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“The Future of Innovation: Fate or Fatality?”
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Greetings to all of you. We have the Washington Academy of Sciences to thank for bringing this distinguished and congenial group together. What a pleasure to be reminded that scientists and engineers are a force to be reckoned with in the nation’s Capital.

Many of you are both scientists and public servants, working in the zone of convergence between scientific research and public policy. Those of you who work in academia or industry understand that policies can either help or hinder your attempts to meet increasing demands for new knowledge and innovative technologies.

Working as partners in the zone where science, technology and policy converge is vitally important at a time when many nations are challenging America’s leadership in science and technology. We as scientists and engineers must not be timid about our strength and our usefulness. In many ways, we hold in our hands the difference between a fabulous future and the fate of fortune.

Why do I feel this moment in America’s history is so crucial?

As Director of the National Science Foundation, I am often asked: “What keeps you awake at night?” My emphatic answer is: “The economic future of the nation and its continuing ability to compete in world markets.”

I’m not alone in my “sleepless nights.” In just the past four years, nearly fifty reports from industry, academia, and government have raised a growing clamor about the potential waning of American competitiveness. Factors that underlie these disturbing trends have been well highlighted by recent reports of the National Research Council, the Council on Competitiveness and the National Science Board, and by prominent experts who write on this subject.

I am in good company in losing sleep!

All of these voices raise the stark question: “Can America still compete?” Can we continue to be leaders through science and engineering strength and technological leadership?

The *Gathering Storm* report¹, with its strong emphasis on investment in research and education, seemed to crystallize growing concerns, and provide a stimulus for action.

¹*Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*; The National Academies Press, 2007.

In his recent sequel to that report, Norm Augustine, former CEO of Lockheed Martin, framed the consequences of *inaction* with frank clarity. Unless substantial investments are made to the engine of innovation, "...the current generation may be the first in our country's history to leave their children and grandchildren a lower sustained standard of living."

As you know, both the Administration and Congress have vowed to support increased funding for basic research, through the American Competitiveness Initiative and the America COMPETES Act.

Regrettably, however, the funding has failed to appear. The 2007 budget request included some of the funds, but the appropriations bill stalled. The 2008 budget request also included the funds, but the spending was not approved by the Congress. As often happens in politics, the short term squeezed out the long term.

Once again, funding is provided in the 2009 budget request, but I'm not going to bet the bank just yet.

Why do I lose sleep at night? It is not only the realization that the nation is at risk of losing its relative economic strength in the future, with the concomitant loss in quality of life.

It is also the recognition that NSF, our sister agencies, and our partners in the science and engineering community are capable of addressing most of the critical threats and taking advantage of many, if not all, of the opportunities.

Despite this, we are beset with the constant struggle of defending basic R&D budgets, and losing this tussle at the final moment of the appropriation process. This struggle is much like the plight of Sisyphus, rolling a heavy rock up a hill only to have it roll down again as it nears the top.

Concern among industry leaders about this "slippage" is increasing. A letter signed by CEOs of IBM, Dell, Intel, Hewlett-Packard and six other companies on the Technology CEO Council recently landed on Congressional desks with this message:

"With key budgets that grew at less than the rate of inflation, our science agencies have no choice but totread water rather than lead."²

When it comes to increased funding for research and education, we haven't even left the starting gate. America is not taking the necessary steps *to remain a leader* and to ensure a prosperous future. Indeed, there are those who suggest that the wolf is already at the door, hungering after the spoils.

A startling new report on technology indicators from Georgia Tech concludes that China may soon rival the United States in worldwide technological competitiveness. One newspaper,

² Washingtonpost.com: (last accessed February 28, 2008); http://www.washingtonpost.com/wp-dyn/content/article/2008/02/26/AR2008022602697_pf.html

reporting on this study, carried this astonishing headline: “Move over US—China to be new driver of [the] world’s economy and innovation.”³

What lies behind these predictions?

Trade is one warning signal of the looming competition. The balance of payments for U.S. high-tech trade has gone from positive to negative.....and has remained negative for the past five years. The rapid reversal is due primarily to growing imports of semiconductors and electronic products from China and South East Asia.⁴

In fact, China has been the world's largest exporter of information and communications technology for the past three years.⁵ In 2007, Mainland China—excluding Hong Kong—eclipsed the U.S. as Japan's biggest trading partner. If you include Hong Kong, China became Japan's No.1 trading partner back in 2004.⁶

Emerging economies are growing at a breathtaking pace. The combined economies of Brazil, Russia, India and China now represent about 15% of global Gross Domestic Product. According to Goldman Sachs analysts, China needs to grow by just 5% each year—which is only *half* its current growth rate—to become the world’s largest economy well within two decades.⁷

In January, the Economist projected that,⁸ “Within a few months China will overtake America as the country with the world's largest number of internet users.” China already has the same number of mobile-phone users (about 500 million) as the whole of Europe.

To quote Norm Augustine again, “America and the world are on the precipice of a change of seismic proportions, a tipping point ... and no one will be immune to its impact.”

That seismic change is a result of globalization. But globalization is not the wolf at the door. At its best, globalization can create a more secure world of sustainable prosperity. We all know that the rapid development of emerging economies is strengthening the global economy and bringing a better quality of life to millions—if not billions—of individuals.

Everyone should benefit from a world of expanding markets and rapidly growing middle class populations. Expanding economic opportunities could bring about greater global security, and eventually, a world of peace and plenty.

There is no question that the world is changing radically. The vital concern—the one that keeps me awake at night—is whether we in the U.S. are paying attention and reacting appropriately.

³ Science Daily, January 28, 2008; <http://www.sciencedaily.com/releases/2008/01/080124103159.htm>

⁴ Science and Engineering Indicators, 2008; National Science Board

⁵ *Alternative reality*, The Economist, January 31, 2008.

⁶ Business Week Japan, April 29, 2007.

⁷ Goldman Sachs; Jim O’Neill Interview. February 2008; <http://www2.goldmansachs.com/ideas/brics/index.html>

⁸ *Alternative reality*, The Economist, January 31, 2008

Are we—policy makers, academics, researchers, industrial leaders, educators—looking at our own institutions and making the tough choices required to reform and revitalize them?

Many continue to point out that the U.S. is the undisputed leader in some areas. America's talent for entrepreneurial endeavor, combined with an environment friendly to business, is a good example. America has always been a nation of pioneers. Exploration and invention are woven into the fabric of our institutions and our culture. This entrepreneurial culture is a strong suit for the nation when it comes to competitiveness. Surely we have not lost that spirit, drive and energy.

We have been the world's teacher in this respect. But other nations have learned well, and continue to learn at an accelerating pace. Among Business Week's latest Info Tech 100 [Companies]—the movers and shakers in the information and communications revolution—only eleven of the top 25 companies are based in the U.S. In the year 2000, that figure was 20 out of 25.

Surely there can be no doubt that U.S. universities and colleges continue to lead the world in academic excellence. Seventeen of the top 25 universities in the recent world ranking by Shanghai Jiao Tong University are U.S. institutions.⁹ In fact, 38 of the top 50 are located in the U.S. But when we consider the top 100—only 54 are U.S. institutions.

There are many similar indicators. I don't want to belabor the statistics, but rather emphasize that time is fleeting. Complacency today is not a solution for tomorrow.

If you ask me where our greatest vulnerabilities are, I would have to say—in educating our future workforce and in R&D investment.

Nations around the globe are investing more in education and talent. Every nation in the world today now understands that innovation and economic growth in a knowledge-based economy are driven by investment in R&D, education, and infrastructure, primarily information and communication infrastructures.

For these reasons not only developed but also developing nations have been increasing their investments in R&D and improving the quality of their education systems, especially graduate education. These investments are where the future battle for international economic leadership will be fought and where the U.S. is faltering.

The accepted target for R&D investment in the world since the Lisbon accord is 3.0% of gross domestic product. Already, at least four countries exceed that goal: Japan, Sweden, Norway and Finland. Others are approaching it. China has set a goal of reaching 2.5 percent by year 2020. In comparison, the U.S now invests about 2.6% of GDP in R&D, and this level of investment has

⁹ Top Universities 2007, Shanghai Jiao Tong University: http://ed.sjtu.edu.cn/rank/2007/ARWU2007_Top100.htm and <http://www.arwu.org/rank/2007/ARWU2007TOP500list.htm> Last accessed March 19, 2008.

been decreasing slightly. The U.S. now ranks seventh among OECD countries in R&D investment intensity.

There are many who clamor for more applied research and development at the expense of basic research? Why not give in to these short term pressures? To my mind that would be myopic, even dangerous.

New discoveries and technological concepts are the foundation for applied research and development. They are the mother lode, and without the nuggets, we don't stand a chance of minting the gold. And yet, basic research—the source of most new concepts—accounts for only 18% of the total U.S. R&D investment.

Unfortunately, this share has been declining. The nation's colleges and universities have been particularly hard-hit. The four-year period from 2004 to 2007 may represent the first continuous decline in federal investment in basic R&D at colleges and universities in the past twenty-five years.

In the past, investments in basic R&D often produced returns only in the long term. That has changed as research productivity accelerates and more and more researchers collaborate, many across the globe.

The truth is that decision makers commonly overlook *the most rapid returns of all*. Those returns accrue when R&D is integrated with the education and training of graduate and undergraduate STEM talent at the nation's colleges and universities.

As these freshly minted graduates move into the private sector, they carry with them the new knowledge that could generate the next “killer app.” This contribution is one of the most valuable made by all of you and NSF to the nation's innovation system. In this respect, holding back basic R&D investment at colleges and universities is shortchanging our economic future.

My emphasis on basic research is not intended to diminish the importance of applied research and development. Two-thirds of U.S. investment in R&D is supplied by the private sector and most of that is applied research and development.

With the acceleration of discovery and innovation worldwide, pressures are mounting to reduce the interval between technological concept and marketable item. To be the first with a new innovation can destabilize existing markets and result in a huge competitive advantage.

Like Alice in Wonderland, everyone must run faster just to stay in the same place. For the U.S. to move ahead requires added agility, effectiveness, and an extensive network of interconnections within the U.S. innovation system.

Regrettably, signs of trouble are also appearing on the science and engineering workforce front. The demand for STEM talent in the U.S. is growing at a rate of about 5% per year, while the growth rate in science and engineering degrees is only about 1.5% per year.

Much of the modest growth in science and engineering degrees comes from foreign students, who now earn about 47% of graduate degrees. As economies strengthen in countries such as China and India, more of these students are likely to remain at home, leading to declining “brain gains” in the U.S.

Add to this the number of retirees expected among “baby boomers” in the coming decade and an even greater “hollowing out” of the nation’s STEM workforce looms on the horizon.

This problem will become especially severe for defense and aerospace industries, and for many federally-funded laboratories. An adequate supply of domestic STEM graduates who can be cleared for classified research is paramount for these industries and institutions.

Domestic STEM talent needs to be nurtured in our own K-12 education system. Finding innovative educational paths to guide our young students on to undergraduate and graduate studies really IS rocket science. It will take the same level of intelligence, will and vigilance that once took us to the moon.

I simply cannot overstate the importance of educating all of our citizens in science and technology through public outreach and continuing education. We must train a generation of scientists, engineers, and technicians skilled in adapting to fast-changing knowledge and technology.

Today, no one questions that discovery feeds innovation and that new technological concepts drive economic growth and job creation. Nourishing this path to comparative advantage will allow us to prosper in the “red-hot” competition of the global economy.

I have no doubt that the spirit of discovery and innovation is thriving here in the Capital—in research and education, in industry, and in government. It’s time to marshal that energy. The urgency and necessity to meet the challenge of sustaining leadership in science, engineering and technology have never been as acute as they are today. I remind you of the quote from Norm Augustine about the possible fate of future generations of Americans.

Regrettably I don’t sense that the threat is felt as deeply or as broadly as it merits. That causes most of my sleepless nights.

I call upon you tonight, because you are among the wise and experienced, to encourage, support and foster an understanding within your own institutions and community, as well as in industry, government, and Congress, of what is at stake for the nation.

I ask you to make the case that a commitment to cutting-edge research and education, together with the will to use that new knowledge and talent to innovate, are just what America needs at this critical moment in our nation’s history. Without a robust and growing economy, the nation will be seriously strained to meet pressing social needs.

America needs bold efforts, at the most demanding levels of creative enterprise, to sustain a leadership role in the global economy. I urge you to step forward and help to lead us in that endeavor.

Thank you.