up, which encourages this type of productive interaction, what the OECD calls "highly-mobile human capital."

So, there's a good reason to be here [in the United States]. But there's good news and bad news. We have the world's largest investment in health research, about $32 billion a year, not counting $5 billion in supplemental funds (so $37 billion). But non-defense, basic, and applied research is a problem that our Senate doesn't understand. Look how big that is [see graph]. That's in health research. That's the National Science Foundation.

This development is on the defense side, and there's a reason for that. We're trying to solve roadside bombs; we're trying to make sure that a new fighter jet works right the first time, every time; you have to make sure it works. You don't want an experimental submarine. On the other hand, we are seriously overstating to ourselves how much we're spending in research. We spend less than we pretend.

Good news and bad news: the US R&D budget for 2011.
Total R&D by agency, FY 2011 (budget authority in billions of dollars)




Source: OMB R&D budget data, agency budget justfications, and other agency documents.
R&D includes conduct of R&D and R&D facilities

Now, the Obama administration should be an inspiration to the world. In the last three weeks I've been in Slovakia, the Czech Republic, and Germany, having high-level meetings with our German colleagues, and, as I mentioned, in Canada. The president's innovation strategy is really one of the most comprehensive that we've seen at any time. Going back 40 years, it's clearly the best; the commitment to more research, a focus on skilled work force. We have a terrible problem with our immigration policies. We are, collectively, idiots. We bring in some of the best and brightest; we spend $150,000 to $200,000 to educate them up to the Ph.D. level, and then we kick them out, often back to the very countries that want to compete with us. This is profoundly stupid, and unfortunately, it's tied up with problems on the Mexican border.

We're focused on infrastructure. This is something we share with Brazil. I was very impressed to read that you're constructing three new superhighways around the state of Rio. We're beginning to work on a high-speed rail network in the country. It's only taken us 30 years, but we're beginning. The French -- whom, for some reason, the Americans love to hate -- put up a sign in Dulles Airport not long ago. You know, our trains are known for not being the fastest, and we celebrate our fast food. So the sign said, "Come to France, the land of slow food and fast trains." I'm not sure it encouraged tourism, but it was funny.

We're investing in clean energy innovation. We are a private sector, free market economy. Great! So, when we wanted a battery industry, what did we do? The president allocated $2.5 billion to help start the battery industry in this country, to help bring back American technology from China and Korea.

We've developed some new institutions. We now have ARPA-E. We have the Startup America initiative, which is going to help supplement our venture capital industry. We're working on improving patent, and, of course, we have an endless task of trying to improve our elementary and high school education.

This is quite an agenda. It's the most comprehensive, well-thought innovation policy we've ever seen. I think that's indisputable. Unfortunately, it took the administration the first two years, when they controlled the Congress, to come up with this idea. Now that they've come up with the idea, they no longer control Congress. Will these programs be funded? Will they work? That would be a complicated discussion, but we could do that

by sector. There's also the question we all focus on, which is how do we get these into the market?

This is one of the things we struggle with here. In our country, we often have this statement: "If it's a good idea, the market will fund it." The reality is, and as several Nobel Prize economists demonstrate, that is not the case. New ideas suffer from a real problem: they're new. I would like to point out the case of two young guys in Silicon Valley who were trying to raise money to start their company about 10 years ago, and they had a very hard time. They were turned down by almost all major venture firms. The two young guys were Larry Page and Sergey Brin, who founded Google. It's not always obvious.

One of the things that we all wrestle with is this: We spend about $150 billion on research, but as I mentioned, these new ideas can't get support. So how do you get across to where you can start to grow a product? Many good ideas end up dead in this Valley of Death. A challenge for you, working with FINEP, but I think also some other programs, is how do you help your firms, your academic entrepreneurs get across this valley? It's a core policy challenge all over the world.

Many people say, "Well, you can't have this problem here." When I was in the Senate doing some testimony not long ago, the first response was, "What about venture capital? If you've got a good idea, the venture guys will fund you." Well, no. Actually, the venture market is constrained. Only about $1.7 billion is in early-stage deals. It is also subject to fashion. One year, they're doing bio. The next year, they're doing nano. The next year, they're doing solar. They tend to herd together. It's also limited. It's only $21 billion in a $14 trillion economy. It's down from about $28 billion in 2008. It was $17 billion in 2009. Now it's back up, but it's a model that is under strain.

Let me quickly talk about one proven path across the Valley of Death. We call it SPIR. It's a great program because it takes a percentage of the research budget and applies it to national needs. The fact that it's an allocation means that it's budget neutral. If we had to vote for this in this country every year, we wouldn't have the program. It's also large scale. It's $2.5 billion a year. And because it's a large scale and it's been around for a while, we get what we call a "portfolio effect"-- that is, a whole series of investments. Some of them will work, some won't. It's also decentralized and adaptive. It's administered by a whole series of different agencies in different ways.

This is what I'd like to commend to you. FINEP is great, but what about having your Ministry of Health also encourage innovation? What about having your Ministry of Transport encourage innovation? Why do I suggest that? The truth is, in most countries around the world, there is an oligopoly supply system for major ministries. And this is a way of breaking through that. It's a very competitive program here; only about 20 percent of the companies get to Phase I. Only about half of them make it to Phase II, where they can pick up a million dollars. We don't ask for the money back. These are not loans. There's no recoupment. They're either research contracts or outright grants.

It's a second chance program. If you don't make Phase I to Phase II, you can get another Phase I. We like to compare it to a basketball game or soccer, to put it, perhaps, more in the Brazilian context. You take a lot of shots, you don't always score. But there's only one way to win a soccer game and that's scoring. Taking those shots is incredible, and this helps that. It provides that first money, which is the hardest money to get. The entrepreneurs control the company. They don't lose control to venture capitalists.

We did a major assessment of this. We spent $5 million for me to be able to tell you what we're saying here. We brought together 20 researchers in the field. We had 20-person oversight committee. Many of the companies were created because of the awards. The research was initiated because of the awards. They partner with universities. If I asked you, "Do your universities work enough with industry?" I would bet your answer would be, "No." So how do we get them to do that? This is one way. It creates jobs, it creates innovations; it solves problems for the government.

I understand that São Paulo has initiated a program like this, which is a good thing. It should be a demonstration to others. Can you encourage programs like this? Can you modify what FINEP is doing? But above all, can you spread the innovation process across the different ministries?

Now, let me just say a few words about the 21st century university. You want a university that teaches the next generation, does research, but also that works on commercialization and generates market-ready students. I talked to one of the major corporate leaders from a U.S. multinational in India and I asked him about the quality of his students. He said the ones from the Indian institutes of technology are the best in the world. But, below that, they have three problems: they're not used to working on teams; they don't speak really good English, which makes it hard to integrate in

the global economy; and they can't do PowerPoint. So it's hard to figure out what they know and what they don't know.

Universities should not be seen as a place where there are guys in white coats. They are centers of regional development and growth, the same way an airport is. Linking airports and universities is a very powerful combination. You need new leadership; you need people to actually be responsible for their university. You need to give them authority and funds, and you need to hold them accountable.

Let me give you a personal view. Do you know what the great danger is to innovation around the world? It's the Ministries of Education. They know everything. They change nothing. Every centralized Ministry of Education -- whether it's in Sweden, China, or India -- is a threat to change. They're a threat to innovation. They're a threat to the growth of knowledge. Getting them to change is really hard. Outside programs can help.

My conclusion is if innovation is key, then it needs your focus. You've made really good investments in research and in FINEP. Is it enough? I would respectfully submit to you, ladies and gentlemen, it is not enough. You need to up the game. When you have a winning soccer team, do you stop buying new players? Do you stop bringing in new coaches? No, you up the game. And I think that's exactly analogous. Brazil has to up the game because now you're competing in the big leagues.

We would like to make sure that innovation policy is not a hobby. It's not something you do when everything else is done. Resource inputs are essential, but they're not sufficient. You've got to get the incentives right. You have to drive changes across the economy.

Now we have a common challenge of how we're going to deal with this rapidly changing global economy. We need to get our incentives in place. We need to learn from each other and to work together. It's a privilege to be here with you to encourage that dialogue.

# Biographic Notes of Speakers

## PAULO SOTERO, DIRECTOR, BRAZIL INSTITUTE, WOODROW WILSON INTERNATIONAL CENTER FOR SCHOLARS

Paulo Sotero is the director of the Brazil Institute of the Woodrow Wilson International Center for Scholars. An award winning journalist, from 1989 to 2006 he was the Washington correspondent for Estado de S.Paulo, a leading Brazilian daily newspaper. Sotero began his career at Veja in the late 1960s and worked for the magazine in São Paulo, Recife, Brasília, and Paris, until he was named its correspondent in Portugal after the democratic revolution of April 25, 1974. Sotero has been in Washington, D.C., since 1980, where he has been a correspondent for Istoé weekly magazine and the financial newspaper Gazeta Mecantil. He is a frequent guest commentator for the BBC, CNN, AlJazeera, Voice of America, National Public Radio, Globo News Television and the Brazilian Radio Network - CBN. He also contributes regularly to Brazilian and international newspapers, magazines, and scholarly journals. A native of the state of São Paulo, Sotero holds a Bachelor's degree in History from the Catholic University of Pernambuco, and a Master's in Journalism and Public Affairs from the American University, in Washington, D.C. He has been an adjunct lecturer at the Edmund A. Walsh School of Foreign Service, Georgetown University, and is currently on the adjunct faculty of the Elliott School of International Affairs, George Washington University.

## ANTONIO BRITTO FILHO, EXECUTIVE PRESIDENT, INTERFARMA

Britto worked for Rede Globo as a political commentator and was responsible for the coverage of the Presidency and the Federal Congress for six years. He has also worked for other major Brazilian newspapers and magazines. In 1985, he was appointed to be Press Secretary for Tancredo Neves, the first civil president after the military period. Subsequently Britto became a Federal Representative for eight years. He was one of the main coordinators in writing the current Brazilian Constitution, particularly the chapters about Communication, Science and Technology and Social Security. Between 1992 and 1994 he was Federal Minister of Social Security. In the same year, he was elected Governor of the State of Rio Grande do Sul. For the past ten years Britto has been working as an executive in the private sector. He has been CEO of Azaleia, a member of Claro's Board of Directors and a member of the board of Braskem. Since May 2009 Britto has served as the Executive President of Interfarma.

## KENT HUGHES, FORMER DIRECTOR OF THE PROGRAM ON AMERICA AND THE GLOBAL ECONOMY, WOODROW WILSON INTERNATIONAL CENTER FOR SCHOLARS

Kent H. Hughes is the former Director of the Program on America and the Global Economy (PAGE) at the Woodrow Wilson International Center for Scholars. As part of the PAGE agenda, he published a book, Building the Next American Century: The Past and Future of American Economic Competitiveness (Wilson Center Press 2005), which emphasizes the importance of innovation and education to America's future. Prior to joining the Center, Dr. Hughes served as Associate Deputy Secretary at the U.S. Department of Commerce, president of the private sector Council on Competitiveness, and in a number of senior positions with the U.S. Congress. Prior to his congressional service, Dr. Hughes served as a staff attorney for the Urban Law Institute. He was also an International Legal Center Fellow and Latin American Teaching Fellow in Brazil where he worked on a reform of Brazilian legal education.Dr. Hughes holds a Ph.D. in economics from Washington University, a LL.B. from Harvard Law School and a B.A in Political and Economic Institutions from Yale University. He serves

on the Executive Advisory Board of FIRST Robotics and is a member of the D.C. Bar, American Bar Association and the American Economic Association.

## JOHN R (JAY) THOMAS, PROFESSOR, GEORGETOWN UNIVERSITY LAW CENTER

Professor Thomas joined the Georgetown Law Center faculty in 2002. He has served as a Visiting Scholar at the Congressional Research Service for the past decade. He previously was a member of the faculty of the George Washington University Law School, and has served on the visiting faculties at Cornell Law School and the University of Tokyo. Professor Thomas formerly served as law clerk to Chief Judge Helen W. Nies of the U.S. Court of Appeals for the Federal Circuit; visiting fellow at the Max Planck Institute for Foreign and Comparative Patent, Copyright and Unfair Competition Law in Munich, Germany; and research scholar at the Institute of Intellectual Property in Tokyo, Japan. Professor Thomas has published numerous articles and five books on the subject of intellectual property law.

## BILL RUSSELL, HEAD OF BILATERAL RELATIONS TEAM, INTELLECTUAL PROPERTY OFFICE

The Bilateral Relations team works with international partners, other government departments, businesses and other stakeholders to develop an international intellectual property framework that meets the challenges of today's markets. By building relationships with stakeholders and policymakers globally, they help shape the global debate on intellectual property matters.

## JOHN HORRIGAN, VICE PRESIDENT FOR POLICY RESEARCH, TECHNET

In July 2009, John Horrigan was named by FCC Chairman Genachowski to the leadership team tasked with developing the National Broadband Plan (NBP). Prior to joining the FCC, Mr. Horrigan was Associate Director, Research, with the Pew Internet & American Life Project, where he studied the online behavior of broadband internet users, mobile internet

users, and consumers of other leading edge information technology. He has spoken at numerous conferences and seminars, including appearances at the Organization for Economic Cooperation and Development, the World Economic Forum, the Associated Press Broadcast Advisory Board. Mr. Horrigan is also Chairman of the Board of the Telecommunications Policy Research Conference. Earlier in his career, Horrigan was a staff officer for the Board on Science, Technology, and Economic Policy at the National Research Council. He received his Ph.D. in public policy from the University of Texas at Austin and his B.A. in government and economics from the University of Virginia.

## STEPHEN EZELL, SENIOR ANALYST, INFORMATION TECHNOLOGY AND INNOVATION FOUNDATION

Stephen Ezell is a Senior Analyst with the Information Technology and Innovation Foundation (ITIF), with a focus on international information technology competitiveness and national innovation policies. Mr. Ezell comes to ITIF from Peer Insight, an innovation research and consulting firm he co-founded in 2003 to study the practice of innovation in service industries. At Peer Insight, Mr. Ezell co-founded the Global Service Innovation Consortium, published eight research papers on service innovation, and researched national service innovation policies being implemented by governments worldwide. Prior to forming Peer Insight, Mr. Ezell worked in the New Service Development group at the NASDAQ Stock Market. Previously, Mr. Ezell founded two successful innovation ventures, the high-tech services firm Brivo Systems and Lynx Capital. Stephen holds a B.S. from the School of Foreign Service at Georgetown University, with an Honors Certificate from Georgetown's Landegger International Business Diplomacy program.

## DR WEN HWA LEE, SCIENTIFIC COORDINATOR, STRUCTURAL GENOMICS CONSORTIUM, UNIVERSITY OF OXFORD

Dr Lee is currently Scientific Coordinator at the Structural Genomics Consortium, University of Oxford. Under the SGC's main ethos of Open Access and Pre-Competitive Research, Lee has been involved in the plan-

ning of strategies, collaborations and alliances with external partners at institutional level to promote the discovery of new medicines and therapies through basic research. His training included Biology, Molecular and Structural Biology, Protein Crystallography, Computational Biology and Drug Discovery, gathered in places as diverse as Brazil, USA, France and UK.

## PROFESSOR SUNIL KHILNANI, AVANTHA PROFESSOR AND DIRECTOR, INDIA INSTITUTE, KING'S COLLEGE LONDON

Professor Khilnani's research interests lie at the intersection of various fields: intellectual history and the study of political thought, the history of modern India, democratic theory in relation to its recent non-Western experiences, the politics of contemporary India, and strategic thought in the definition of India's place in the world. He was educated at Trinity Hall, Cambridge, where he took a first in Social and Political Sciences, and at King's College, Cambridge, where he gained his PhD in Social and Political Sciences. Prior to becoming Director of the King's India Institute he was, from 2001 to 2011, the Starr Foundation Professor at the Johns Hopkins University's School of Advanced International Studies (SAIS) in Washington D.C., and Director of South Asia Studies at SAIS, a programme that he established in 2002. Sunil Khilnani was formerly Professor of Politics at Birkbeck College, University of London, and has been a Fellow of the Woodrow Wilson International Center for Scholars in Washington. His latest book, The Idea of India (4th edition: Penguin, 2011), has been translated into several languages. Professor Khilnani joined the King's India Institute as its Director and Professor of Politics in June 2011.

## PROFESSOR DENISE LIEVESLEY, HEAD OF SCHOOL OF SOCIAL SCIENCE AND PUBLIC POLICY, KING'S COLLEGE LONDON

Professor Lievesley is one of the UK's leading social statisticians, who has campaigned for evidence to be used as the basis for the development of sound public policies within the UK and more widely. Having enjoyed a distinguished career, which has included the posts of founding Chief Executive of the English Information Centre for Health and Social Care;

Director of Statistics at UNESCO –where she established its new Institute for Statistics –, and Director of the UK Data Archive (and simultaneously Professor of Research Methods in the Mathematics Department, University of Essex), most recently Professor Denise Lievesley was a special advisor at the African Centre for Statistics of the UN and was based in Addis Ababa.

## MARY WALSHOK, VICE-CHANCELLOR FOR PUBLIC PROGRAS; DIRECTOR, THE EXTENSION SCHOOL; CO-FOUNDER OF CONNECT UCSD

Mary Walshok is an author, educator, researcher, and Associate Vice Chancellor for Public Programs and Dean of Extension at the University of California San Diego. She is a thought leader and subject matter expert on aligning workforce development with regional economic growth.She is the author of more than 100 articles and reports on regional innovation, the role of research institutions in regional economies and workforce development. As an industrial social scientist studying the dynamics of regional economic development and transformation, Walshok has studied various communities across America. Walshok has developed outreach efforts to help accelerate the San Diego region's economic vitality, assure a globally competitive talent pool and help college graduates transition to employment areas that are in higher demand. She also helps provide access to a vast array of regional intellectual resources through the award-winning UCSD-TV and nationwide through UCTV, which reach over 22 million households and millions more around the globe through on-demand Internet downloads.A native of Palm Springs, California, she received her bachelor's degree in sociology from Pomona College in 1964, her master's degree in sociology in 1966 and her Ph.D. in sociology in 1969 from Indiana University.

## IVOR ROYSTON, FOUNDING MANAGING PARTNER AT FORWARD VENTURES

Dr. Royston has been involved in the biotechnology industry in San Diego from its inception in 1978 with the founding of Hybritech, Inc. (later acquired by Eli Lilly) and with the founding of Idec Pharmaceuticals in 1986 (which later merged with Biogen). He has been instrumental in

the formation, financing, and development of numerous successful public biotechnology companies. He was previously the Founding President and CEO of the Sidney Kimmel Cancer Center (1990-2000) and on the faculty of the medical school and cancer center of the University of California, San Diego (1977-1990). He received his B.A. (1967) and M.D. (1970) degrees from the Johns Hopkins University and completed post-doctoral training in internal medicine and medical oncology at Stanford University. In 1997, President Clinton appointed Dr. Royston to a six-year term on the National Cancer Advisory Board.

## JEFFREY STEINDORF, DIRECTOR OF OPERATIONS, STANFORD CONSORTIUM

Jeff Steindorf guides the strategic direction and manages the administrative, capital, and financial operations of the Sanford Consortium. Previously, as Associate Vice Chancellor for campus planning at the University of California, San Diego, Steindorf provided leadership in near-term and long--range capital planning, enrollment planning, environmental impact analyses, and physical planning, and led institutional research and indirect cost rate negotiations with DHHS. Prior to assuming administrative responsibilities, he received individual support from NIH to conduct postdoctoral research in cognition and decision-making at UC San Diego and from NSF to train in quantitative methods at the Inter-university Consortium for Political and Social Research at the University of Michigan. Dr. Steindorf received his Ph.D. in Psychology from Northern Illinois University

## DAVID HALE, MEMBER OF CONNECT & HYBRITECH

Mr. Hale is a serial entrepreneur who has been involved in the founding and/or development of a number of life sciences technology companies. In 1982, after joining Hybritech, Inc., the first monoclonal antibody company, he served as COO, President and then Chief Executive Officer, until Hybritech was acquired by Eli Lilly and Co. in 1986. From 1987 until 1997 he was Chairman, President and CEO of Gensia, Inc., which merged with SICOR to become Gensia Sicor, Inc., which was later acquired by Teva Pharmaceuticals. He was President and CEO of Women First HealthCare, Inc. from late 1997 to June 2000, before joining CancerVax in October 1999. Before joining Hybritech, Mr. Hale was Vice President and

General Manager of BBL Microbiology Systems, a diagnostics division of Becton, Dickinson & Co. and from 1971 to 1980, held various marketing and sales management positions with Ortho Pharmaceutical Corporation, a division of Johnson & Johnson, Inc. Currently, he is Chairman and CEO of Hale BioPharma Ventures LLC, a private company focused on the formation and development of biotechnology, specialty pharma, diagnostic and medical device company. He has been the Chairman of various other pharmaceutical companies such as Santarus, Inc., and Conatus Pharmaceuticals, Inc.

## PRADEEP KHOSLA, CHANCELLOR, UC SAN DIEGO

Pradeep K. Khosla, is UC San Diego's eighth Chancellor. At UC San Diego, he has initiated a comprehensive, all-inclusive strategic planning process to develop a vision and shared goals for the future of the campus. Khosla previously served as Dean of Engineering at Carnegie Mellon University. Chancellor Khosla is an elected member of the National Academy of Engineering and the American Society for Engineering Education. He is a Fellow of the Institute of Electrical and Electronics Engineers, the American Society of Mechanical Engineers, the American Association for Advancement of Science, the American Association of Artificial Intelligence and the Indian Academy of Engineering. He is an Honorary Fellow of the Indian Academy of Science. Khosla is also the recipient of numerous awards for his leadership, teaching, and research, including the 2012 Light of India Award, a Lifetime Achievement Award from the American Society of Mechanical Engineers, and the George Westinghouse Award for contributions to improve engineering teaching. In 2012, he was named as one of the 50 most influential Indian-Americans by SiliconIndia.He received his bachelor's degree in electrical engineering from the Indian Institute of Technology, and his master's and doctoral degrees in electrical and computer engineering at Carnegie Mellon.

## JOSEPH PANETTA, PRESIDENT, BIOCOM

Joe Panetta became the first appointed President & CEO of Biocom in 1999 as the association initiated a new advocacy and growth agenda. Joe has more than 30 years of career experience in government, biotechnology and corporate sectors, including roles as a senior policy analyst with the

U.S. EPA in Washington, D.C, Vice President of Regulatory and Public Affairs for San Diego-based Mycogen Corporation and Global Leader of Biotechnology Governmental Affairs for Dow Agrosciences. He is a member of the Board of Directors of the San Diego Chamber of Commerce, the San Diego Regional EDC and CONNECT, Chair of the Board of the CA Biotechnology Foundation, and former Chair of the Board of the San Diego Workforce Partnership and the Council of State Bioscience Associations. Joe earned a Bachelor of Science degree in biology from LeMoyne College and a Master of Public Health degree in industrial and environmental health from the University of Pittsburgh. He is a graduate of the Brookings Institution program for executives and the Harvard program on negotiation.

## CLAUDIO JOAZEIRO, DOCTOR & ASSISTANT PROFESSOR, DEPARTMENT OF CELLULAR BIOLOGY, THE SCRIPPS RESEARCH INSTITUTE

Dr. Joazeiro is currently Associate Professor at the Department of Cell and Molecular Biology of The Scripps Research Institute, an institution that has generated over 60 spin-off biotech companies. Dr. Joazeiro graduated from the University of São Paulo in 1990, with both a B.S. in Biology and an M.S. in Biochemistry. He then pursued Ph.D. studies at the University of California, San Diego, graduating in 1996. After spending a year at UCLA for Post-Doctoral training, Joazeiro became a Post-Doctoral Research Fellow at the Salk Institute (1997-2000) where he discovered the largest family of "ubiquitin ligases", enzymes implicated in a wide range of biological processes and diseases. This discovery landed him a position at the Genomics Institute of Novartis (GNF), where he was Head of Laboratory until 2006. Dr. Joazeiro is a member in an American Cancer Society grant study section and has served several times as an Ad Hoc reviewer for the National Institutes of Health. Finally, he leads several initiatives aimed at promoting innovation in the development of Bio-pharmaceuticals in Brazil.

## BRENT JACOBS, EXECUTIVE DIRECTOR OF CUSHMAN & WAKEFIELD; CO-FOUNDER, BIOCOM

Brent Jacobs has been Executive Director of C&W's GLSP for more than 30 years and is cofounder of BIOCOM, where he co-chairs the facilities committee. Mr. Jacobs is also co-founder of Big Bear Bio, a consulting firm that links North American biotechnology companies with Asian Capital. He has brokered more than 10 million sq. ft. of laboratory space, including more than 1.5 million sq. ft. of leasing and acquisition for Idec Pharmaceuticals and Biogen Idec. He is regularly a bio-industry speaker and SIOR on biotechnology facilities. Mr. Jacobs is on the Executive Board of Directors of the Sanford-Burnham Institute, one of the nation's top biomedical research institutes, and he recently chaired the Oversight Committee for the Sanford-Burnham Institute's 175,000 sq. ft. laboratory facility in Orlando, Florida. He is a board member of the American Technion Society and a past Trustee of the Ruben H. Fleet Science Center and The La Jolla Institute for Molecular Medicine. He chairs CONNECT's Entrepreneur Hall of Fame and is Chairman of the San Diego Innovation Center.

## MAGDA MARQUET, CHAIR OF THE BOARD, BIOCOM; COFOUNDER, ALTHEA TECHNOLOGIES

Dr. Marquet is co-founder and co-Chair of Ajinomoto Althea, and served as its co-President and CEO for ten years. Dr. Marquet is also co-founder and Director of Althea Dx, a spin-off of Althea Technologies focusing in companion diagnostics development. She is the Chairman of BIOCOM and she is on the Board of UCSD Moores Cancer Center. She is also a member of the UCSD Biological Sciences Dean Leadership Council. She is currently involved as investor, adviser, and board member in over twenty local companies. She serves as a Board member for Sente, Portable Genomics and she is a Board observer for Independa. She is also co-Chairman of the Advisory Board of MD Revolution, advisor for Mesa Verde Venture Partners and for City National Bank and a Trustee for Pitzer College (Claremont, CA). Dr. Marquet has over twenty five years of experience in the biotechnology industry in the United States and Europe. She was formerly Executive Director of Pharmaceutical Development at Vical Incorporated, where she patented several novel methods for the production of clinical grade DNA for use in gene therapy and DNA vaccines. Dr. Marquet holds a Ph.D in Biochemical Engineering from INSA/University of Toulouse, France.

## LARRY SMARR, FOUNDING DIRECTOR, CALIFORNIA INSTITUTE FOR TELECOMMUNICATIONS AND INFORMATION TECHNOLOGY

Larry Smarr is the founding Director of the California Institute for Telecommunications and Information Technology (Calit2), a UC San Diego/UC Irvine partnership, and holds the Harry E. Gruber professorship in Computer Science and Engineering (CSE) at UCSD's Jacobs School. At Calit2, Smarr has continued to drive major developments in information infrastructure-- including the Internet, Web, scientific visualization, virtual reality, and global telepresence--begun during his previous 15 years as founding Director of the National Center for Supercomputing Applications (NCSA). Smarr served as principal investigator on NSF's OptIPuter project and currently is principal investigator of the Moore Foundation'sCAMERA project and co-principal investigator on NSF's GreenLight project. In October 2008 he was the Leadership Dialog Scholar in Australia.

## KRISTIINA VUORI, PRESIDENT AND INTERIM CEO, SANFORD-BURNHAM MEDICAL RESEARCH INSTITUTE; PAULINE AND STANLEY FOSTER PRESIDENTIAL CHAIR; PROFESSOR

Dr. Vuori earned her M.D. and Ph.D. degrees at University of Oulu, Finland. She received postdoctoral training at Sanford-Burnham in 1992-1995 with then-President & CEO Dr. Erkki Ruoslahti. Dr. Vuori was appointed to faculty in 1996. She was appointed Deputy Director of the Sanford-Burnham's NCI-designated Cancer Center in 2003, and Director of the Cancer Center in 2006. In 2008, she was appointed Executive Vice President for Scientific Affairs. She has been President of the Institute since April 2010. Dr. Vuori is also co-Director of the Conrad Prebys Center for Chemical Genomics at Sanford-Burnham. .Throughout her career, Dr. Vuori has received numerous research grants and awards from NIH, NCI, Department of Defense (DoD), and the California Cancer Research Programs. Dr. Vuori was selected as a PEW Scholar in the Biomedical Sciences in 1997 (dubbed as "20 most promising scientists in America"). Additionally, Dr. Vuori serves in a wide variety of advisory capacities to NCI and

other cancer organizations, including advisory roles for the NCI's Developmental Therapeutics Program and Center for Strategic Scientific Initiatives. She has served on several NIH and DoD study sections, and is past chair of the DoD Breast Cancer Research Program's prestigious "Innovator Award" panel.

## LARRY GOLDSTEIN, DISTINGUISHED PROFESSOR, DEPT OF CELLULAR AND MOLECULAR MEDICINE & DEPT OF NEUROSCIENCES AT UCSD SCHOOL OF MEDICINE; DIRECTOR, UC SAN DIEGO STEM CELL PROGRAM; SCIENTIFIC DIRECTOR, SANFORD CONSORTIUM FOR REGENERATIVE MEDICINE; DIRECTOR, SANFORD STEM CELL CLINICAL CENTER

Larry S.B. Goldstein, Ph.D., is a professor of cellular and molecular medicine at the University of California, San Diego (UCSD) School of Medicine. His research is focused on understanding the molecular mechanisms of intracellular movement in neurons and the role of transport dysfunction in neurodegenerative diseases. His lab provided the first molecular descriptions of kinesin structure and organization, and has recently discovered important links between transport processes and diseases such as Alzheimer's disease and Huntington's disease. Goldstein received a doctorate in genetics from the University of Washington, Seattle, and a bachelor's degree in biology and genetics from the University of California, San Diego. He conducted postdoctoral research at the University of Colorado at Boulder and the Massachusetts Institute of Technology.

## TODD KUIKEN, RESEARCH ASSOCIATE, PROJECT ON EMERGING NANOTECHNOLOGIES

Dr. Kuiken is Director of the Center for Bionic Medicine and Director of Amputee Services at The Rehabilitation Institute of Chicago (RIC), designated the "#1 Rehabilitation Hospital in America" by U.S. News & World Report since 1991. Working with researchers at RIC and institutions around the world, Dr. Kuiken developed the TMR procedure for upper-limb amputees in 2002. TMR is an innovative surgical procedure

that reroutes brain signals from nerves severed during amputation to intact muscles, allowing patients to control their prosthetic devices by merely thinking about the action they want to perform. After completing his B.S. in Environmental Management and Technology at Rochester Institute of Technology he worked with renowned scientists on the biogeochemical cycling of mercury at the Oak Ridge National Laboratory. He earned an M.A. in Environmental and Resource Policy from The George Washington University and has a Ph.D. from Tennessee Tech University.

## JOEL VELASCO, SENIOR VICE-PRESIDENT, AMYRICS

Mr. Joel Velasco is the Senior Vice President of External Relations at Amyris, Inc. As chief representative in North America for the Brazilian Sugarcane Industry Association (UNICA) over the last three years, Velasco led UNICA's efforts to expand North American biofuel and sugar markets. Prior to joining UNICA, Velasco was managing director of Stonebridge International, a strategic advisory firm based in Washington, D.C. Velasco also served as senior advisor to the U.S. Ambassador to Brazil and as a personal aide to Vice President Al Gore in the White House. Velasco will remain an informal advisor to UNICA on matters pertaining to U.S. biofuels policy.

## CHAD EVANS, SENIOR VICE PRESIDENT, COUNCIL ON COMPETITIVENESS

Chad Evans is senior vice president at the Council on Competitiveness. He also currently leads several of the Council's core projects – its National Innovation Initiative, Global Innovation Initiative, Technology Leadership and Strategy Initiative, and international benchmarking. In 2005, Chad led the first US-EU Innovation Summit under the auspices of the Prime Minister of the Netherlands in cooperation with the Council of the European Union – as well as the first US-Japan Innovation Summit with the Japanese Ministry of Economy, Trade and Industry and the Ministry of Education, Culture, Sports, Science and Technology. In 2007, Chad created and managed the first US-Brazil Innovation Summit, endorsed by Presidents Bush and Lula. Chad is a 2007 American Marshall Fund Fellow from the US German Marshall Fund. He holds a Master's of Science from the Georgetown University School of Foreign Service, an Honors con-

centration in International Business Diplomacy from Georgetown's Landegger Program, and a BA in international affairs from Emory University. He serves on the Georgetown University MSFS Admissions Committee.

## CHARLES WESSNER, DIRECTOR AT NATIONAL ACADEMY OF SCIENCES

Dr. Charles Wessner is an internationally recognized expert on many aspects of innovation policy, including entrepreneurship, early-stage financing, the high-technology industry, and bridging the gap between public and private entities. He is the founder and director of the National Academy of Sciences Technology, Innovation, and Entrepreneurship Program. While collaborating closely with government agencies and branches, including Congress and the White House, he offers his input to technological agencies, government ministries, and foreign diplomats alike. He has served as an advisor on the OECD's Committee on Science and Technology Policy and the national technology agencies of Finland and Sweden. Along with that, Dr. Wessner has also been an active member of the Canadian Council of Academies' Expert Committee on Science and Technology and the Norwegian Technology Forum. His multiple publications and extensive research has led to his official recognition by being selected as a National Academies Scholar.

# The Brazil Institute

An emerging global power and the America's second largest democracy and economy, Brazil is playing an increasingly influential role on the world stage. To help policymakers better understand this rapidly evolving dynamic, the Brazil Institute advances policy analysis on the critical issues facing the two countries. It fosters bi-national dialogue on public policy in areas of mutual interest, and informs Washington about political, economic and social policy developments in Brazil. The Brazil Institute was created out of the conviction that Brazil and the U.S.--Brazilian relationship deserve greater attention within the Washington policy community. In keeping with the Center's mission to bridge the worlds of scholarship and policymaking, the Brazil Institute sponsors activities on a broad range of key policy issues:

• Regular policy forums and seminars. Forums stimulate debate on a range of critical issues, including trade and economic development; Brazil as an emerging world and hemispheric leader; science, technology and energy policies; and Brazilian national politics. Conferences, meetings, and seminars regularly gather high-profile policymakers, scholars, and business and civil society leaders.

• Outreach and publications: The Institute publishes research on a variety of issues relevant to Brazil-US relations. Recent publications address Brazil-U.S. diplomatic relations, Brazil's economic future, climate change, infrastructure and the environment, civil political engagement, Brazil as a regional leader, and public policies and business strategies on innovation. The Institute places special emphasis on effective outreach to decision--makers and stakeholders who shape the bilateral agenda. Over the past couple of years, it has organized two Brazilian Congressional Study Missions on Innovation in the US and Europe, Judicial Dialogues, and three FAPESP Weeks, with the São Paulo Research Foundation, which convene Brazilian and American scientist and scholars in conferences on scientific collaboration.

# The Woodrow Wilson International Center for Scholars

## VISION STATEMENT

The Wilson Center seeks to be the leading institution for in-depth research and dialogue to inform actionable ideas on global issues.

## MISSION STATEMENT

The Wilson Center, chartered by Congress as the official memorial to President Woodrow Wilson, is the nation's key non-partisan policy forum for tackling global issues through independent research and open dialogue to inform actionable ideas for Congress, the Administration and the broader policy community.

For more information about the Wilson Center's activities and publications, please visit us online at www.wilsoncenter.org.