Priming The Innovation Pump

America Needs More Scientists and Engineers

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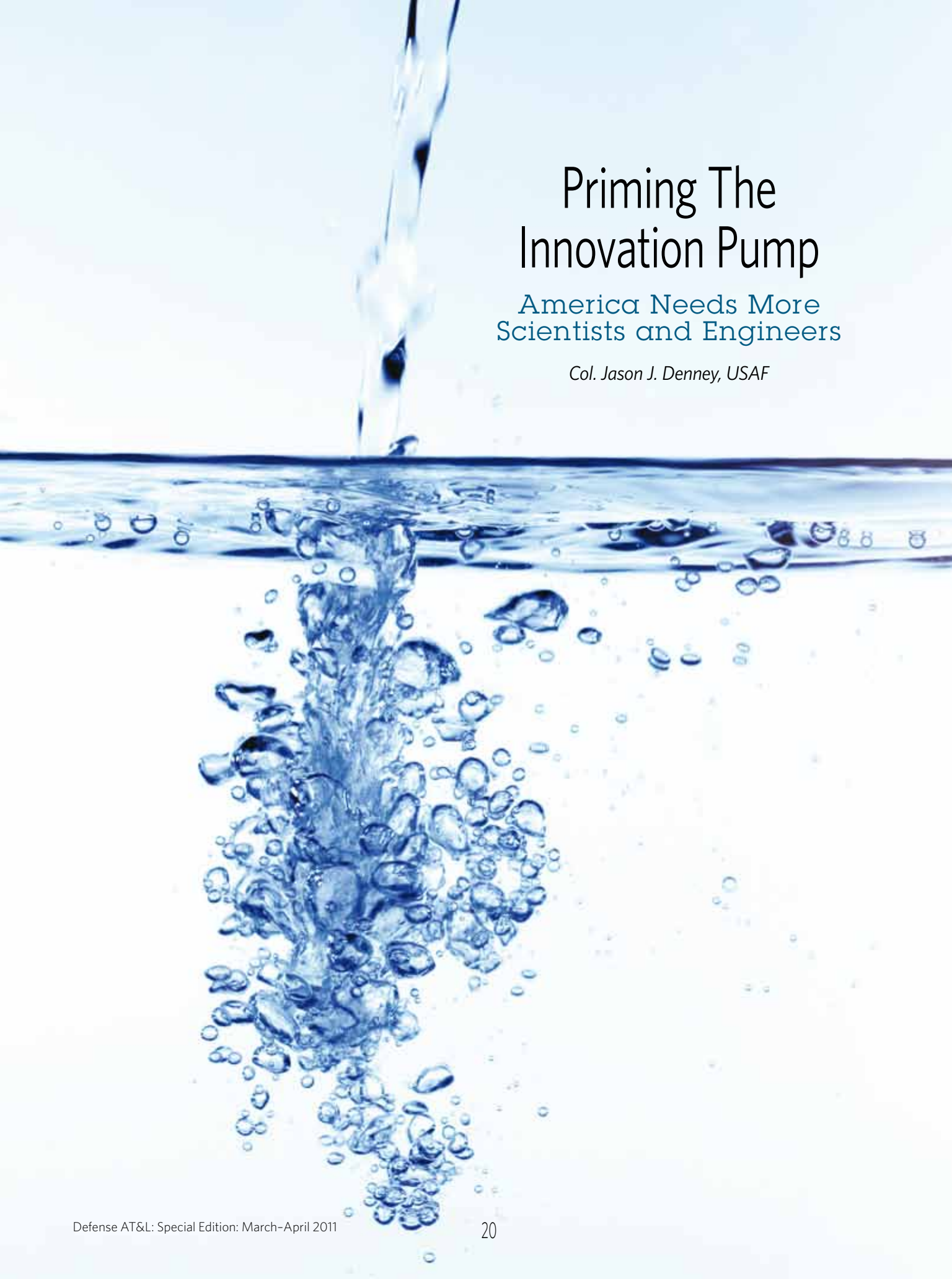
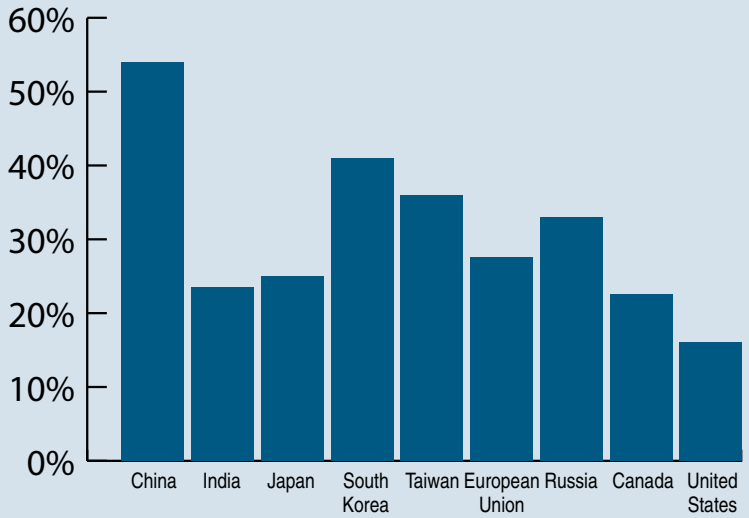


The United States has led the world in science, technology, knowledge generation, and innovation; however, the nation can no longer take its position for granted. Nations fueled by globalization and competitiveness are on a fast track to surpass the United States in scientific excellence and technological innovation. Specifically, downward trends in the number of U.S.-born scientists and engineers (S&Es) are exacerbating this challenge and creating troubling implications for U.S. economic prosperity and national security.

United States Lags in Percent of University Students Receiving Degrees in Science and Engineering



Note: Adapted from Innovation and U.S. Economic Growth, by R. D. Atkinson, Feb. 5, 2009, Information Technology and Innovation Foundation presentation to Industrial College of the Armed Forces.

From Producing Stuff, to Producing Ideas

The liberal, neo-classical economic doctrine and its principle that capital drives growth have given way to knowledge economics and its principle that innovation drives growth. During the Industrial Revolution, physical capital was the competitive advantage, and growth was the product of land, labor, and capital—in other words, how much "stuff" was produced. In 1930, Joseph Schumpeter, an Austrian economist, first pointed out that innovation is the key to economic growth. Today, Paul Romer's new growth theory builds on Schumpeter's premise by stressing that information leads to knowledge and then knowledge leads to innovation. Unfortunately, the U.S. innovation engine—fueled by the supply of U.S.-born S&Es—is quickly losing ground to international competitors. Of specific concern is the general lack of interest among American-born youth in pursuing careers in the science, technology, engineering, and math (STEM) fields. If this trend continues, the United States will find itself at a severe disadvantage.

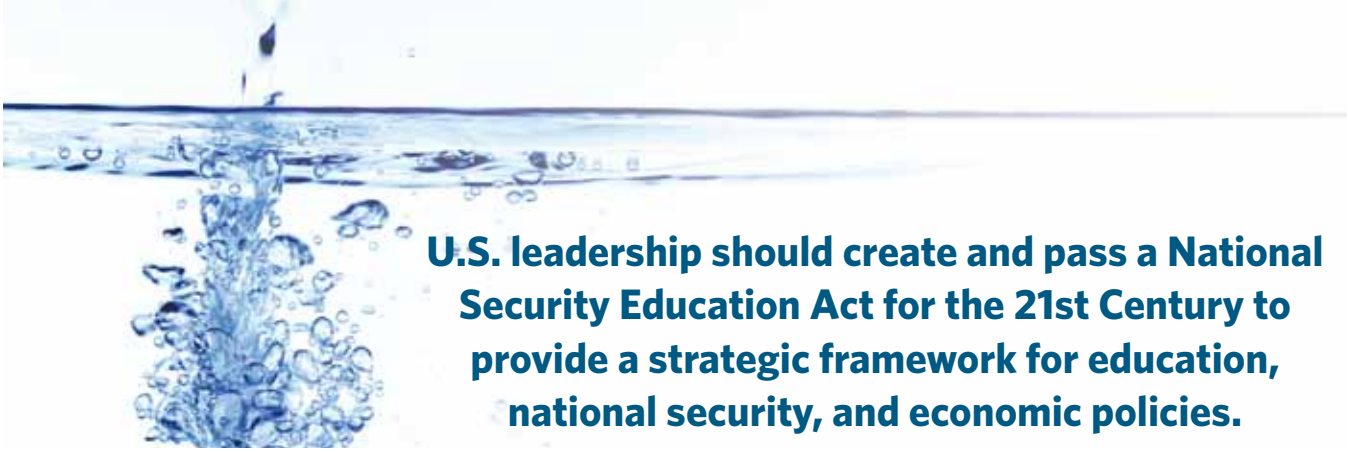
Losing Ground on All Fronts

By most science and technology (S&T) metrics, the United States leads the world. However, the nation has already lost and is continuing to lose ground in critical technology output metrics such as its trade balance of high-tech goods, the number of technical articles published, and the number of technical articles cited by others. Growth in overseas S&E talent and infrastructure has increased the off-shoring of U.S. industrial research and development. According to William Berry and Cheryl Loeb of the National Defense University, the world's S&T investment increased by 96 percent from 1996 to 2006, with China's growth at 9 percent, dwarfing all other countries, including the United States, whose S&T investment decreased by 6 percent. The U.S. output of native-born S&E talent is a major contributor to this strategic dilemma.

As depicted in the bar chart, the United States lags global competitors in the percentage of undergraduates earning S&E degrees. In 2002, the National Science Foundation (NSF) found that only 17 percent of U.S. undergraduates earned engineering degrees, as compared to 53 percent in China. In addition, the U.S. global share of S&E doctorates and undergraduate degrees fell from 40 to 20 percent and from 30 to 14 percent respectively, between 1970 and 2000. The NSF also determined that 58 percent of engineering doctorates awarded in the United States in 2003 went to non-citizens, while greater than half of the students enrolled in U.S.-taught engineering programs were foreign-born. Also, according to the Aerospace Industries Association, in a recent survey of more than 270,000 U.S. college freshmen only 7.5 percent said they intended to major in engineering—the lowest level since the 1970s. This is especially worrisome since over half the American-born S&E workforce is over 40 and will retire in the next 20–30 years.

The Department of Defense (DoD) alone, based on National Defense Education Program statistics, is expected to lose more than 13,000 S&Es in the next decade. Industry is not immune either. Sixty percent of the aerospace industry workforce is 45 or older, and 27 percent of its engineering workforce is qualified for retirement, based on AIA data. Foreign-born S&Es are earning the lion's share of undergraduate and graduate S&E degrees, but security concerns with foreign-born S&Es limit their opportunities within the DoD, and its supporting contractors, as well as other federal agencies. Even the U.S. economy cannot rely on a steady influx of foreign S&E talent.

Foreign students, particularly Asian students, are less likely to study in the United States for several reasons. First, foreign countries are growing their own higher education capabilities. According to the Task Force on the Future of American Innovation, the number of Chinese, South Korean, and Taiwanese doctoral students at U.S. universities dropped by 19 percent from 1994 to 1998, while their enrollment at institutions in their native countries doubled. Berry and Loeb found in 2006 that five Chinese universities ranked in the top 100 universities for science, with Peking University ranking 12th. Second, foreign countries are developing their own high-tech industries and research capacity. As a result, increasing numbers of U.S.-educated doctoral S&E graduates are returning to their native countries to pursue research opportunities. And finally,



U.S. leadership should create and pass a National Security Education Act for the 21st Century to provide a strategic framework for education, national security, and economic policies.

tighter visa restrictions post-9/11 deter foreign students from studying in the United States. As a result of this reduction in foreign S&E talent to supplement innovation, the United States must produce more homegrown STEM talent to maintain its economic and national security edge.

The U.S. Innovation Engine… Running Lean on S&Es

U.S. investment in the physical sciences and engineering has not kept pace with demands of the global economy and national security threats. September 11, 2001, and its continuing aftermath underlie the need for a powerful U.S. S&T effort; however, the number of U.S. citizens enrolling in graduate math, engineering, and physical science programs—the fields of broadest DoD application—fell by 25, 21, and 17 percent, based on NSF data. How can this be, given that the majority of Americans believe S&T plays a significant role in national security, is critical to stopping future terrorist threats, and will impact the nation's future economic prosperity? Actions need to match sentiment for a shift to occur.

The U.S. technological and military dominance is the product of S&T investments in education, infrastructure, and research and development made in the 1950s through the 1970s; therefore, shortsightedness today may concede U.S. military and technological dominance 10, 20, and up to 30 years or more in the future. It is akin to a farmer who wishes only to harvest and not to sow. If the United States does not invest to rebuild its S&E talent, it will not maintain its global economic and military position long into the 21st century.

Rebuilding the S&E Talent Pool…It Starts with K-12 Math and Science Education

The American K-12 education system is failing our children and threatening the U.S. economy and national security. Specifically, downward trends in math and science education—particularly on international assessments—has troubling implications. U.S. leaders must make the strategic connection between math and science education, the ability of our high school graduates to even pursue STEM degrees, and its link to economic and national security. One only needs to review the latest 2009 Program for International Student Assessment results released in December 2010 to see that America's kids are not making the grade, particularly in math and science in which they scored 24th and 19th out of 64 developing and developed countries. As compared to the 33 Organisation for Economic Cooperation and Development countries (for a more apples-to-apples comparison), American 15-year olds were 18th in math and 13th in science. These results are sobering given that the United States prides itself as having a technologically advanced society, economy, and military. Those days are quickly becoming numbered unless we cultivate our kids to love science and math, and hence, to have the abilities to pursue STEM degrees.

Implications of a U.S. S&E "Brain Drain"

The productive power of the U.S. economy and its national security lies primarily with its people. The Office of Management and Budget estimates that privately owned capital in the United States is worth $13 trillion, while its human, intellectual capital is worth $48 trillion. According to Alan Greenspan, "If we are to remain preeminent in transforming knowledge into economic value, the U.S. system of higher education must remain the world's leader in generating scientific and technological breakthroughs and in preparing workers to meet the evolving demands for skilled labor."

Since 1980, S&E positions in the United States have grown by five times the rate of other professions, according to the Task Force on the Future of American Innovation. However, the number of S&E degrees earned by U.S. citizens is decreasing. This is especially critical to DoD laboratories and agencies like the National Security Agency, where U.S. citizenship is a security requirement. Additionally, the time and cost to pursue S&E graduate degrees have increased while the compensation in S&E fields has declined relative to other high-level occupations. These trends clearly signal the need to create incentives—such as higher wages, fellowships, and employment guarantees—to maintain the pipeline of quality S&E talent that our nation's economy and national security structure sorely need. Unless more U.S. students choose S&E fields, the U.S. public and private innovation sectors will experience a significant "brain drain."

Industry has been working to avoid this "brain drain" for some time, but is still struggling to hire the talent it needs. According to the Aerospace Industries Association, 13 percent of the overall aerospace and defense workforce is qualified for retirement, and within 10 years this figure will grow to 50 percent. And, of the 70,000 engineering bachelor's degrees awarded

in the United States annually, most disciplines are not in high demand by DoD contractors. With an aerospace and defense workforce that is half its size at the end of the Cold War, DoD and industry are in a precarious position, particularly when it takes several years to grow an experienced engineer from entry-level talent. To stop and reverse this innovation "brain drain," new policies are needed to increase the number of quality American-born S&Es, in addition to supplementing the private sector with foreign S&E talent.

Policy Recommendations

U.S. technological leadership requires effective government policies to keep the nation at the leading edge of the scientific frontier. The September 11, 2001, attack is analogous to the Sputnik launch that created the National Defense Authorization Act in 1958; however, Americans need to once again find the excitement and urgency of 50 years ago that led to technological achievements such as the Apollo moon landings. Time is of the essence because the Apollo generation is ripe for retirement. U.S. leadership should create and pass a National Security Education Act for the 21st Century to provide a strategic framework for education, national security, and economic policies. The following policies, while not an exhaustive list, would be a step in the right direction.

National Innovation Policy Recommendation

Simply educating more S&Es is not enough. The United States must create national innovation policies to provide focus, to promote the diffusion of innovative ideas across private and public lines, to advocate for innovative projects, to ensure a continuous supply of quality S&Es and basic research and development resources, and to tie innovation to the U.S. economic and national security.

S&E Policy Recommendations

Increase the number and value of S&E graduate research fellowships (GRFs). At a minimum, the NSF should restore the ratio of GRFs to undergraduate engineering degrees to the ratio that existed in the early 1960s, following Sputnik. Increasing GRFs will incentivize the most talented S&E students to continue on to graduate work versus pursuing more lucrative fields.

Continue to attract the best and brightest S&Es from abroad. Highly skilled immigrant S&Es contribute significantly to U.S. economic growth. According to the Brookings Institution's Hamilton Project, a third of all businesses founded in the Silicon Valley in the 1990s were started by foreign-born S&E entrepreneurs. Also, foreign-born competition will drive U.S.-born S&Es to achieve greater educational heights and innovation to compete.

Increase the H-1B visa caps to pre-9/11 levels. The United States is failing to take full advantage of the global talent pool. The Hamilton Project found that the number of international S&E students in U.S. graduate programs declined by 20 percent between 2001 and 2004. The United States must reverse this trend to maintain its innovative edge.

Improve STEM education. By developing programs that demonstrate the practical uses of math and science, the government can generate interest in STEM careers and support students interested in these programs through government-funded fellowships, thus providing a steady stream of S&E talent.

K-12 Education

Create a national standard for math and science education. High standards improve teaching and learning. The time has come for the adoption of national math and science standards. Algebra is algebra and photosynthesis is photosynthesis, no matter what your zip code is; therefore, a national math and science standard—based on the broad inputs of educators, elected officials, federal agencies, community and business leaders, and experts in pedagogy—is the natural starting point to focus other math and science education reforms.

Establish a rigorous and challenging math and science curriculum. According to former Assistant Secretary of Education Susan Sclafani, the strongest predictor of completing a STEM degree is a rigorous high school math and science curriculum.

Establish initiatives to retain and recruit "quality" math and science teachers. According to the NSF, 80 percent of public schools report teacher vacancies—74 percent in math and 56 percent in science. In addition, the highest percentage of out-of-field teachers (teaching without a degree in the subject) are in math and science, based on National Center for Education Statistics.

Conclusions

Innovation is more important to the U.S. economy and national security now than in the past. Since World War II, the United States has been the leader in innovation; however, international competition is posing a growing challenge to U.S. technological supremacy. The United States has the best market environment in the world to support innovation, but arguably weak innovation policies. Effective government innovation policies are critical to keeping the nation at the leading edge of the scientific frontier. Knowledge and innovation are powerful drivers of economic growth; therefore, America must rebuild its foundation of competitiveness—its supply of S&E talent—that has served the country so well for the past 50 years. America must also recognize that the strength of this foundation starts with improving K-12 math and science education—sowing the seeds of innovation from the start. The challenges are real and growing, so knowledge generation and innovation must become a national priority...America's future depends on it!

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