Statement of Dr. John P. Holdren
Director, Office of Science and Technology Policy
Executive Office of the President of the United States
to the
Committee on Appropriations
United States Senate
on
Driving Innovation through Federal Investments
April 29, 2014

Chairwoman Mikulski, Ranking Member Shelby, and Members of the Committee, it is my distinct privilege to be here with you today to discuss the importance of continued Federal investments in research and development (R&D) to the Nation's future.

President Obama continues to place a high priority on research and development and on science, technology, engineering, and math (STEM) education, recognizing that these are critical to providing for the future of the Nation's economy; the health of the American people; the quality of our environment and the sustainability of the services it provides; and our national and homeland security.

Federal investments in R&D help to: sustain the Federal component of the world-leading U.S. research, development, and innovation enterprise; incentivize the private sector to lift its game in research, development, and innovation; advance public-private partnerships that are restoring U.S. leadership in advanced manufacturing; boost research on growing public-health challenges including neurodegenerative diseases and antibiotic resistance; support further advances in cleaner, American energy; enhance the Nation's capacity to address global climate-change through a combination of emissions reductions, preparedness and resilience, and global leadership; and continue to provide for the technological advances that have always given our armed forces the edge over every potential adversary. And investments in STEM education provide for the next generation of discoverers, inventors, and high-tech entrepreneurs; ensure that the Nation has the tech-savvy workforce that the jobs of the 21st century require; and help create the science-savvy citizenry so important to a well-functioning democracy in a world where many of the issues before our policy makers have a science dimension.

As past budgets from this Administration did, the President's 2015 Budget proposes to invest intelligently in research, innovation, education, and infrastructure to lay the foundations for the industries, jobs, workforce, and environmental and national-security benefits of tomorrow. But, of course, we need the continued support of the Congress to get it done. I say "continued support" because much of the President's Federal research and education investment portfolio has enjoyed bipartisan support. Congress has recognized that retaining America's global leadership position in science, technology, and innovation is not a partisan issue. The Administration hopes to extend and to build on this mutual understanding and appreciation, in our interactions with both the Senate and the House, in order to continue to strengthen the Nation's science and technology portfolio and the economic and other societal benefits it underpins.

In what follows, I elaborate on how the science and technology components of the President's 2015 Budget support this agenda, particularly as they relate to economic

competitiveness, job creation, and continuing U.S. leadership in a global economy that is increasingly based on innovation.

We know from decades of research in economics that a significant portion of U.S. economic growth over the past several decades has come from technological advances, in some studies up to half of U.S. economic growth after World War II. Such advances generally are the result of decades of research and development. And while the share of U.S. R&D supported by the Federal government has fallen from as much as two-thirds in the 1960s to under one-third today, with the difference made up mainly by growing contributions from the private sector, the Federal government remains the largest funder of the basic research that produces the seed corn from which all applied advances grow. The Federal government also funds a substantial amount of applied research in domains such as biomedicine and clean energy, where potential societal benefits are large but high risk and long timescales have limited private investment.

In addition, the Federal government promotes policies to encourage private firms to invest in R&D and provides an institutional, legal, and regulatory environment that further encourages private innovation. As already indicated, the Federal government also supports and encourages, in a variety of ways, STEM education and worker training to develop the human capital in the workforce needed for the Nation to take full advantage of the fruits of R&D.

Today's U.S. economy continues to depend heavily on innovation built on the foundation provided by Federal investments in research. These investments have helped to create entirely new industries in which American firms were pioneers and are now leaders, including information technology, nanotechnology, biotechnology, and advanced-manufacturing techniques. For example, the Defense Advanced Research Projects Agency (DARPA) began to invest in a computer network called the ARPANET in the 1960s, which provided the technical foundation for today's Internet. The National Science Foundation's (NSF) "Digital Library Initiative" program funded research on Internet search engines by two Stanford graduate students, Larry Page and Sergey Brin, who became the cofounders of Google. Many of the technologies that allowed companies to develop the capabilities in the smartphone, such as the Global Positioning System, touchscreen displays, and the voice-activated assistant Siri, were also supported by Federal research and development. These advances in information and communications technology are important not only for high-tech firms, but for other firms that use technology to compete and win in the global marketplace by reducing the time required to develop new products, orchestrating complex supply chains, and increasing the productivity of their employees.

The Federal role in research has been especially important for research in which the eventual applications can't be foreseen. It is in recognition of the unexpected and unpredictable impacts of fundamental research that a coalition of science and engineering societies recently introduced an annual Golden Goose Award to make the case that Federal support for research is a golden goose that lays golden eggs for the American people. The award honors researchers whose federally funded research no one could have predicted would end up having significant practical applications. One group of honorees, whose research over several decades was supported in part by NSF and in part by the National Institutes of Health (NIH), studied why a certain species of jellyfish glows green. They isolated a green fluorescent protein (GFP), used the protein to map gene expression in other organisms, modified the protein to express stronger luminescence and different colors, and eventually saw their work point the way to key biomedical imaging techniques leading to advances in genetics, cell biology, developmental biology, and neurobiology, and to methods used widely by the pharmaceutical and biotechnology industries.

Federal investments in research also play an important role in the development of strong regional economies. Federal research has helped promote the emergence of vibrant "innovation ecosystems" not only in Silicon Valley, but in communities such as Pittsburgh (robotics), San Diego (wireless communications), Central Florida (photonics), Maryland (biotechnology), and upstate New York (nanoelectronics).

Although the United States is a leader in science, technology, and innovation, the Obama Administration believes that we cannot take that leadership for granted. Other nations have been increasing their investments in research and development, no doubt inspired by the example of the United States and how this country's past investments in research built the world-leading U.S. science, technology, and innovation enterprise.

No single data set can capture the complexity of the innovation enterprise, and there is no magic number to describe the right level of national effort in R&D investments. Nevertheless, by looking at multiple data sets and multiple international comparisons it is possible to draw some conclusions about U.S. capabilities in relation to those of other nations and about what focuses of U.S. R&D efforts may need more attention.

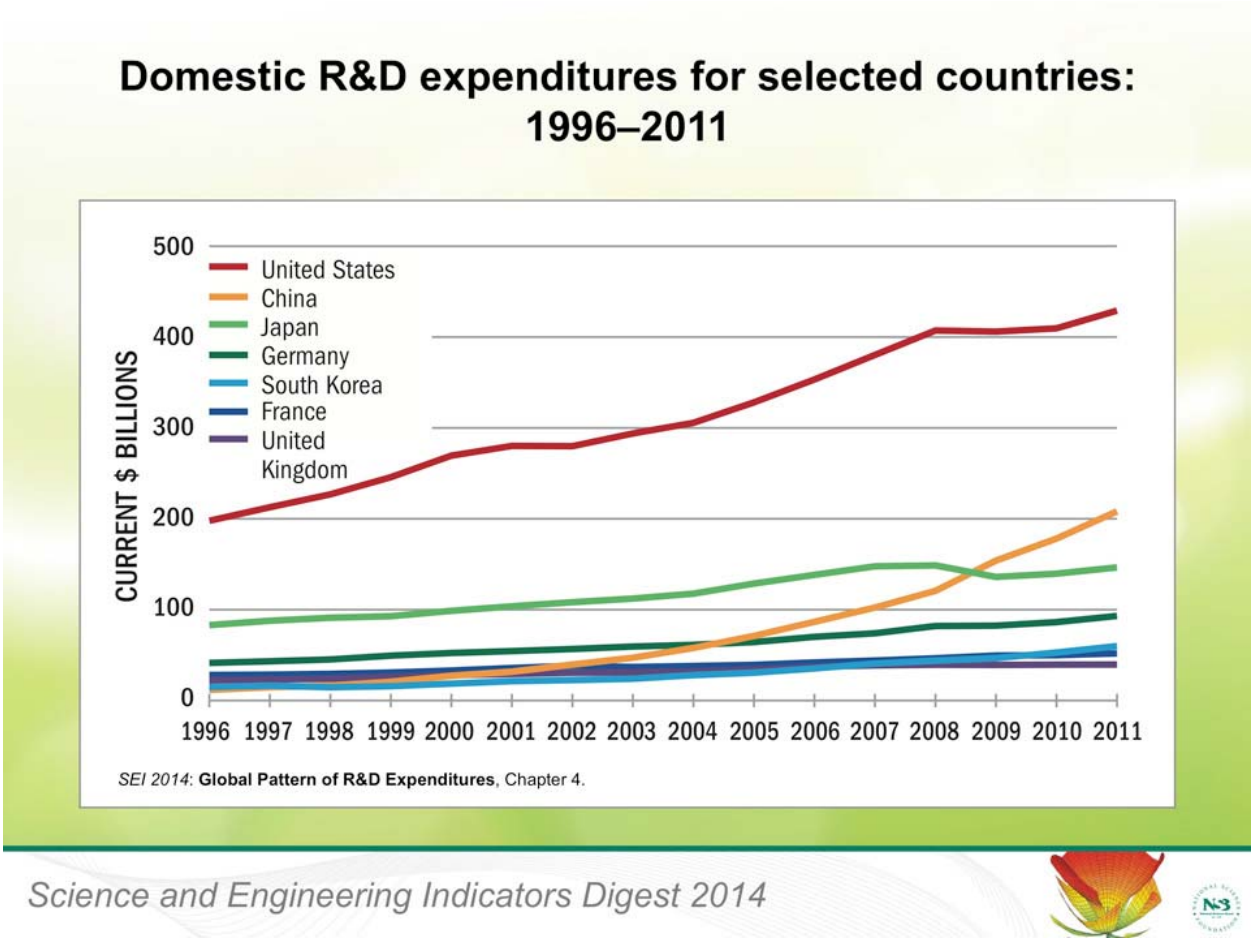

Figure 1.

For data on U.S. and other nations' science, technology, and innovation enterprises there's no better place to go than NSF's National Center for Science and Engineering Statistics (NCSES),

particularly the compilation of its work provided in the National Science Board's biennial *Science and Engineering Indicators* (SEI) report. In what follows, I provide some of the information from the 2014 edition that underscores the importance of sustaining Federal investments in R&D.

One relevant indicator is total national investment in R&D, combining private and public sources of funding. The data in the 2014 SEI report show that U.S. R&D expenditures accounted for about 31% of the worldwide total in 2011 (see Figure 1). The United States remains the dominant performer of R&D in the world, though the U.S. share is down from 38% a decade earlier. For the last few decades, the Federal R&D investment has accounted for roughly one-third of the total U.S. total (with a dominant role in supporting basic research), while U.S. companies support most of the remaining two-thirds (with a dominant role in supporting development). Most other advanced nations have similar ratios of public to private support of R&D. In 2011, total U.S. R&D investments were $429 billion. In second place was China with $208 billion in purchasing power parity dollars, still less than half the U.S. total. But China is increasing its R&D investments rapidly, while the U.S. investments have been growing more slowly (more on this below).

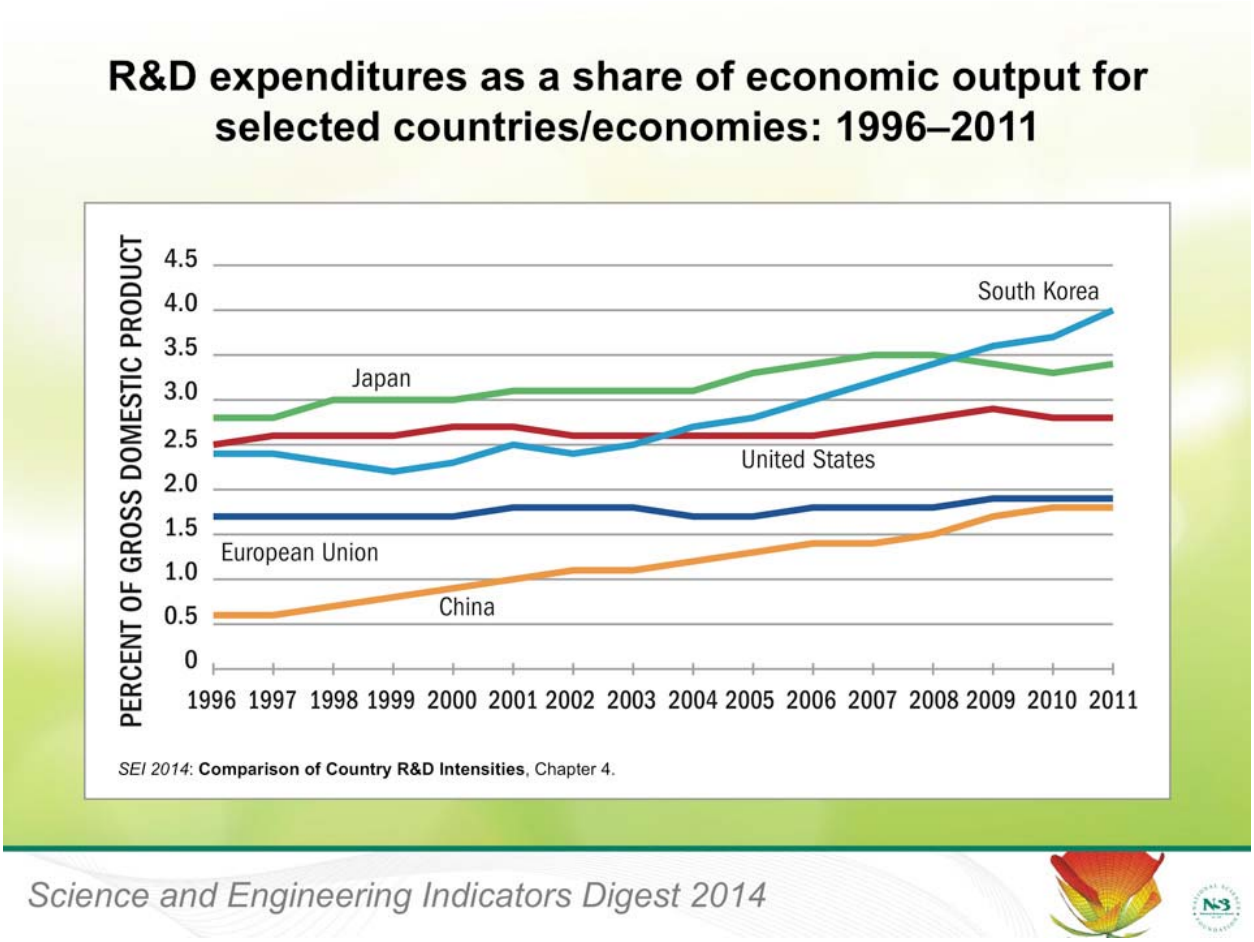

Figure 2.

Another important indicator is how much a nation invests in R&D as a share of its economy, or the R&D to Gross Domestic Product (GDP) ratio. In his 2009 address to the National Academy of Sciences and several times since then, the President set a goal for America to invest three percent of our GDP in public and private R&D, aiming to surpass the peak value of 2.88% achieved in the 1960s at the height of the space race. In 2009, the U.S. R&D/GDP ratio hit 2.90%,

the highest ratio on record, before falling to 2.81% in 2010 and then increasing to 2.84% in 2011 (see Figure 2). The good news is that the most recent NSF data (not shown in the graphic) show U.S. R&D/GDP ratio in 2012 at a preliminary 2.89%, the second-highest ratio on record.

But the data also show that other nations have not been standing still (see Figure 2). The most recent data show that America is in 10th place among economies in its R&D/GDP ratio. Japan and South Korea have had higher R&D/GDP ratios for a long time, and recently Germany caught up. In 2011, China's R&D/GDP ratio was 1.84%, well below most developed nations, but China's ratio has been increasing dramatically as both government and private R&D spending increase faster than economic growth. These sustained gains in China's R&D investments show a remarkable national commitment to investing in R&D to expand China's innovative capacity and to make Chinese firms and workers formidable economic competitors in global, technology-intensive industries. Other nations have also increased their R&D investments faster than growth in their economies over the past decade, while total U.S. R&D has grown only slightly faster than overall economic growth.

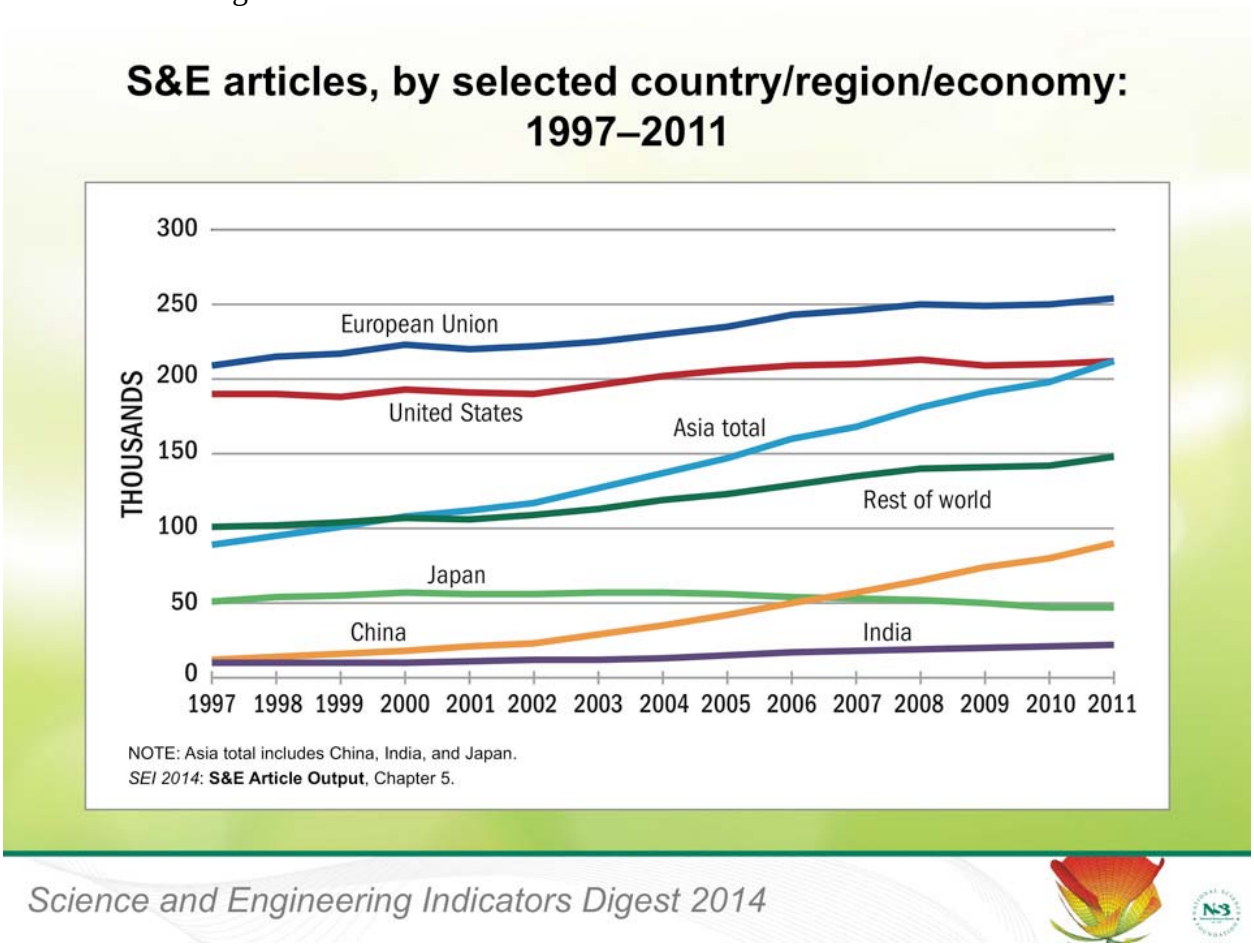

Figure 3.

Similar trends for the European Union, the United States, and China and other Asian nations can be seen in other indicators such as: science and engineering articles, highly cited papers, patents, and STEM graduates. For example, the results of research are commonly published in the form of science and engineering articles, often in peer-reviewed journals. The international data show that U.S. scientists and engineers remain the largest contributors to the world scientific literature when categorized by author nationality (see Figure 3). But other nations' researchers are

increasing their authorship of science and engineering articles. Other data show that U.S. authors become more dominant the higher one goes in the impact rankings of S&E articles as measured in citations by other articles. That is, U.S. researchers are authors of a disproportionate share of the top 10 percent most-cited articles, and an even more disproportionate share of the top 1 percent most-cited articles. But U.S. leadership is diminishing, even in the most-cited articles, as other nations' researchers improve their capabilities based on their nations' research investments.

I welcome the efforts of other nations to build their capacities in science, technology, and innovation, insofar as they add to the talent pool participating in research to address the many challenges that societies around the world face in common, such as defeating disease, poverty, and climate change. This, and the increase in the overall pace of advance of human knowledge, are benefits of the globalization of science and technology.

But I am also aware that the efforts of other nations present a challenge for the United States to keep up. World-leading science, technology, and innovation capabilities here in the United States have long given U.S. companies and workers an edge in global economic competition. To maintain that competitive edge and to enable Americans to participate fully at the frontiers of innovation, the United States needs to keep investing in its capabilities in the STEM fields, and for the needed investments in fundamental and early-stage applied research, especially, the Federal government's role remains indispensable.

The Administration's current and past budgets for R&D and innovation have strived to meet that responsibility. The President's 2015 Budget provides $135.4 billion for the Federal investment in research and development (R&D), an increase of $1.7 billion or 1.2 percent over 2014 levels, sustaining the Administration's longstanding commitment to science, technology, and innovation. The 2015 Budget proposes an increase in defense R&D (Department of Defense (DOD) and Department of Energy (DOE) defense programs) to $69.5 billion, $1.2 billion or 1.7 percent more than the 2014 enacted level, and $65.9 billion for non-defense R&D, an increase of 0.7 percent or $477 million over the 2014 enacted level.

The Federal investment in basic and applied research (the "R" in "R&D") totals $64.7 billion in the 2015 Budget, up $251 million or 0.4 percent compared to the 2014 enacted level. The Federal investment in development (the "D" in "R&D") totals $68.0 billion in the 2015 Budget, an increase of 2.3 percent compared to the 2014 enacted level. Funding for R&D infrastructure, including facilities and capital equipment, totals $2.6 billion, down $121 million from the 2014 enacted funding level.[1]

The Budget overall adheres to the 2015 spending levels agreed to in the Bipartisan Budget Act (BBA) of 2013, proposing painful but necessary cuts and reforms to make room for investment in priority areas such as research, clean energy, early learning, and ending homelessness. But even with those tough cuts and reforms, the discretionary levels set by the BBA simply are not sufficient to ensure that the Nation is achieving its full potential in creating jobs, growing the economy, and promoting opportunity for all. There are clearly additional opportunities to make investments in

[1] All comparisons in the testimony are between the 2015 Budget and enacted 2014 appropriations. The testimony discusses changes in current dollars, not adjusted for inflation. The latest economic projections show inflation of 1.7 percent between FY 2014 and FY 2015 for the economy as a whole, using the GDP deflator. Unless noted otherwise, budget figures exclude the additional investment proposals in the Opportunity, Growth, and Security Initiative.

the future of the Nation, including Federal investments in R&D, which cannot be accommodated under the current cap.

That is why the President has included with his Budget submission a supplementary, fully-paid-for $56 billion Opportunity, Growth, and Security Initiative, which identifies additional investments that could be made in critical areas to better meet the challenges and exploit the opportunities facing the Nation. The Initiative is split evenly between defense and non-defense priorities and includes investments in the critical areas of education; research and innovation; infrastructure and jobs; opportunity and mobility; public health, safety, and security; and more efficient and effective government; and national defense.

$5.3 billion of the Initiative would support research and development. It would: provide nearly $1 billion in additional funding for the National Institutes of Health (NIH) to support 650 additional new research grants, increase funding for a DARPA-like initiative at NIH, and increase NIH's contribution to the multi-agency BRAIN Initiative; provide more than half a billion in additional funding for the National Science Foundation (NSF) to support a thousand additional NSF grants to expand knowledge across disciplines and accelerate innovation across industries; and provide additional funding to develop and scale new manufacturing technologies through a nationwide network of manufacturing innovation institutes. The Initiative would also invest in additional applied research at the Department of Energy (DOE) to develop and deploy clean energy technologies, to modernize and increase the resilience of the nation's energy sector, and to advance nuclear nonproliferation technologies and keep nuclear weapons safe, reliable, and effective. And it would invest an additional $2.1 billion in Department of Defense (DOD) R&D to maximize the potential of defense R&D investments, such as those made by DARPA, to contribute to military and economic security through world-leading science and technology capabilities.

Considering both the base budget and the Opportunity, Growth, and Security Initiative, the President's 2015 Budget provides a comprehensive and detailed plan for making investments that will drive the Nation forward. Unless further action is taken, funding levels in 2016 and beyond will continue to preclude the investments needed to protect our Nation or enable our economy to achieve its full potential, because the BBA did not provide even partial sequestration relief after 2015. The 2015 Budget proposes to restore discretionary spending to a path that would continue to support economic growth, opportunity, and safety and security. These investments would also be paid for with a combination of reforms to mandatory spending programs and targeted tax loophole closers included in the Budget.

I will add that long-term Federal support of research is important not only to preserve U.S. leadership in science and engineering and the innovation and economic competitiveness that U.S. leadership underpins, but also because it is in our national interest for U.S. scientists, engineers, and innovators to be the first to discover and exploit the many opportunities we see before us. My fellow panelists will provide more examples of the many challenges that could be addressed and opportunities that could be pursued in their agencies' portfolios, but I will offer a few here. We have the opportunity to:

- Dramatically increase our understanding of how the brain works through investments in the BRAIN Initiative;

- Eliminate the often-agonizing waits for an organ transplant by pursuing advances in regenerative medicine;

- Accelerate the development of advanced materials that are stronger than steel and a fraction of the weight;

- Develop new sources of clean energy such as solar energy that is as cheap as other sources of electricity; and

- Enable small teams to design and make a growing range of products using emerging custom manufacturing technologies.

These potential breakthroughs should be made by researchers at American institutions, so that American companies and workers start out as leaders in the industries of the future just as they started out as leaders in the industries of today. Federally-supported breakthroughs can be and should be commercialized under American leadership. The United States can remain the world leader in the clean-energy industries of the future; in the advanced manufacturing processes enabling American highly-paid, highly-skilled workers to be competitive with manufacturing workers around the world; in cutting-edge biotechnology and medical industries; in the communications and information technology industries where American companies have been the pioneers; and many other industries. If the Administration and Congress work together to provide robust and reliable Federal support for research and other key investments, that future is within our reach.

Conclusion

The Administration's 2015 Budget reflects the President's appreciation of the profound importance of continued progress in science and technology for advancing the well-being of all Americans, even as we work to ensure fiscal responsibility.

As this Committee has long emphasized, the best approach to supporting across-the-board innovation and long-term economic growth and opportunity is to invest in a broad and balanced research portfolio—one that will produce not just the planned-for and predictable benefits to the Nation but also the entirely unexpected windfalls for society and the world. This country's overall prosperity in the last half century is due in great measure to America's pursuit of this formula and its commitment to a three-way partnership including academia, industry, and government. The 2015 Budget for science, technology, and STEM education continues this approach.

The Obama Administration recognizes that leadership across the frontiers of scientific knowledge is not merely a cultural tradition of our Nation; it is an economic, environmental, and national-security imperative. The Administration also recognizes that America can't take this leadership for granted at a time when other nations are pursuing their own visions of leadership. This Administration is committed to ensuring that America remains at the epicenter of the global revolution in scientific research and technological innovation—a revolution that promises to generate new knowledge, create new jobs, build new industries, and propel the Nation to a vibrant future.

I will be pleased to answer any questions the Members may have.